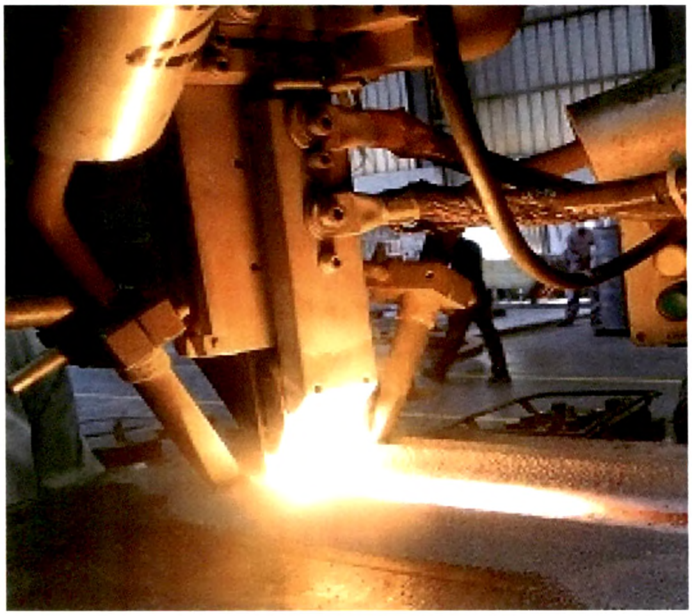
# CHAPTER-4

# RESULTS & DISCUSSION



# 4.1 Effect of alloy variation on Corrosion behaviour of weld overlays at different locations

### 4.1.1 Corrosion Behaviour of weld overlays at different location in 0.1 N $HHO_3$ Solution

#### 4.1.1.1 Corrosion behaviour 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution

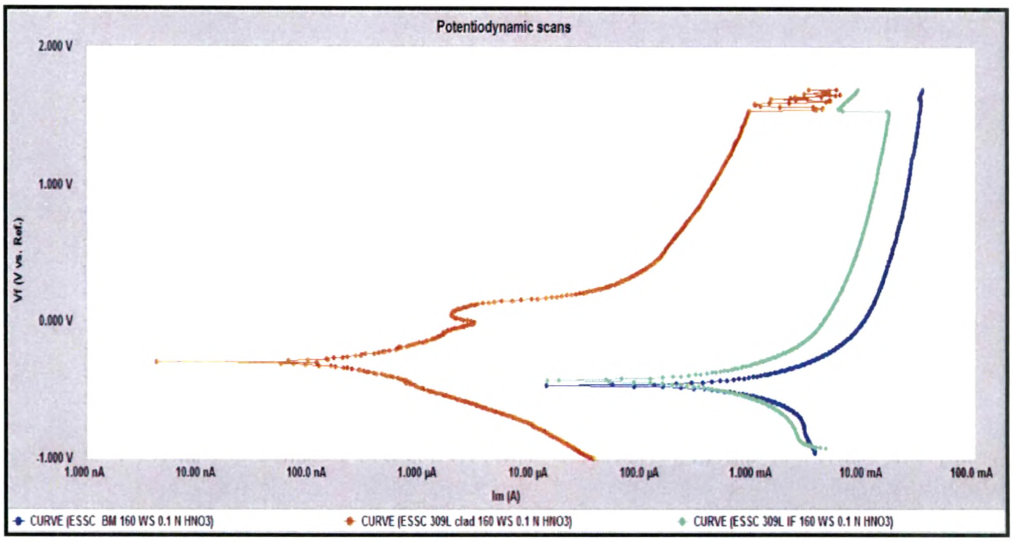



**Fig. 4.1: Potentiodynamic scans of 309 L cladded weld overlay develop with 160mm / min. welding speed at different locations in 0.1 N $HHO_3$Solution**

**Table-4.1: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 160 WS | 609.0 | -465 | 228.9 |
| 2 | ESSC 309L IF 160 WS | 431.2 | -428 | 161.7 |
| 3 | ESSC 309L Clad 160 WS | 361.3 | -374.0 | 135.5 |

Fig. 4.1 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr

and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.1.2 Corrosion behaviour 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution

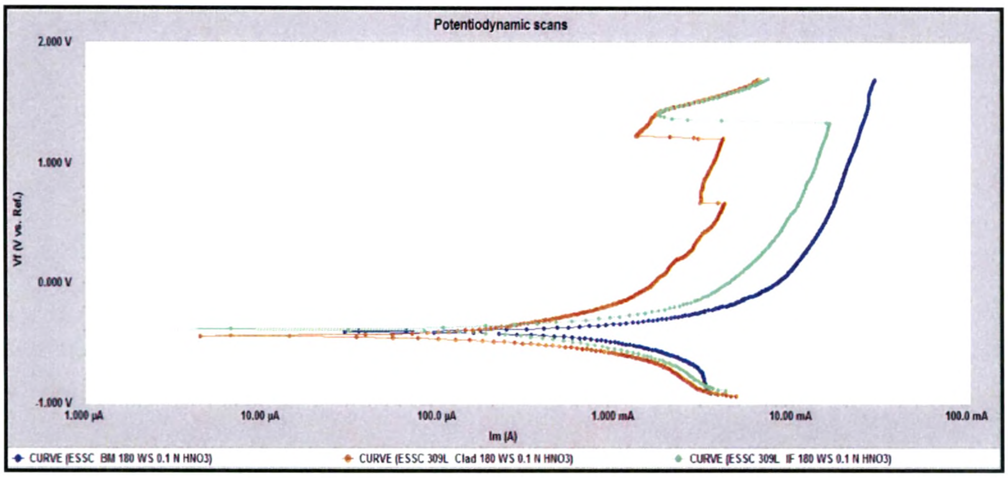



**Fig. 4.2: Potentiodynamic scans of 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$Solution**

**Table-4.2: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 180 WS | 567.0 | -404.0 | 213.0 |
| 2 | ESSC 309L IF 180 WS | 254.0 | -383 | 95.31 |
| 3 | ESSC 309L Clad 180 WS | 48.5 | -440 .0 | 18.24 |

Fig. 4.2 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i)

all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.1.3 Corrosion behaviour 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

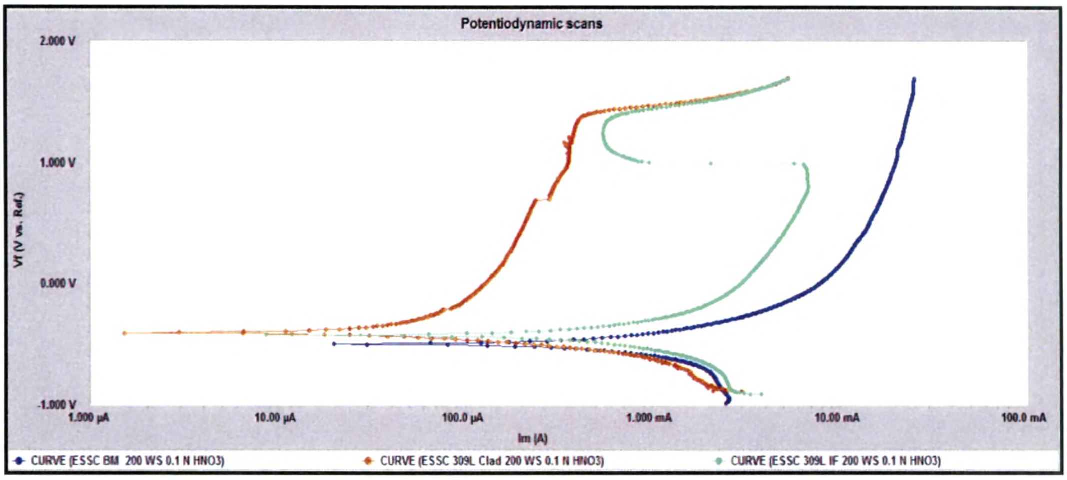



**Fig. 4.3: Potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

**Table-4.3: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 200 WS | 518.0 | -404.0 | 194.6 |
| 2 | ESSC 309L IF 200 WS | 245.0 | -423 | 92.1 |
| 3 | ESSC 309L Clad 200 WS | 35.7 | -402.0 | 13.41 |

Fig. 4.3 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution.. By comparing corrosion behavior of weld overlay at different locations, it shows that (i)

all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.1.4 Corrosion behaviour 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

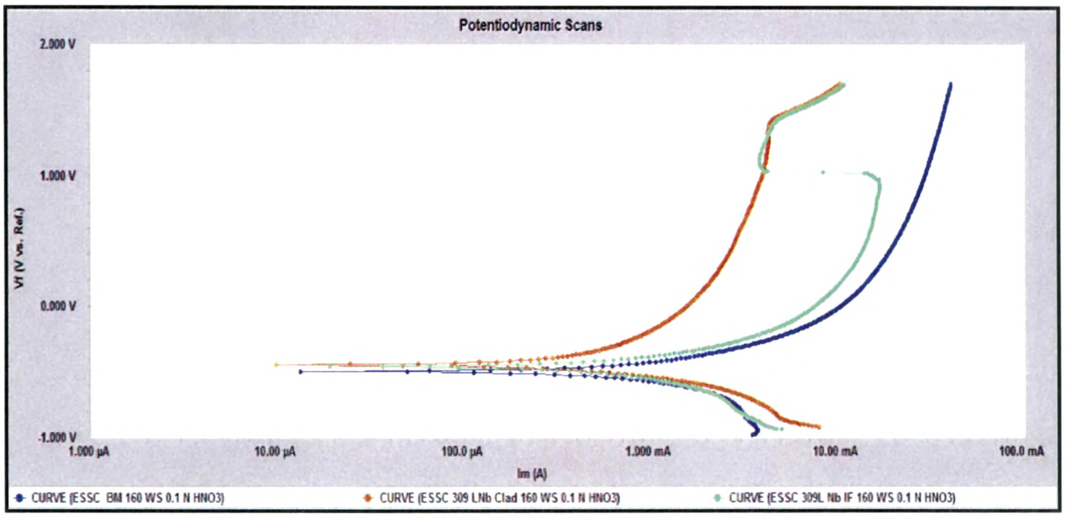



**Fig. 4.4: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $HHO_3$Solution**

**Table-4.4: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 160 WS | **609.0** | **-465** | **228.9** |
| 2 | ESSC 309L Nb IF 160 WS | **564.0** | **-458** | **211.6** |
| 3 | ESSC 309L Nb Clad 160 WS | **393.0** | **-424.0** | **147.3** |

Fig.4.4 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution.

By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.1.5 Corrosion behaviour 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

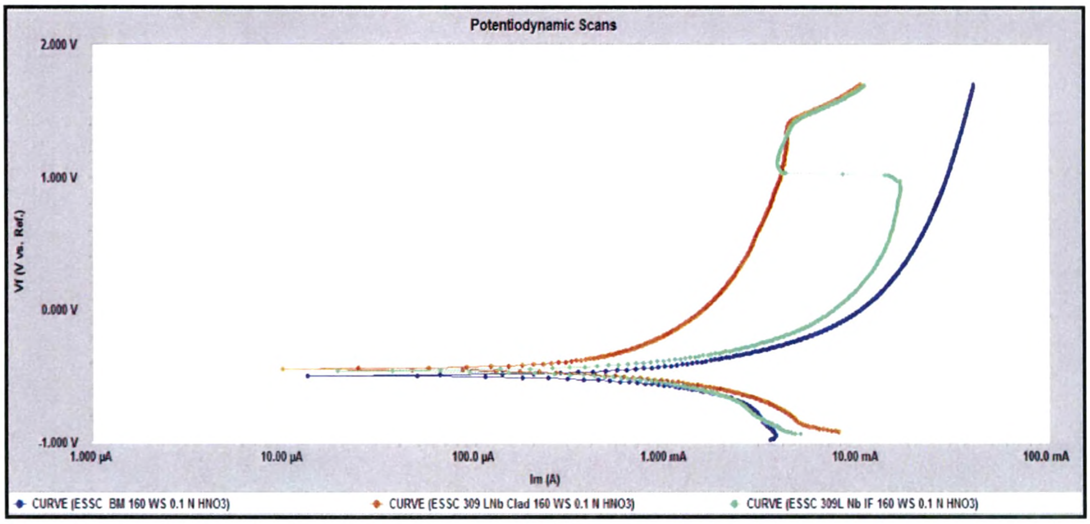



**Fig. 4.5: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$Solution**

**Table-4.5: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 180 WS | **567.0** | **-404.0** | **213.0** |
| 2 | ESSC 309L Nb IF 180 WS | **436.0** | **-386** | **163.6** |
| 3 | ESSC 309L Nb Clad 180 WS | **257.6** | **-354.0** | **96.62** |

Fig. 4.5 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.1.6 Corrosion behaviour 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

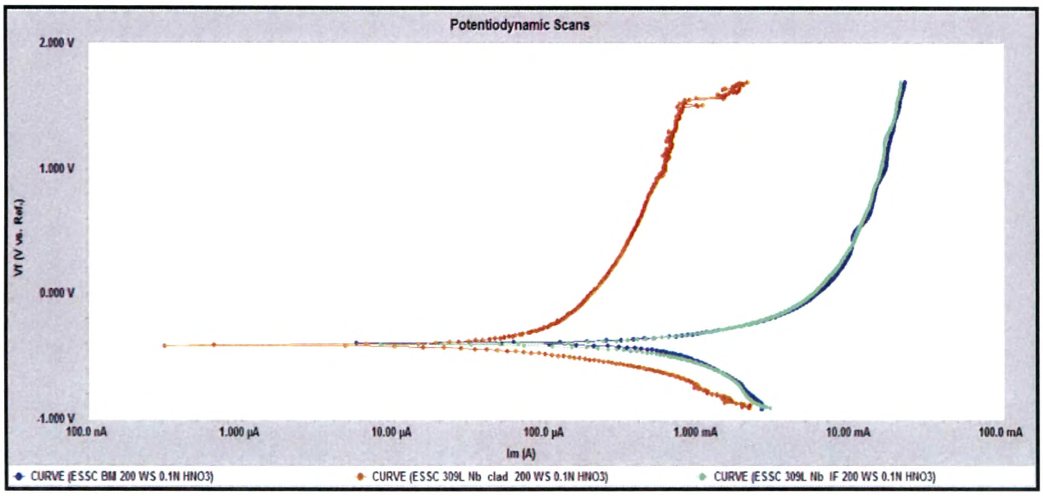



**Fig. 4.6: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

**Table-4.6: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 200 WS | **518.0** | **-496** | **194.6** |
| 2 | ESSC 309L Nb IF 200 WS | **441.0** | **-406** | **163.7** |
| 3 | ESSC 309L Nb Clad 200 WS | **242.1** | **-359.0** | **90.80** |

Fig.4.6 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N $HHO_3$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

## 4.1.2 Corrosion Behaviour of weld overlays at different location in 0.1 N HCl Solution

### 4.1.2.1 Corrosion behaviour 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution

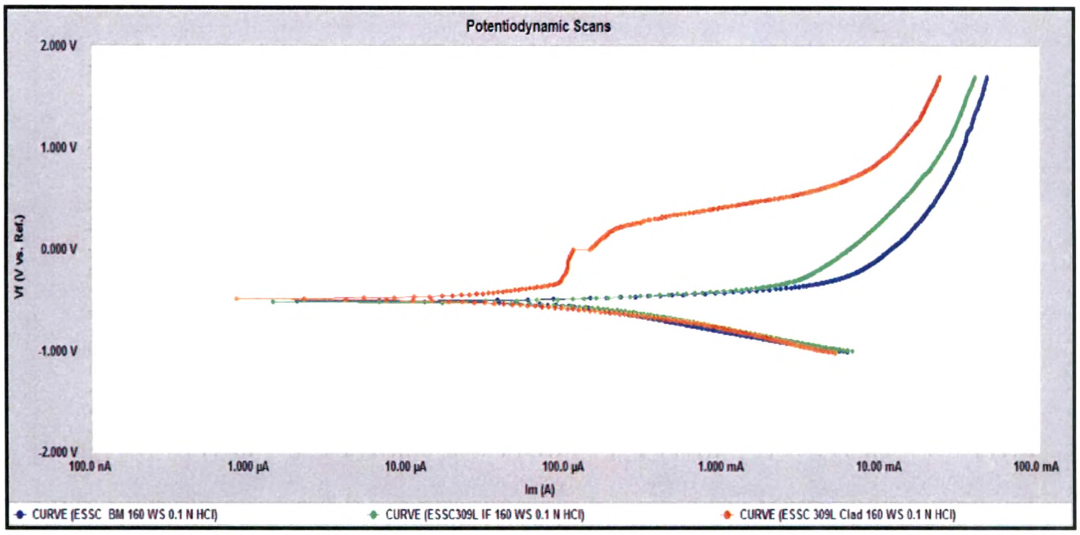



**Fig. 4.7 Potentiodynamic scans of 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.7: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 160 WS | 91.8 | -509 | 34.5 |
| 2 | ESSC 309L IF 160 WS | 48.50 | -523 | 18.22 |
| 3 | ESSC 309L Clad 160 WS | 26.7 | -486 | 10.03 |

Fig. 4.7 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N HCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some

amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

### 4.1.2.2 Corrosion behaviour 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution

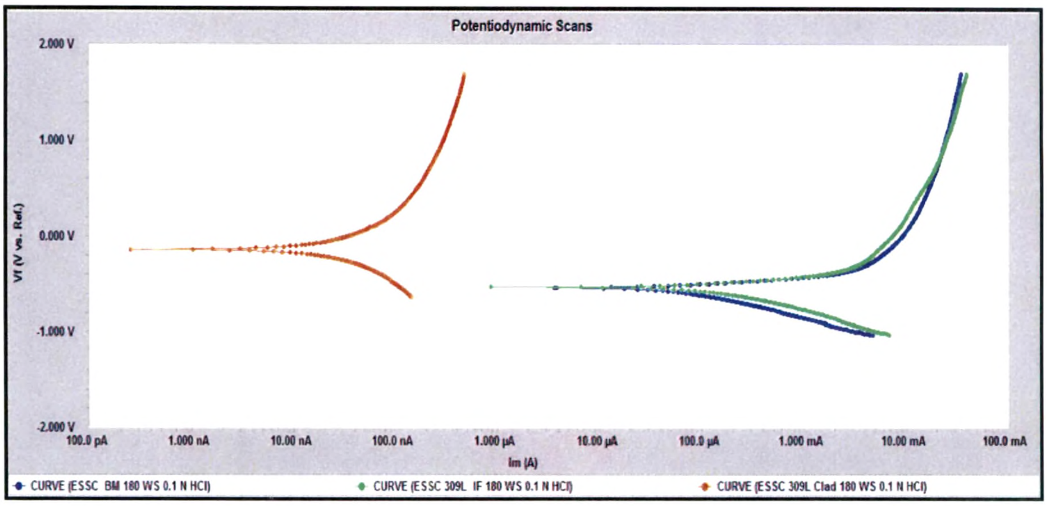



**Fig.4.8 Potentiodynamic scans of 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.8: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 180 WS | 60.5 | -535 | 22.73 |
| 2 | ESSC 309L IF 180 WS | 42.50 | -528 | 15.97 |
| 3 | ESSC 309L Clad 180 WS | 0.075 | -137 | 0.0282 |

Fig. 4.8 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N HCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region but does not exhibit any passivation behavior (iii)interface

region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.2.3 Corrosion behaviour 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution

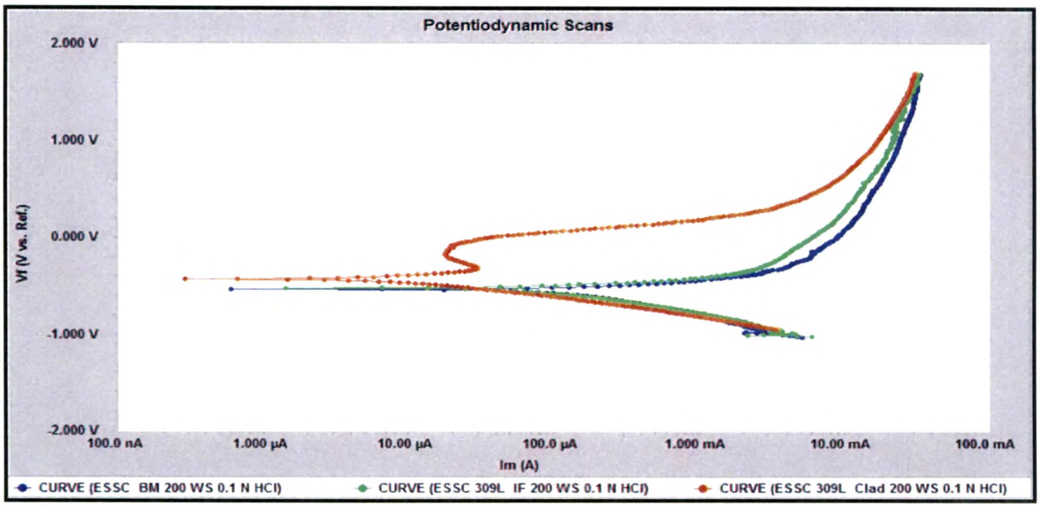



**Fig. 4.9 Potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.9: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 200 WS | 81.5 | -536 | 30.63 |
| 2 | ESSC 309L IF 200 WS | 39.30 | -502 | 14.77 |
| 3 | ESSC 309L Clad 200 WS | 7.56 | -427 | 2.843 |

Fig. 4.9 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N HCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also

having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.2.4 Corrosion behaviour 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution

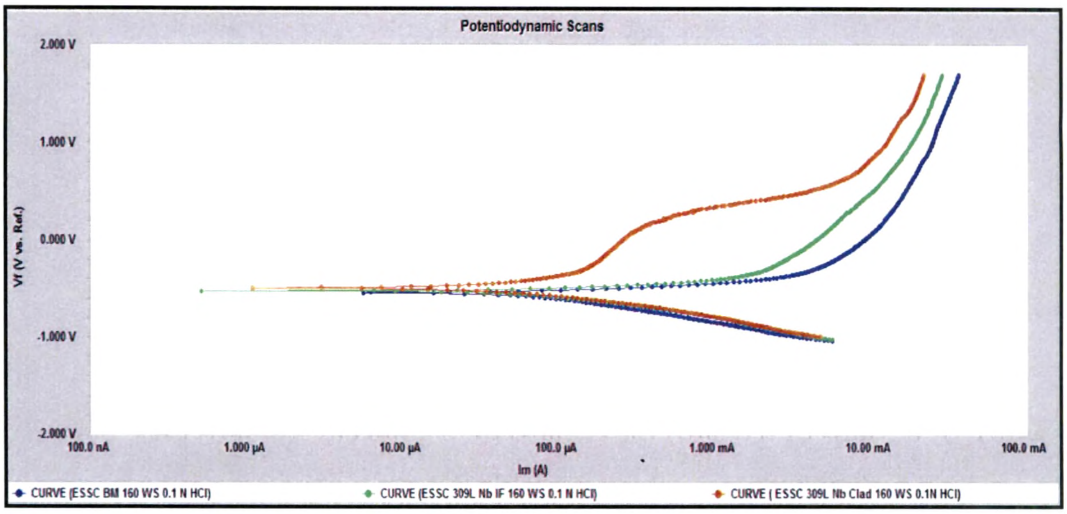



**Fig. 4.10: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.10: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 160 WS | **91.8** | **-509** | **34.5** |
| 2 | ESSC 309L Nb IF 160 WS | **69.6** | **-518** | **26.15** |
| 3 | ESSC 309L Nb Clad 160 WS | **39.6** | **-493** | **14.9** |

Fig. 4.10 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N HCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also

having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.2.5 Corrosion behaviour 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution

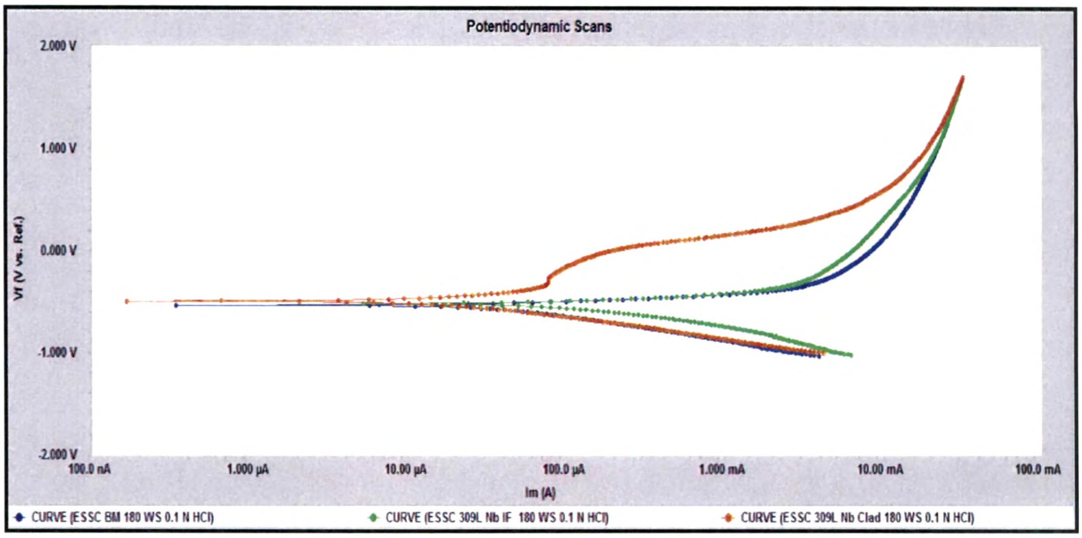



**Fig. 4.11: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.11: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 180 WS | 60.5 | -535 | 22.73 |
| 2 | ESSC 309L Nb IF 180 WS | 50.60 | -513 | 19.01 |
| 3 | ESSC 309L Nb Clad 180 WS | 7.53 | -494 | 2.829 |

Fig. 4.11 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N HCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compare to base metal and interfaces due to higher content of Cr

and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compare to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decrease with increasing the alloying elements from base metal to interface to cladded region.

### 4.1.2.6 Corrosion behaviour 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution

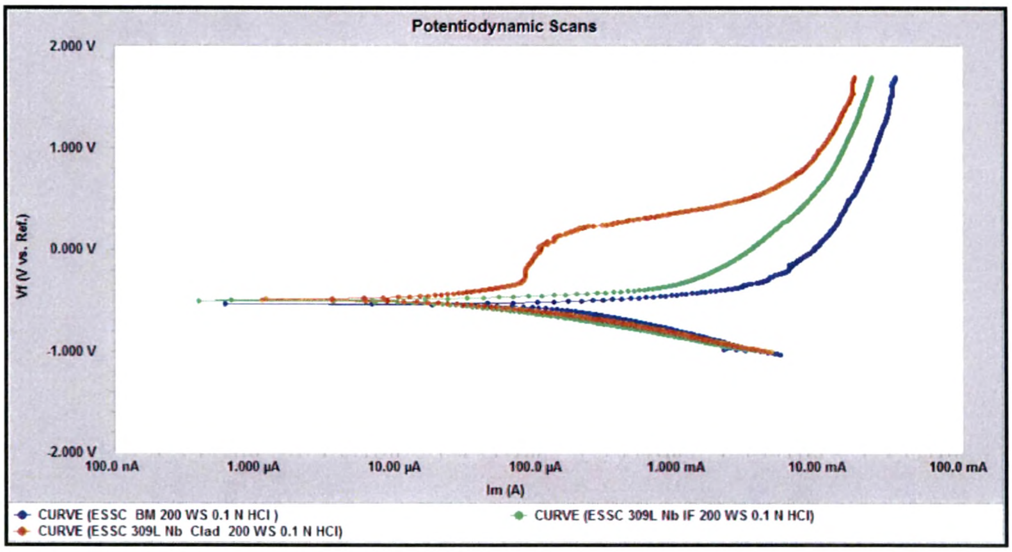



**Fig. 4.12: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution**

**Table-4.12: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 200 WS | 81.5 | -536 | 30.63 |
| 2 | ESSC 309L Nb IF 200 WS | 49.3 | -521 | 17.7 |
| 3 | ESSC 309L Nb Clad 200 WS | 20.9 | -491 | 7.872 |

Fig. 4.12 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N HCl solution.

By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

### 4.1.3 Corrosion Behaviour of weld overlays at different location in 0.1 N $H_2SO_4$ Solution

#### 4.1.3.1 Corrosion behaviour 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution

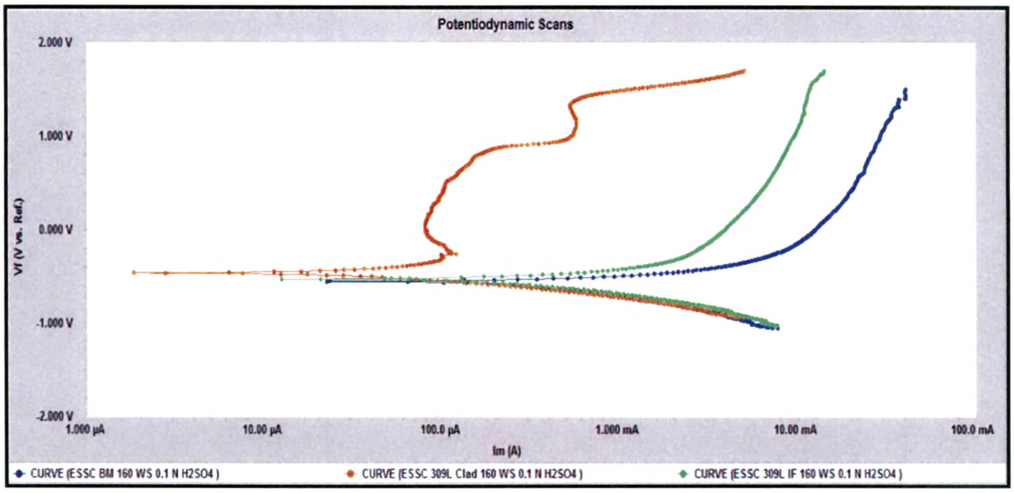



**Fig. 4.13: Potentiodynamic scans of 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.13: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 160 WS | 295.0 | -551.0 | 539.2 |
| 2 | ESSC 309L IF 160 WS | 240.0 | -522.0 | 439.6 |
| 3 | ESSC 309L Clad 160 WS | 85.80 | -462 | 156.8 |

Fig. 4.13 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr

and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.3.2 Corrosion behaviour 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution

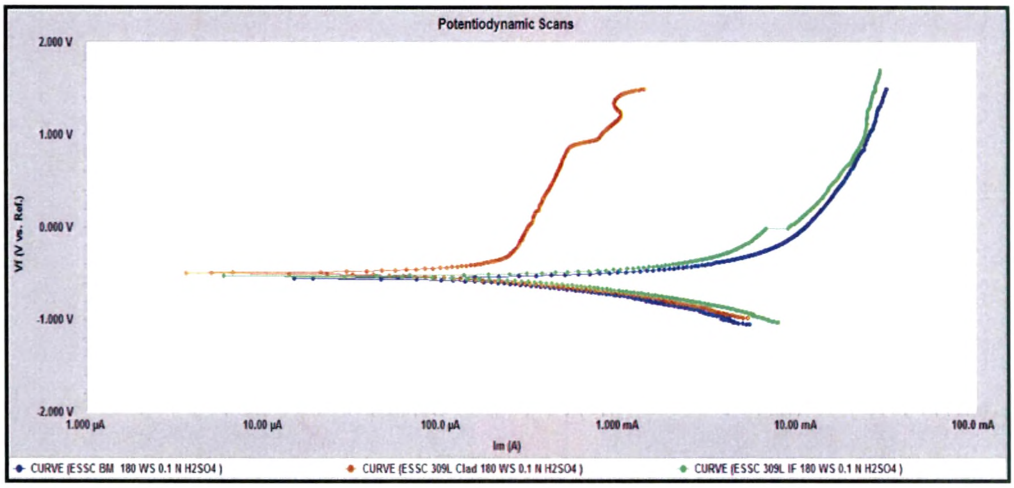



**Fig. 4.14: Potentiodynamic scans of 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.14: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 180 WS | 247.0 | -554.0 | 451.7 |
| 2 | ESSC 309L IF 180 WS | 174.0 | -529.0 | 318.9 |
| 3 | ESSC 309L Clad 180 WS | 56.10 | -493 | 102.5 |

Fig. 4.14 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i)

all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compare to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compare to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decrease with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.3.3 Corrosion behaviour 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution

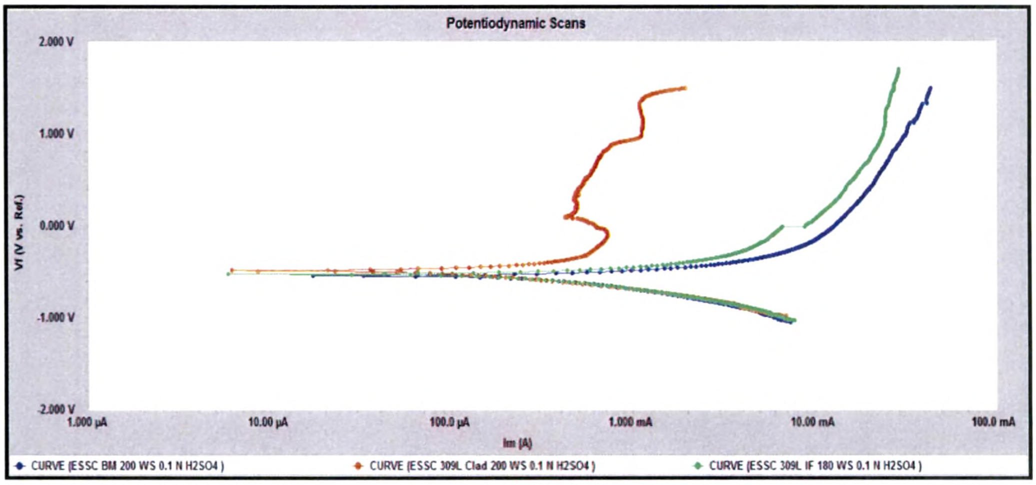



**Fig. 4.15: Potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.15: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 200 WS | **349.0** | **-547.0** | **637.1** |
| 2 | ESSC 309L IF 200 WS | **155.4** | **-478.0** | **284.0** |
| 3 | ESSC 309L Clad 200 WS | **97.30** | **-489** | **177.9** |

Fig. 4.15 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution.

By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.3.4 Corrosion behaviour 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

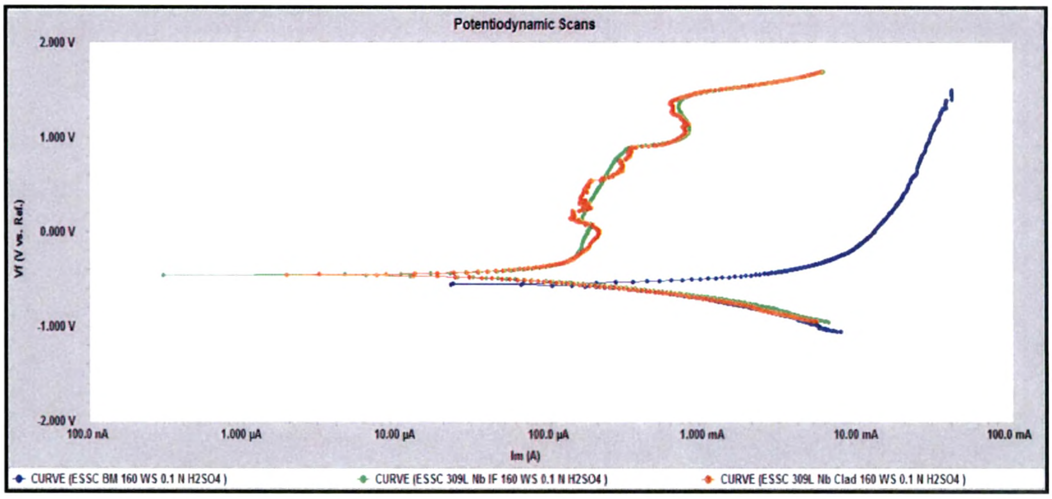



**Fig. 4.16: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.16: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 160 WS | 295.0 | -551.0 | 539.2 |
| 2 | ESSC 309LNb IF 160 WS | 66.40 | -452.0 | 122.8 |
| 3 | ESSC 309L Nb Clad 160 WS | 72.60 | -452.0 | 132.6 |

Fig. 4.16 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.3.5 Corrosion behaviour 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution

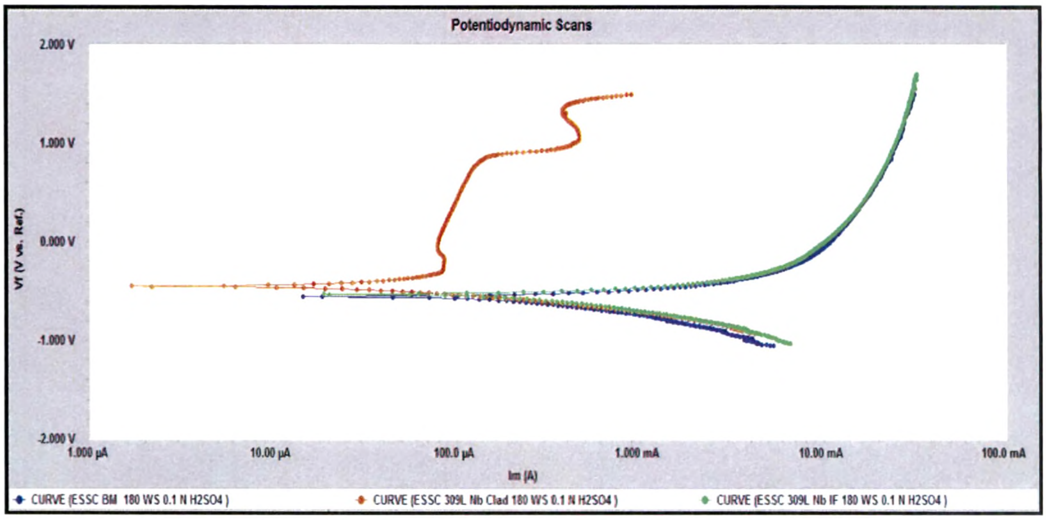



**Fig. 4.17: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.17: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 180 WS | 247.0 | -554.0 | 451.7 |
| 2 | ESSC 309L Nb IF 180 WS | 61.0 | -531.0 | 113.0 |
| 3 | ESSC 309L Nb Clad 180 WS | 53.40 | -451 | 97.64 |

Fig. 4.17 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compare to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compare to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decrease with increasing the alloying elements from base metal to interface to cladded region.

### 4.1.3.6 Corrosion behaviour 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution

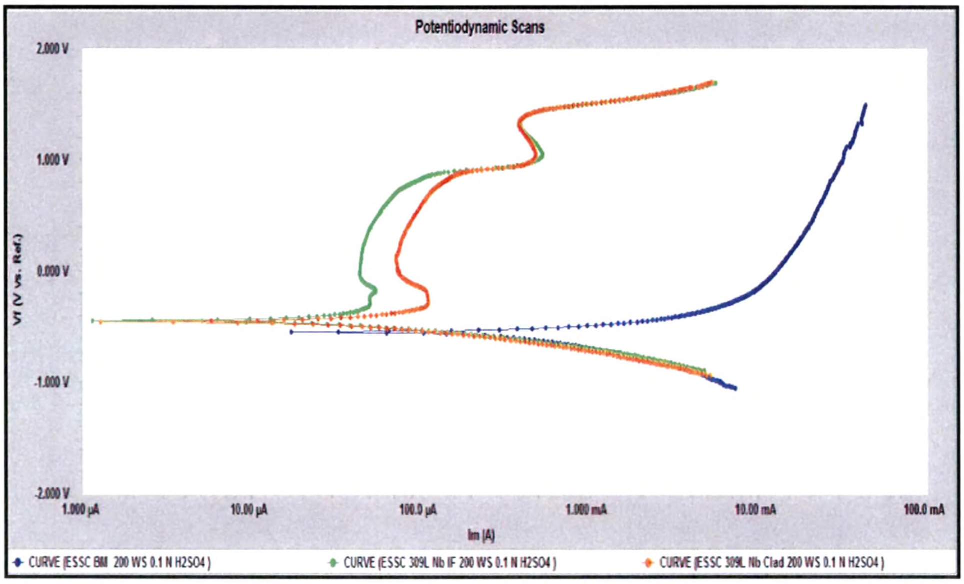



**Fig. 4.18: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

**Table-4.18: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (μA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 200 WS | 349.0 | -547.0 | 637.1 |
| 2 | ESSC 309L Nb IF 200 WS | 75.20 | -440.0 | 137.4 |
| 3 | ESSC 309L Nb Clad 200 WS | 52.8 | -454 | 96.4 |

Fig. 4.18 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different locations in 0.1 N $H_2SO_4$ solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region that lead to passive film formation, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

## 4.1.4 Corrosion Behaviour of weld overlays at different location in 3.5 % NaCl Solution

### 4.1.4.1 Corrosion behaviour 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 3.5 % NaCl Solution

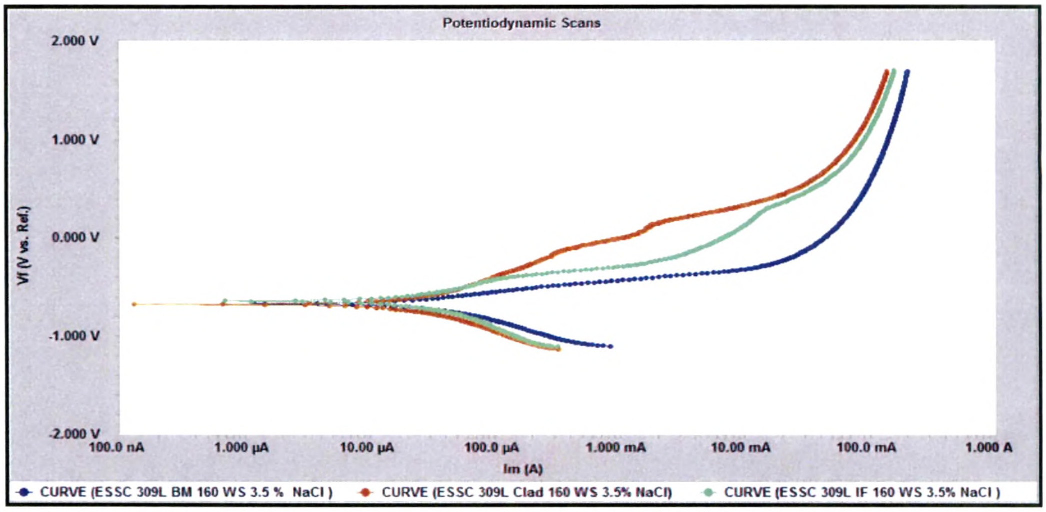



**Fig. 4.19: Potentiodynamic scans of 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in .5 % NaCl Solution**

**Table-4.19 : Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 160mm / min. welding speed at different location in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 160 WS | 157.4 | -668 | 289.6 |
| 2 | ESSC 309L IF 160 WS | 120.2 | -639 | 224.9 |
| 3 | ESSC 309L Clad 160 WS | 102.2 | -462 | 186.8 |

Fig. 4.19 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 160 mm / min. welding speed at different locations in 3.5 % NaCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also

having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.4.2 Corrosion behaviour 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in 3.5 % NaCl Solution**

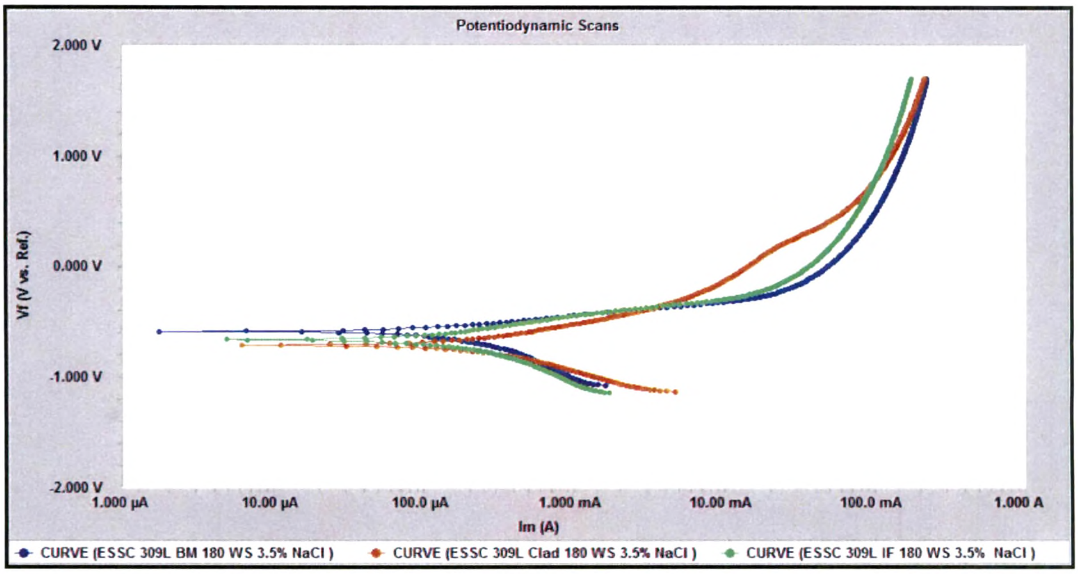



**Fig.4. 20: Potentiodynamic scans of 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in .5 % NaCl Solution**

**Table-4.20 : Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 180mm / min. welding speed at different location in3 .5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 180 WS | 148.0 | -584 | 272.3 |
| 2 | ESSC 309L IF 180 WS | 94.9 | -709 | 174.7 |
| 3 | ESSC 309L Clad 180 WS | 73.61 | -660 | 134.5 |

Fig. 4.20 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 180 mm / min. welding speed at different locations in 3.5 % NaCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i)

all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.4.3 Corrosion behaviour 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 3.5 % NaCl Solution**

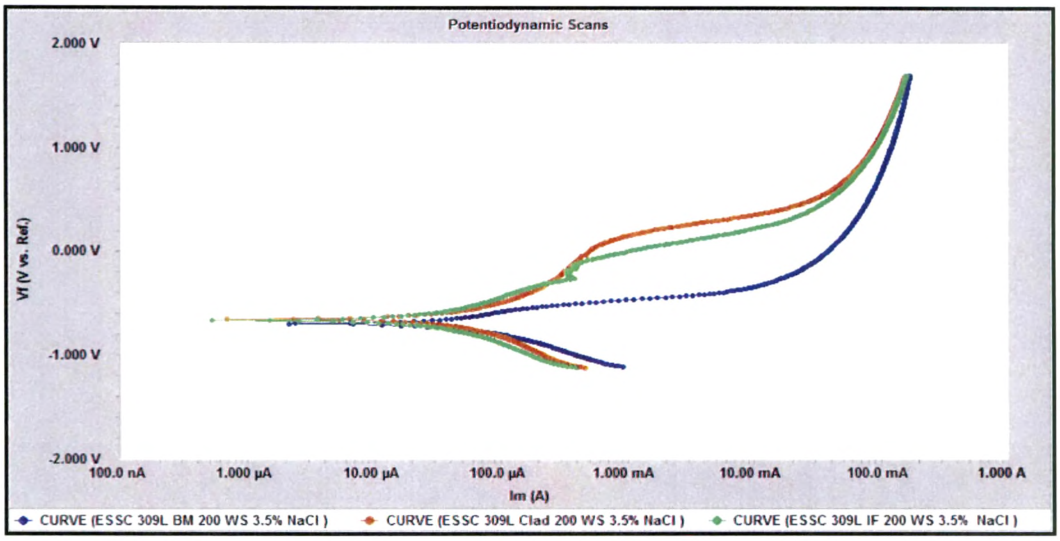



**Fig.4.21: Potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in .5 % NaCl Solution**

**Table-4.21: Electrochemical Parameters of Potentio-dynamic 309 L cladded weld overlay develop with 200 mm / min. welding speed at different location in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L BM 200 WS | 176.1 | -709 | 324.1 |
| 2 | ESSC 309L IF 200 WS | 134.07 | -663 | 246.7 |
| 3 | ESSC 309L Clad 200 WS | 121.61 | -651 | 222.7 |

Fig. 4.21 shows the results of potentiodynamic scans of 309 L cladded weld overlay develop with 200 mm / min. welding speed at different locations in 3.5 % NaCl solution.

By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compare to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compare to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decrease with increasing the alloying elements from base metal to interface to cladded region.

#### 4.1.4.4 Corrosion behaviour 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in 3.5 % NaCl Solution

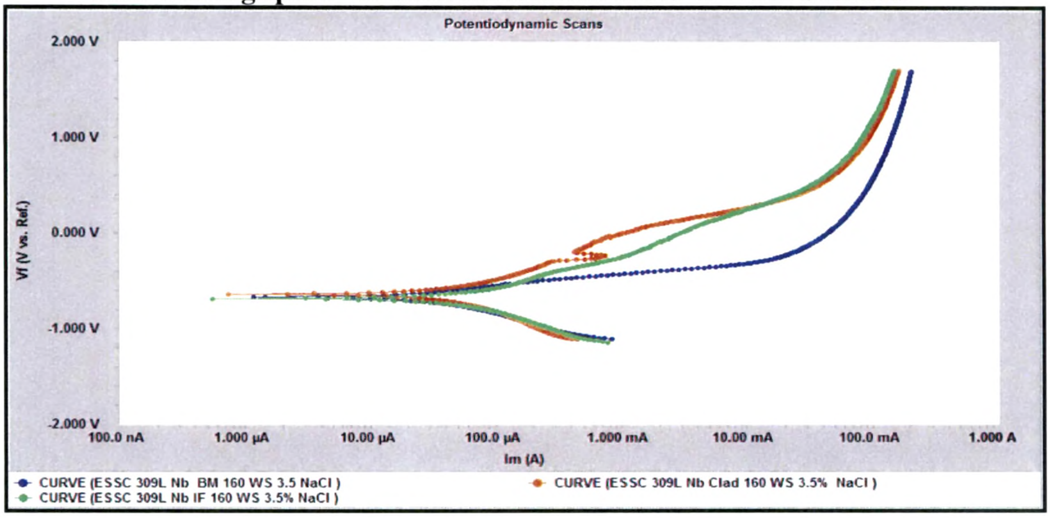



**Fig. 4.22: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in .5 % NaCl Solution**

**Table-4.22: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 160mm / min. welding speed at different location in .5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309LNb BM 160 WS | 157.4 | -668 | 289.6 |
| 2 | ESSC 309L Nb IF 160 WS | 107.0 | -688 | 195.1 |
| 3 | ESSC 309L NbClad 160 WS | 82.7 | -640 | 152.2 |

Fig. 4.22 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at different locations in 3.5 % NaCl solution.

By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compare to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compare to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decrease with increasing the alloying elements from base metal to interface to cladded region.

**4.1.4.5 Corrosion behaviour 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 3.5 % NaCl Solution**

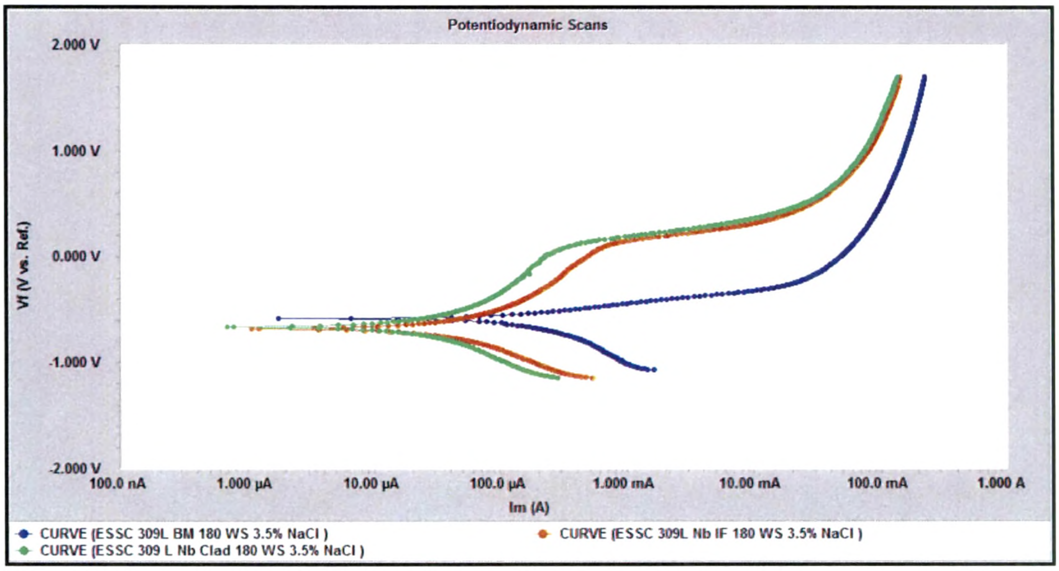



**Fig. 4.23: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 3.5 % NaCl Solution**

**Table-4.23: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 180mm / min. welding speed at different location in 3 .5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 180 WS | 148.0 | -584 | 272.3 |
| 2 | ESSC 309L Nb IF 180 WS | 86.00 | -681 | 157.3 |
| 3 | ESSC 309L Nb Clad 180 WS | 57.40 | -661 | 104.9 |

Fig. 4.23 shows the results of potentiodynamic scans of 309 LNb cladded weld overlay develop with 180 mm / min. welding speed at different locations in 3.5 % NaCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivation behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

**4.1.4.6 Corrosion behaviour 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in 3.5 % NaCl Solution**

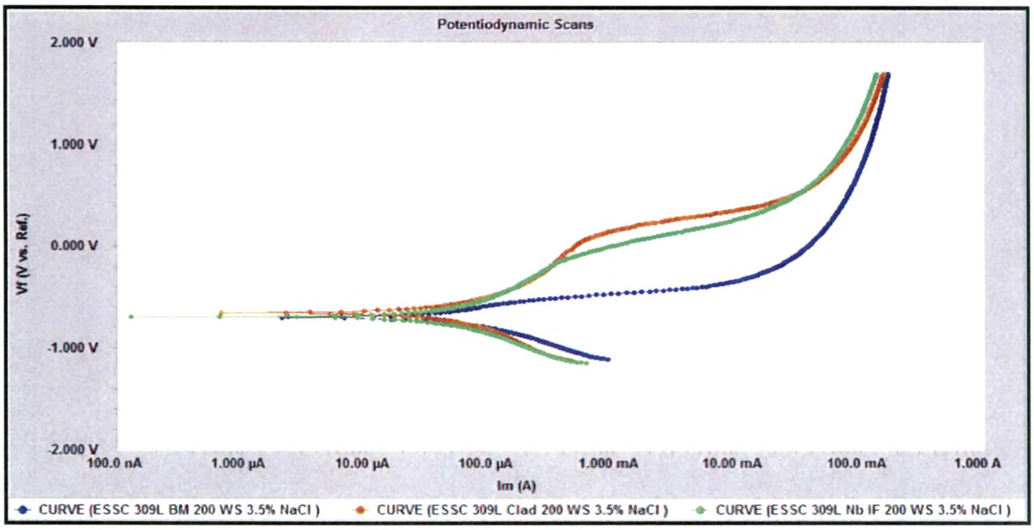



**Fig. 4.24: Potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in .5 % NaCl Solution**

**Table-4.24: Electrochemical Parameters of Potentio-dynamic 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different location in .5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC 309L Nb BM 200 WS | 176.1 | -709 | 324.1 |
| 2 | ESSC 309L Nb IF 200 WS | 115.0 | -692 | 211.7 |
| 3 | ESSC 309L Nb Clad 200 WS | 105.70 | -623 | 194.6 |

Fig. 4.24 shows the results of potentiodynamic scans of 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at different locations in 3.5 % NaCl solution. By comparing corrosion behavior of weld overlay at different locations, it shows that (i) all sample exhibit active potentials in given environments,(ii) cladded region has good corrosion resistance as compared to base metal and interfaces due to higher content of Cr and Ni in cladded region that lead to passive film formation (iii)interface region also having good corrosion resistance as compared to base metal due to presence of some amount of Cr and Ni in interface region but does not exhibit any passivasion behavior, (iv) corrosion rate was decreased with increasing the alloying elements from base metal to interface to cladded region.

# 4.2 Effect of Welding Speed on Microstructural Changes, Ferrite Content, Alloying Elements, Hardness and Corrosion Behaviour of Weld Overlays

### 4.2.1 Effect of Welding Speed on Microstructure of Weld Overlays

#### 4.2.1.1 Effect of Welding Speed on Microstructure of Base Metal:

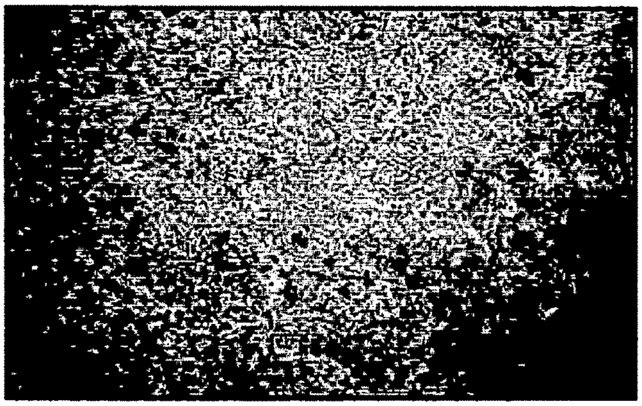


**Fig.4.25 Base Metal (Etchant : 5 % Nital, Magnification : 250X)**

Fig. 4.25 shows the microstructure at base metal which is similar for the both weld overlays developed at different welding speeds. It reveals mixture of tempered bainite with martensite structure.

#### 4.2.1.2 Effect of Welding Speed on clad & interface region 309L & 30L Nb cladded weld overlays

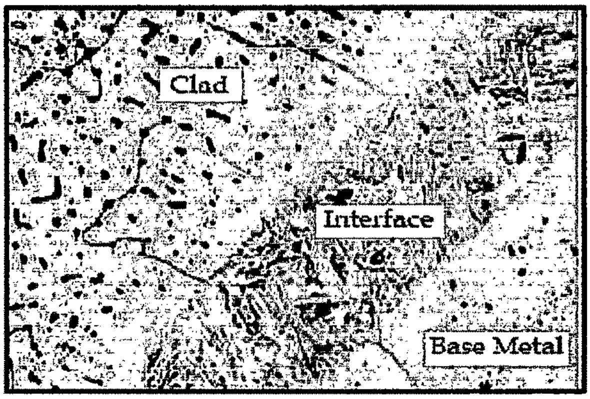



**Fig.4.26 Taper section of 309L Nb cladded weld overlay developed at 180 mm/min welding speed at as-welded condition ( Etchant : Aquaregia , Magnification : 400X)**

- **Results as-welded microstructures**

The microstructure of the cladded region of weld overlay developed with 309L Nb at 180 mm/min welding speed is shown in Fig. 4.26 in as welded condition. This is in the form of a taper section in which the top surface of the specimen makes a small angle with the weld interface so that the width of any interface feature is magnified. The micrograph shows a transition layer between the bulk weld metal at the left and the base metal on the right. The Aquaregia etchant used reveals predominantly the ferrite distribution in the austenite matrix and it may be observed Fig. 4.26 that the mode of solidification as well as the ferrite content changes as one moves from the weld interface into the overlay.

- **Micro-structural characterization**

There are structural changes occurring in the base metal close to the weld, at the weld interface itself and in the bulk weld metal. In the present case, near the top and in the bulk clad metal, the composition approximates to that of the strip electrode, modified by the average dilution, but near the weld interface there are significant composition gradients produced due to a combination of dilution and other factors which have a profound effect on the micro-structural development. The changes in composition and microstructure across the transition zone at the weld interface are of particular importance because this is where possible hydrogen disbonding can occur in service. While the dilution level in the bulk weld metal under ESSC conditions is known to be not more than about 8 to 10 %, near the fusion boundary the degree of dilution will be much higher. This is most likely to be the result of the formation of a stagnant fluid layer in the weld pool adjacent to the base metal. The transition from the low alloy content (Cr, Mo) in the base metal to the high alloy content (Cr, Ni, Nb) in the bulk weld metal occurs in this transition zone. The layer originally had the same composition as the base metal, but develops higher chromium and nickel contents as a result of diffusion from the cladding due to the concentration gradients [79]. The stagnation layer has also been called the unmixed zone [80]. It may be seen from Table 3.39 that Cr contents over 9.06 % and Ni contents around 9.35 % could develop in the transition zone during cladding The composition in the layer is such that during cooling following overlaying this region transforms to martensite.

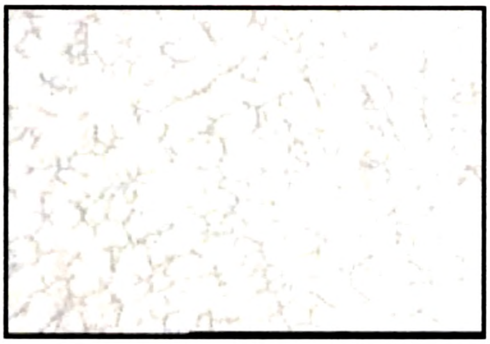


**Fig.4.27 (a) clad region of 3 09 L clad weld overlay 160 WS**

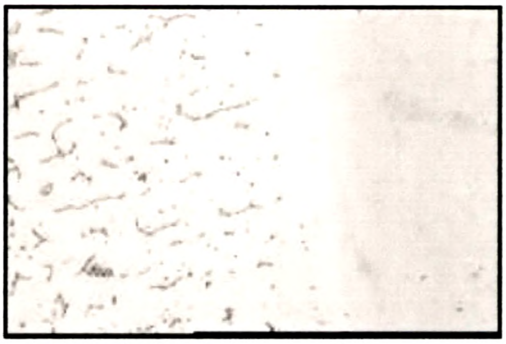


**Fig.4.27 (b) Interface region of 309 L Clad 160 WS**

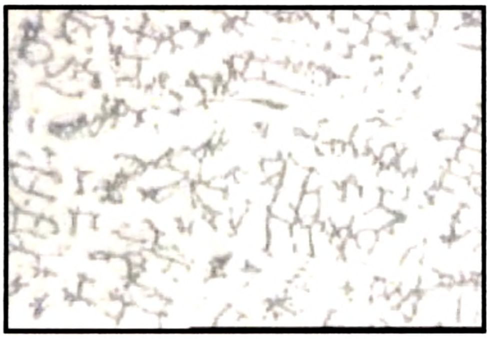


**Fig.4.28 (a) clad region of 309 L Clad 180 WS**

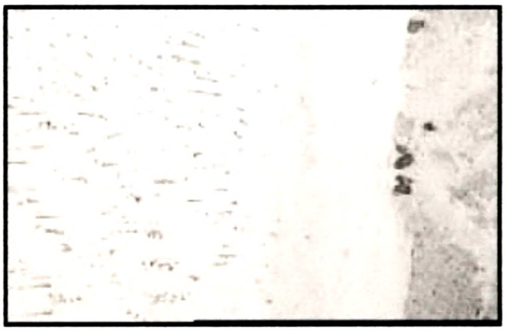


**Fig.4.28 (b) Interface region of 309 L Clad 180 WS**

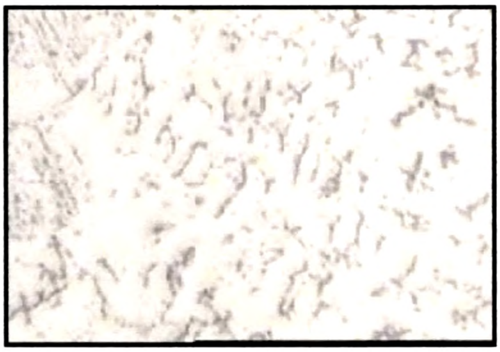


**Fig.4.29 (a) clad region of 309 L Clad 200 WS**

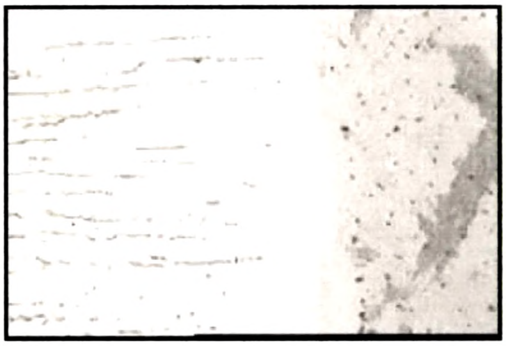


**Fig.4.29 (b) Interface region o 309 L Clad 200 WS**

**Fig.4.30 (a) clad region of 309 L Nb Clad 160 WS**

**Fig.4.30 (b) Interface region o309 L Nb Clad 160 WS**

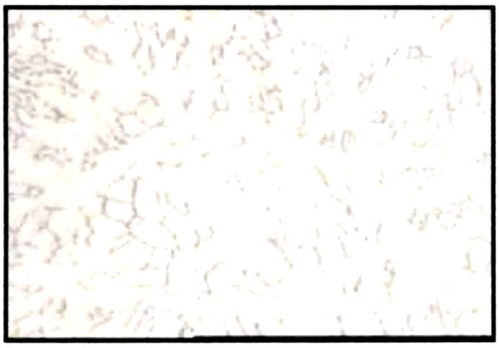


**Fig.4.31 (a) clad region of 309 L Nb Clad 180 WS**

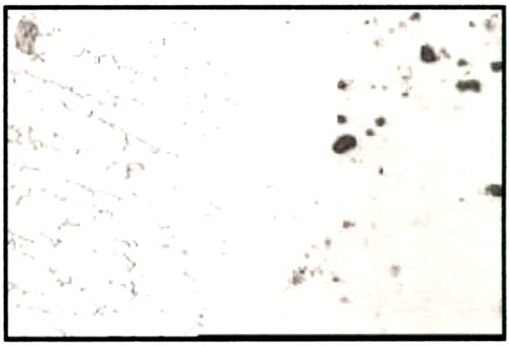


**Fig.4.31 (b) Interface region o 309 L Nb Clad 180 WS**

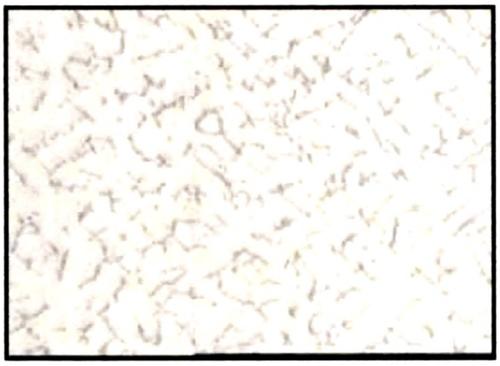


**Fig.4.32 (a) clad region of 309 L Nb Clad 200 WS**

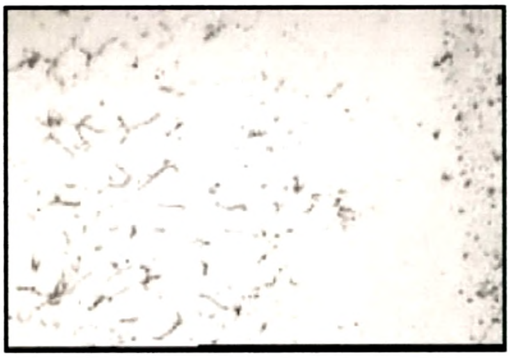


**Fig.4.32 (b) Interface region o 309 L Nb Clad 200 WS**

- **Results as-welded microstructures of both weld overlays**

The microstructure of the cladded region of weld overlay developed with 309L & 309L Nb at different welding speed is shown in Fig. 4.27 (a) to 4.32 (a) in as welded condition. The microstructure of the Interface region of weld overlay developed with 309L & 309L Nb at different welding speed is shown in Fig. 4.27 (b) to 4.32 (b) as welded conditions. The Aquaregia etchant used to reveals predominantly the ferrite distribution in the austenite matrix and it may be observed from Fig. 4.27 to 4.32 that the mode of solidification as well as the ferrite content changes as one moves from the weld interface into the overlay.

- **Discussions -welded microstructures of both weld overlays:**

It may be noted in Fig. 4.27 (b) that the weld metal immediately adjoining the transition zone contains virtually no ferrite and solidification has occurred fully as austenite. As one move away from the interface, primary solidification is still austenitic, but the remaining liquid between the dendrites solidifies as ferrite. This trend continues in Fig. 4.27 (b) to 4.32 (b). Traversing into the bulk cladding, as seen in Fig. 4.27(a) the solidification mode changes from primary austenitic to primary ferritic, both types weld overlays which shows totally skeletal or vermicular ferrite, the ferrite being the primary phase forming at the core of the dendrites. This trend continues in Fig. 4.27 (a) to 4.32 (a). As the welding speed were increases from 160 mm/min (high heat input) to 200 mm /min. (low heat input), the cooling rate were also increases.

From Fig. 4.27 (a) & 4.30 (a), it observed that when 309L & 309L Nb weld overlay developed at 160 mm /min welding speed i.e at higher heat input (0.1875 $kJ/mm^2$) this causes a slower cooling rate which allow more time for nucleation and growth of delta ferrite due to which these weld overlays at cladded region has higher amount of delta ferrite than other weld overlays developed at 180 mm /min & 200 mm /min welding speed.

From Fig. 4.28 (a) & 4.31 (a) it observed that when 309L & 309L Nb weld overlay developed at 180 mm /min welding speed i.e at medium heat input (0.1666 $kJ/mm^2$) this causes a somewhat faster cooling rate compared to 160 mm /min welding speed which allow less time for nucleation and growth of delta ferrite due to which these weld overlays at cladded region has slightly lower amount of delta ferrite than weld overlays developed at 160 mm /min welding speed.

From Fig. 4.29 (a) & 4.32(a) it observed that when 309L & 309L Nb weld overlay developed at 200 mm /min welding speed i.e at lower heat input (0.1500 $kJ/mm^2$) this causes a somewhat faster cooling rate compared to 160 & 180 mm /min welding speed which allow less time for nucleation and growth of delta ferrite due to which these weld overlays at cladded region has slightly lower amount of delta ferrite than weld overlays developed at 160 & 180 mm /min welding speed. It is to note that that Nb is strong ferrite former which leads to increase the amount of ferrite in 309 L Nb cladded weld overlay than 309L cladded weld overlay at all welding speed[81].

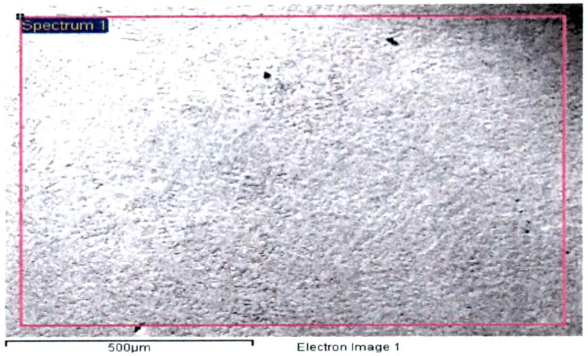
### 4. 2.2 Effect of welding speed on alloying elements of the weld overlay

#### 4.2.2.1 EDAX Analysis of cladded region of 309 L cladded weld overlay at 160 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.25 : EDAX analysis of cladded region of 309L cladded weld overlay at 160 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| Si K | 0.56 | 1.10 |
| Cr K | 20.09 | 21.25 |
| Mn K | 1.37 | 1.37 |
| Fe K | 67.15 | 66.13 |
| Ni K | 10.83 | 10.14 |
| Totals | 100.00 | |



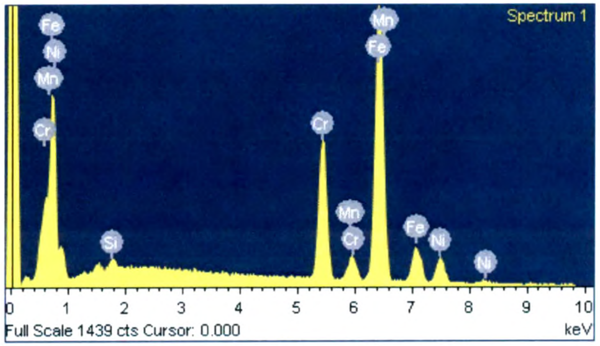




**Fig. 4.33 EDAX analysis of cladded region of 309L cladded weld overlay developed with 160mm/ min welding speed**

## 4.2.2.2 EDAX Analysis of cladded region of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.26: EDAX analysis of cladded region of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| O K | 2.43 | 7.85 |
| Al K | 0.93 | 1.79 |
| P K | 0.16 | 0.26 |
| Cr K | 19.95 | 19.80 |
| Mn K | 1.68 | 1.58 |
| Fe K | 64.64 | 59.75 |
| Ni K | 10.21 | 8.98 |
| Totals | 100.00 | |

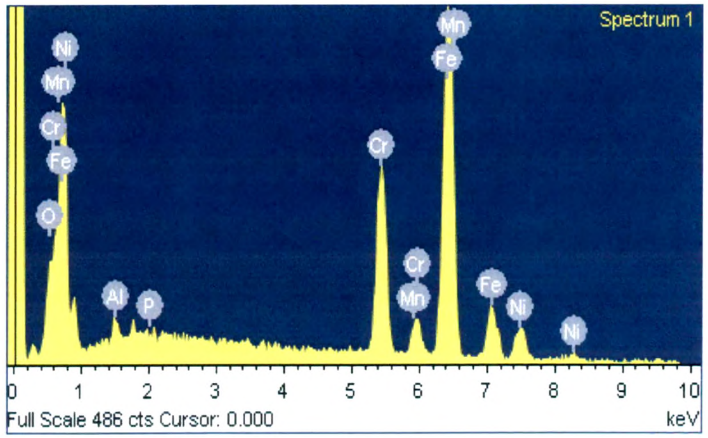




**Fig. 4.34 EDAX analysis of cladded region of 309L cladded weld overlay developed with 180mm/ min welding speed**

### 4.2.2.3 EDAX Analysis of cladded region of 309 L cladded weld overlay at 200 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.27 EDAX analysis of cladded region of 309L Cladded weld overlay at 200 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| Si K | 0.76 | 1.50 |
| Cr K | 17.68 | 18.68 |
| Mn K | 1.57 | 1.57 |
| Fe K | 70.26 | 69.14 |
| Ni K | 9.73 | 9.11 |
| Totals | 100.00 | |

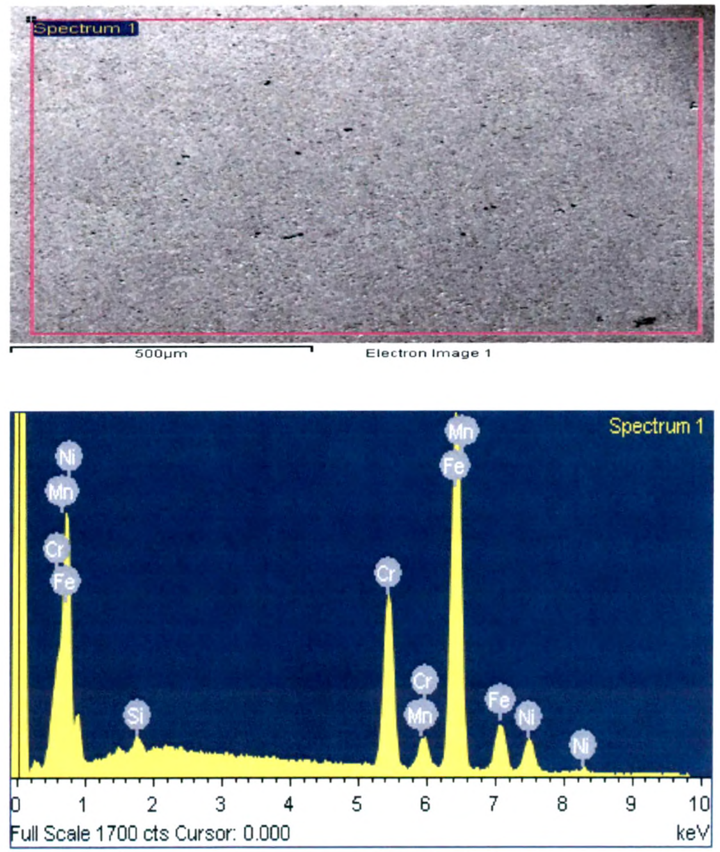


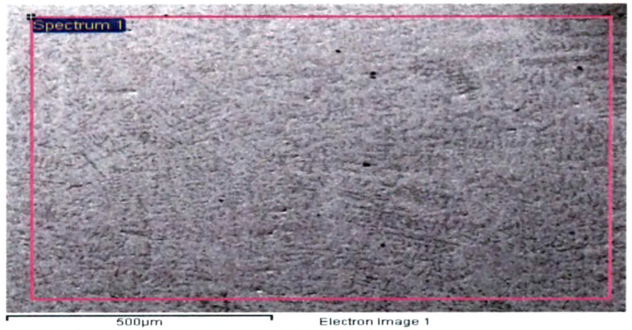

**Fig. 4.35 EDAX analysis of cladded region of 309L cladded weld overlay developed with 200mm/ min welding speed**

## 4.2.2.4 EDAX Analysis of cladded region of 309 L Nb cladded weld overlay at 160 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.28 EDAX analysis of cladded region of 309LNb Cladded weld overlay at 160 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| Si K | 0.68 | 1.32 |
| Cr K | 19.06 | 20.14 |
| Mn K | 1.82 | 1.82 |
| Fe K | 68.27 | 67.19 |
| Ni K | 10.17 | 9.52 |
| Totals | 100.00 | |



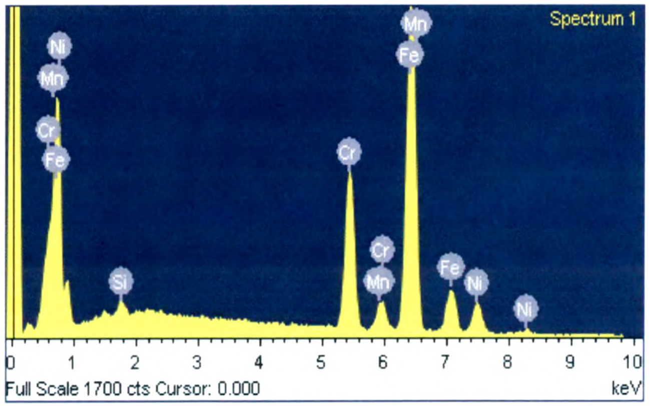



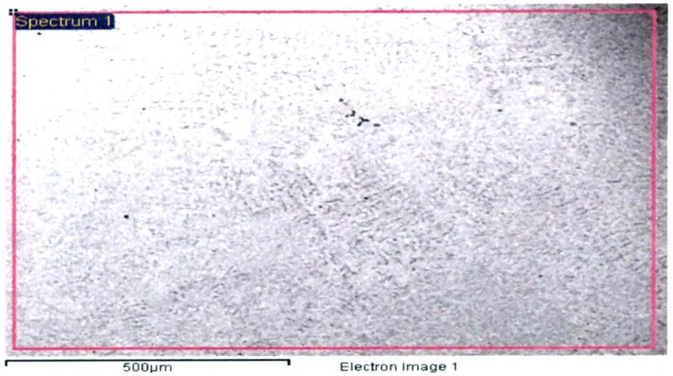

**Fig. 4.36 EDAX analysis of cladded region of 309L Nb cladded weld overlay developed with 160mm/ min welding speed**

## 4.2.2.5 EDAX analysis of cladded region of 309 L Nb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.29 EDAX analysis of cladded region of 309L Nb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| O K | 1.44 | 4.79 |
| Si K | 0.67 | 1.27 |
| Cr K | 19.09 | 19.49 |
| Mn K | 1.73 | 1.67 |
| Fe K | 66.85 | 63.54 |
| Ni K | 10.22 | 9.24 |
| Totals | 100.00 | |



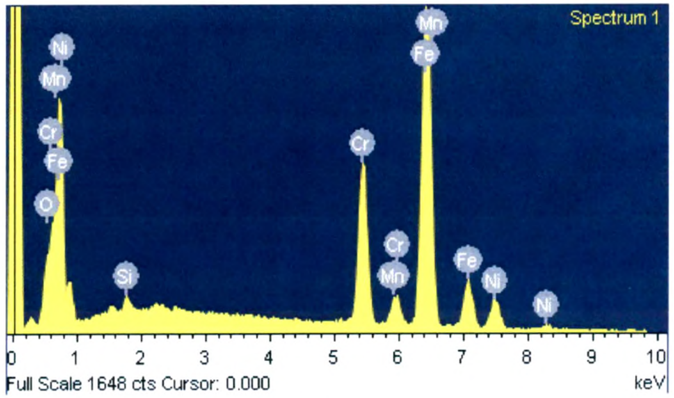



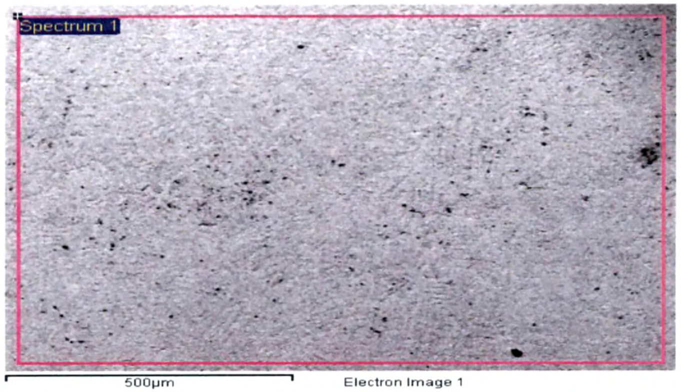

**Fig. 4.37 EDAX analysis of cladded region of 309L Nb cladded weld overlay developed with 180mm/ min welding speed**

## 4.2.2.6 EDAX analysis of cladded region of 309 L Nb cladded weld overlay at 200 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.30 EDAX analysis of cladded region of 309LNb Cladded weld overlay at 200 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| O K | 1.82 | 5.99 |
| Al K | 0.33 | 0.64 |
| Si K | 0.44 | 0.83 |
| Cr K | 18.29 | 18.49 |
| Mn K | 1.53 | 1.46 |
| Fe K | 68.70 | 64.64 |
| Totals | 100.00 | |



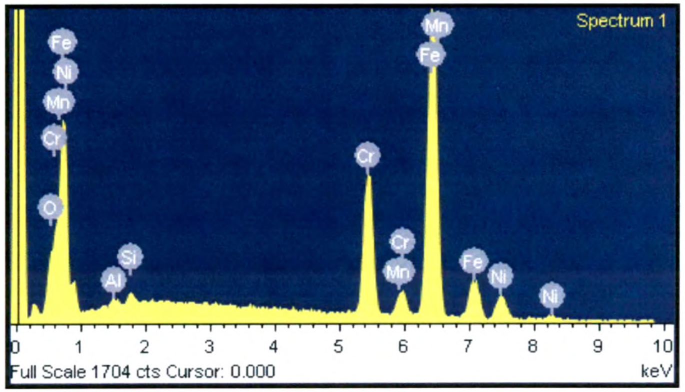




**Fig. 4.38 EDAX analysis of cladded region of 309L Nb cladded weld overlay developed with 200 mm/ min welding speed**

## 4.2.2.7 EDAX analysis of Interface region of 309 L cladded weld overlay at 160 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.31 EDAX analysis of interface region of 309L cladded weld overlay at 160 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C | 0.93 | 3.02 |
| Si K | 0.54 | 0.98 |
| Cr K | 18.30 | 17.97 |
| Mn K | 1.38 | 1.48 |
| Fe K | 68.93 | 67.66 |
| Ni K | 9.92 | 8.89 |
| Total | 100 % | |

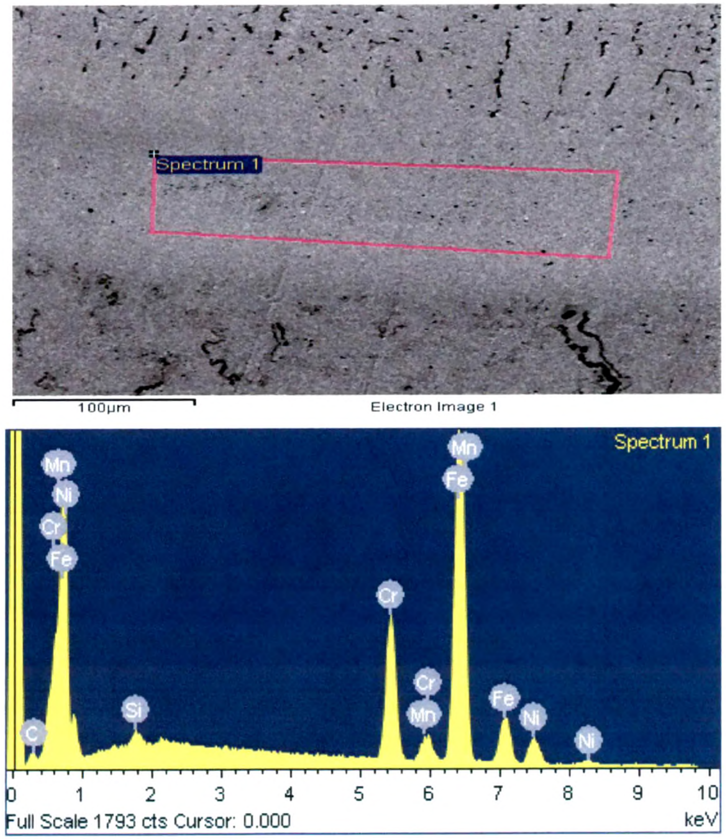


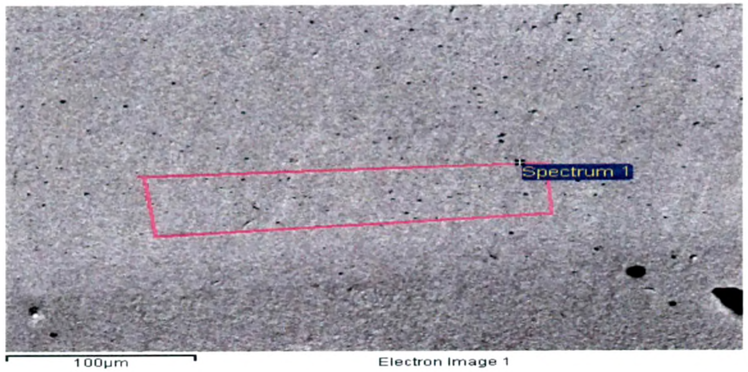

**Fig. 4.39 EDAX analysis of interface region of 309L cladded weld overlay developed with 160mm/ min welding speed**

## 4.2.2.8 EDAX analysis Interface region of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.32 EDAX analysis of interface region of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.41 | 4.78 |
| Si K | 0.67 | 1.20 |
| Cr K | 18.14 | 17.62 |
| Mn K | 1.63 | 1.48 |
| Fe K | 69.05 | 64.23 |
| Ni K | 9.10 | 10.69 |
| Totals | 100.00 | |



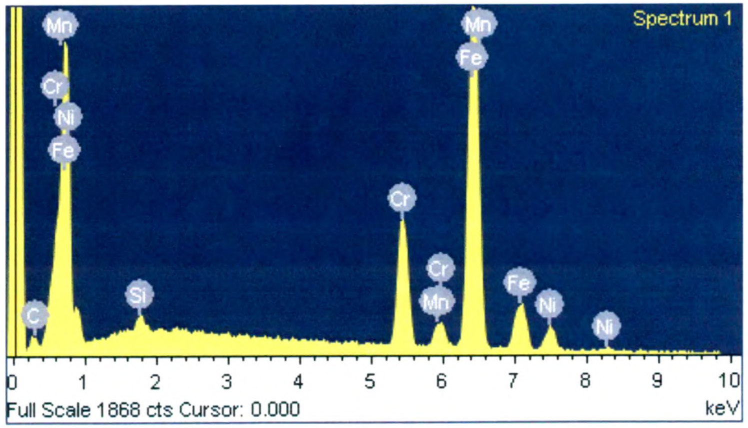




**Fig. 4.40 EDAX analysis of interface region of 309L cladded weld overlay developed with 180mm/ min welding speed**

## 4.2.2.9 EDAX analysis of interface region of 309 L cladded weld overlay at 200 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.33 EDAX analysis of interface region of 309L Cladded weld overlay at 200 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.84 | 4.92 |
| Si K | 0.73 | 1.34 |
| Cr K | 16.02 | 15.72 |
| Mn K | 0.67 | 0.63 |
| Fe K | 71.94 | 70.35 |
| Ni K | 8.80 | 7.04 |
| Totals | 100.00 | |

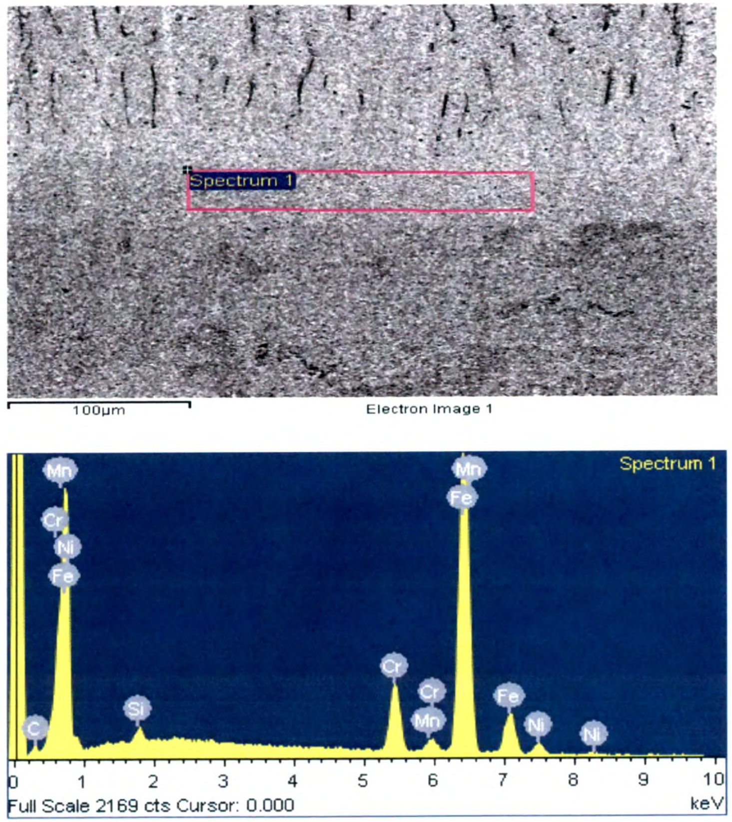


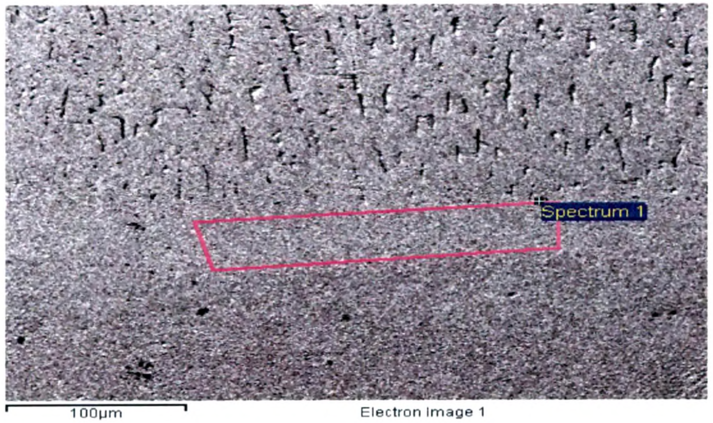

**Fig. 4.41 EDAX analysis of interface region of 309L cladded weld overlay developed with 200 mm/ min welding speed**

## 4.2.2.10 EDAX analysis of interface region of 309 L Nb cladded weld overlay at 160 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.34 EDAX analysis of cladded region of 309LNb Cladded weld overlay at 160 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.4 | 5.98 |
| Si K | 0.40 | 1.17 |
| Cr K | 17.38 | 16.58 |
| Mn K | 1.10 | 0.96 |
| NiK | 9.31 | 8.81 |
| Fe K | 70.41 | 66.50 |
| Totals | 100 % | |



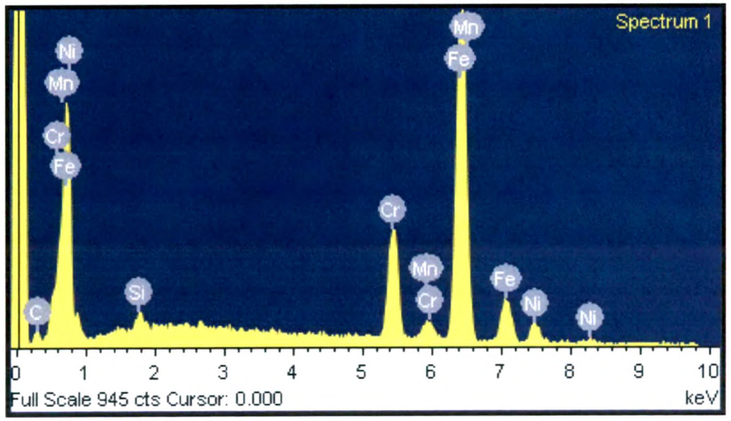



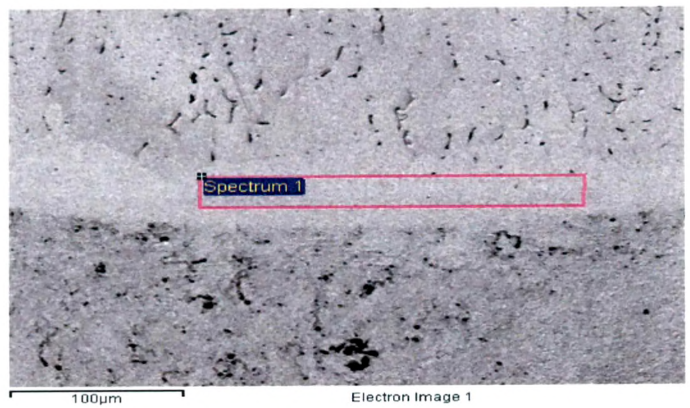

**Fig. 4.42 EDAX analysis of interface region of 309LNb cladded weld overlay developed with 160 mm/ min welding speed**

## 4.2.2.11 EDAX analysis of interface region of 309 L Nb cladded weld overlay at 180 mm /min. welding

Spectrum processing: No peaks omitted

**Table-4.35 EDAX analysis of interface region of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.40 | 7.54 |
| Si K | 0.68 | 1.25 |
| Cr K | 17.36 | 16.51 |
| Mn K | 1.54 | 1.50 |
| Fe K | 69.67 | 65.90 |
| Ni K | 9.35 | 7.30 |
| Totals | 100% | |



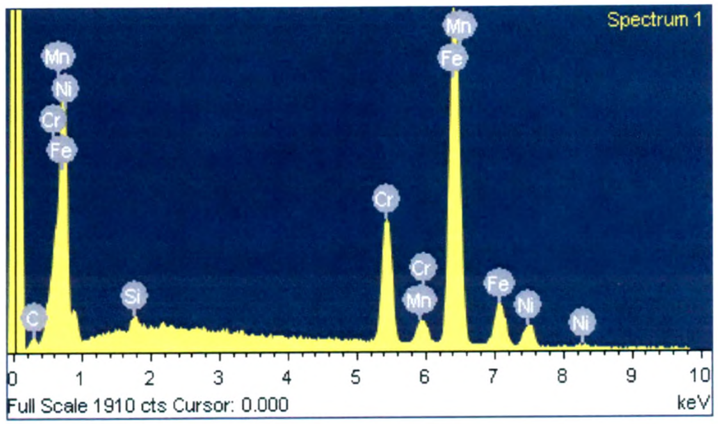



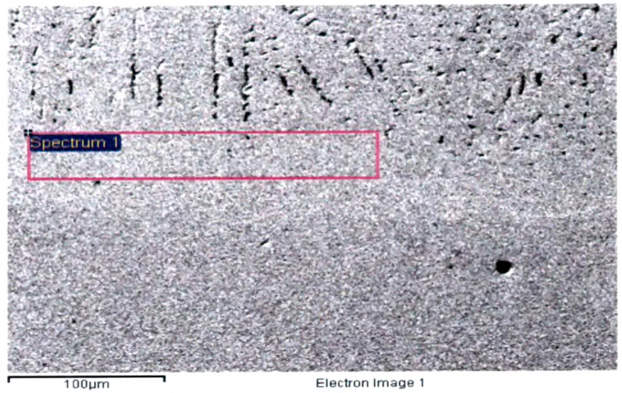

**Fig. 4.43 EDAX analysis of interface region of 309LNb cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.12 EDAX analysis of interface region of 309 L Nb cladded weld overlay at 200 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.36 EDAX analysis of interface region of 309LNb Cladded weld overlay at 200 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| Si K | 0.60 | 1.27 |
| Cr K | 16.56 | 16.31 |
| Mn K | 1.30 | 1.3 |
| Fe K | 73.46 | 73.31 |
| Ni K | 8.08 | 7.81 |
| Totals | 100.00 | |



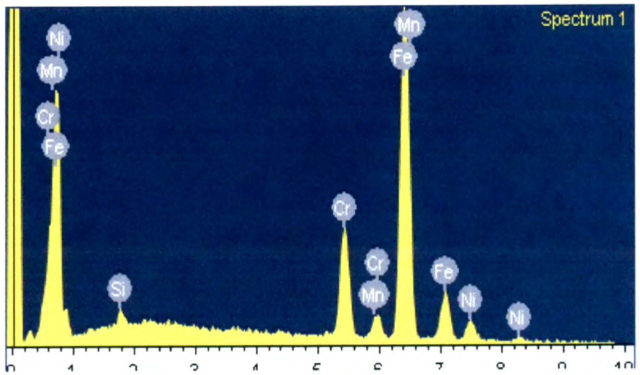




**Fig. 4.44 EDAX analysis of interface region of 309LNb cladded weld overlay developed with 200 mm/ min welding speed**

**Table-4.37 : Elemental Analysis of cladding by EDAX Analysis**

| Strip | Welding Speed (mm/min) | Cr | Ni | Si | Mn |
|---|---|---|---|---|---|
| 309L | 180 | 20.09 | 10.83 | 0.56 | 1.37 |
| | 200 | 19.95 | 10.21 | 0.61 | 1.68 |
| | 200 | 17.68 | 9.73 | 0.76 | 1.57 |
| 309L Nb | 160 | 19.06 | 10.17 | 0.68 | 1.82 |
| | 180 | 19.09 | 10.22 | 0.67 | 1.73 |
| | 200 | 18.29 | 8.88 | 0.44 | 1.53 |

Table -4.37 shows the EDAX Analysis of cladded region of both weld overlays at different welding speeds. The amount of Cr and Ni content in the cladding were increase with increase in the welding speed from 160 to 180 mm / min but with further increase in welding speed from 180 to 200 mm / min. amount of Cr and Ni content in the cladding were decrease.

**Table-4.38 : Elemental Analysis of Interface region by EDAX Analysis**

| Strip | Welding Speed (mm/min) | Cr | Ni | Si | Mn |
|---|---|---|---|---|---|
| 309L | 160 | 18.30 | 9.92 | 0.54 | 1.38 |
| | 180 | 18.14 | 9.10 | 0.67 | 1.63 |
| | 200 | 16.02 | 8.80 | 0.73 | 0.67 |
| 309L Nb | 160 | 17.38 | 9.31 | 0.4 | 1.10 |
| | 180 | 17.36 | 9.35 | 0.68 | 1.54 |
| | 200 | 16.56 | 8.08 | 0.60 | 1.30 |

Table 4.38 shows the EDAX Analysis of interface region of both weld overlays at different welding speeds. The amount of Cr and Ni content in the cladding were increase with increase in the welding speed from 160 to 180 mm / min but with further increase in welding speed from 180 to 200 mm / min. amount of Cr and Ni content in the cladding were decrease. It is to be noted that there were decrease in the amount of Cr & Ni at interface region as compared to cladded region which indicate dilution of alloying element.

**Table 4.39 : Percentage Dilution at interface region**

| Strip | Welding Speed (mm/min) | Cr at cladded region (%) | Cr at interface region (%) | % Dilution of Cr | Ni at cladded region (%) | Ni at interface region (%) | % Dilution of Ni |
|---|---|---|---|---|---|---|---|
| 309L | 160 | 20.09 | 18.30 | 8.90 | 10.83 | 9.92 | 8.40 |
| | 180 | 19.95 | 18.14 | 9.07 | 10.21 | 9.10 | 9.17 |
| | 200 | 17.68 | 16.02 | 9.39 | 9.73 | 8.80 | 9.56 |
| 309L Nb | 160 | 19.06 | 17.38 | 8.81 | 10.17 | 9.31 | 8.45 |
| | 180 | 19.09 | 17.36 | 9.06 | 10.22 | 9.35 | 8.51 |
| | 200 | 18.29 | 16.56 | 9.46 | 8.88 | 8.08 | 9.01 |

Table 4.39 shows that there were decrease in the alloy content at interface region and dilution about 8% to 9% were observed for Cr & Ni elements .

## 4.2.2.13 EDAX analysis of particle at cladded region of 309 L Nb cladded weld overlay at 160 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.40 EDAX analysis of white spot at cladded region of 309LNb Cladded weld overlay at 160 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 7.02 | 26.10 |
| Si K | 0.73 | 1.15 |
| Cr K | 18.50 | 15.88 |
| Mn K | 1.90 | 1.55 |
| Fe K | 54.34 | 43.42 |
| Ni K | 12.44 | 9.45 |
| Nb L | 5.08 | 2.44 |
| Totals | 100.00 | |

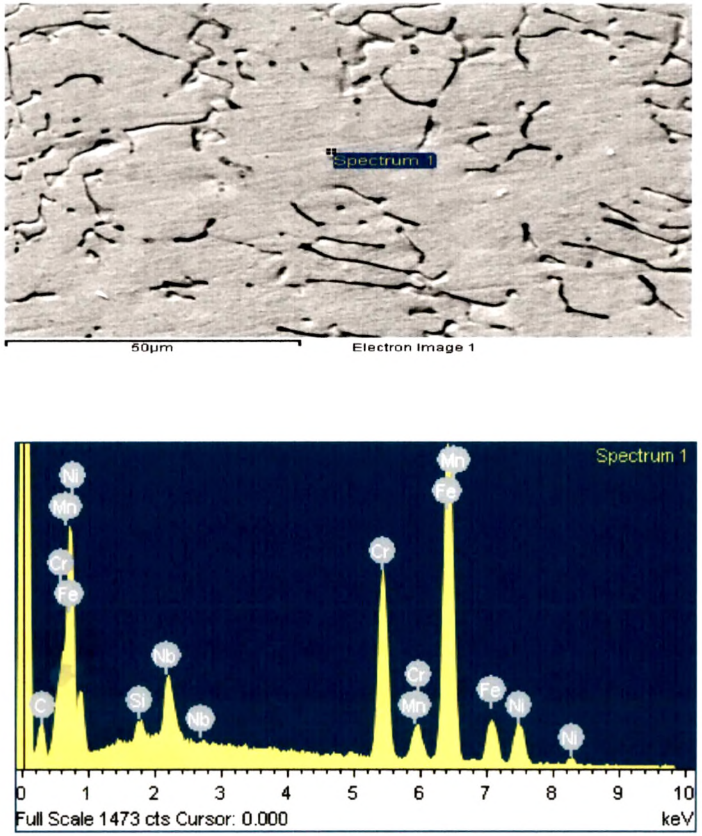


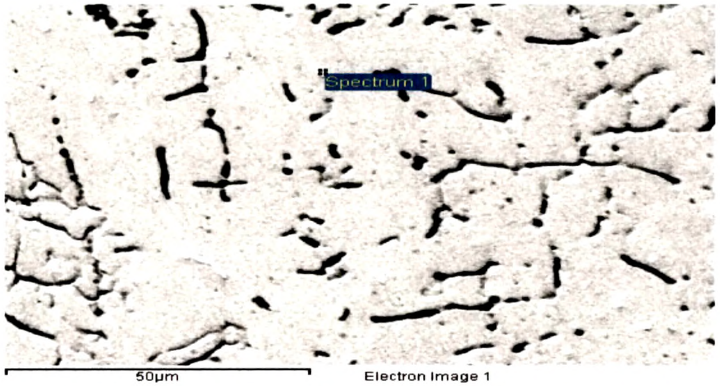

**Fig. 4.45 EDAX analysis of particle at cladded region of 309L Nb cladded weld overlay developed with 160 mm/ min welding speed**

## 4.2.2.14 EDAX analysis of particle at cladded region of 309 L Nb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.41 EDAX analysis of cladded region of 309LNb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 15.46 | 53.07 |
| Cr K | 7.50 | 5.95 |
| Fe K | 19.76 | 14.59 |
| Ni K | 3.80 | 2.67 |
| Nb L | 53.48 | 23.73 |
| Totals | 100.00 | |



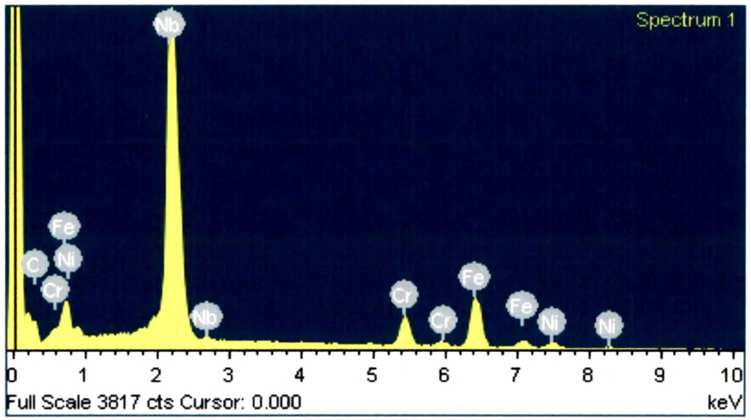



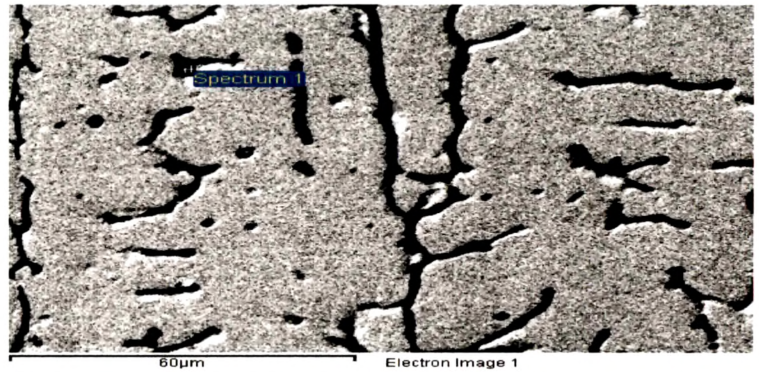

**Fig. 4.46 EDAX analysis of particle at cladded region of 309L Nb cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.15 EDAX analysis of particle at cladded region of 309 L Nb cladded weld overlay at 200 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.42 EDAX analysis of white spot at cladded region of 309LNb Cladded weld overlay at 200 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| Al K | 0.62 | 1.27 |
| Si K | 0.79 | 1.55 |
| Cr K | 18.26 | 19.42 |
| Mn K | 1.34 | 1.35 |
| Fe K | 66.38 | 65.75 |
| Ni K | 9.08 | 8.55 |
| Nb L | 3.54 | 2.11 |
| Total | 100 % | |



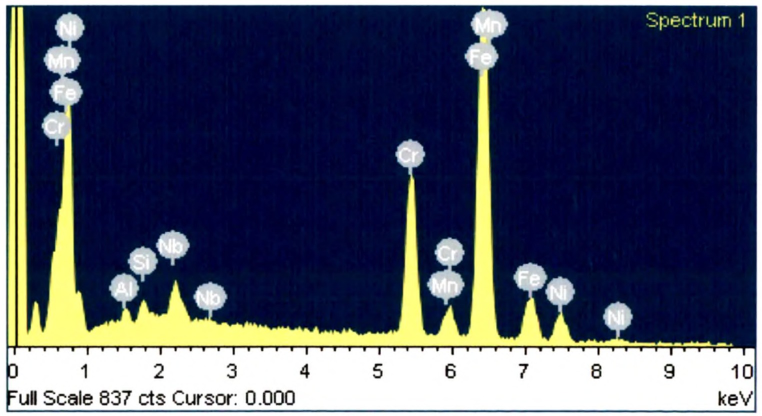



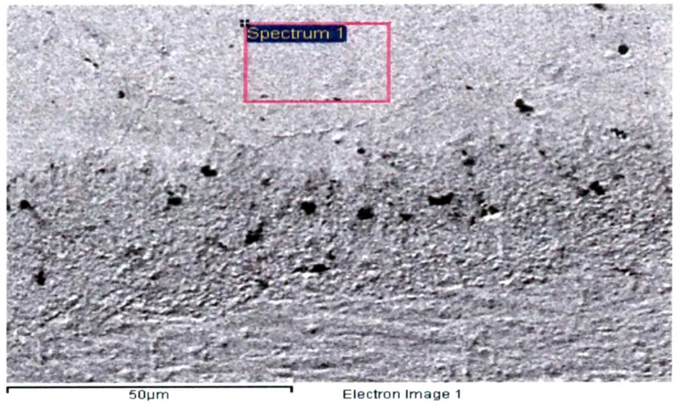

**Fig. 4.47 EDAX analysis of particle at cladded region of 309L Nb cladded weld overlay developed with 200 mm/ min welding speed (900 X magnification)**

## 4.2.2.16 EDAX analysis of clad region near to interface of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.43 EDAX analysis of clad region near to interface of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.92 | 8.24 |
| Si K | 0.58 | 1.06 |
| Cr K | 15.20 | 15.07 |
| Mn K | 0.84 | 0.79 |
| Fe K | 73.30 | 67.67 |
| Ni K | 8.16 | 7.17 |
| Total | 100 % | |
| | | |



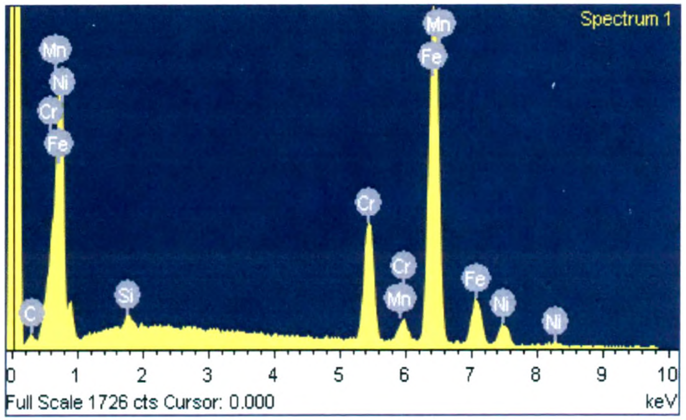




**Fig. 4.48 EDAX analysis of clad region of 309 L cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.17 EDAX analysis at interface of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.44 EDAX analysis at interface of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 4.10 | 16.39 |
| Si K | 0.62 | 1.06 |
| Cr K | 10.88 | 10.06 |
| Mn K | 1.14 | 1.00 |
| Fe K | 79.16 | 68.13 |
| Ni K | 4.10 | 3.36 |
| Total | 100 % | |
| | | |

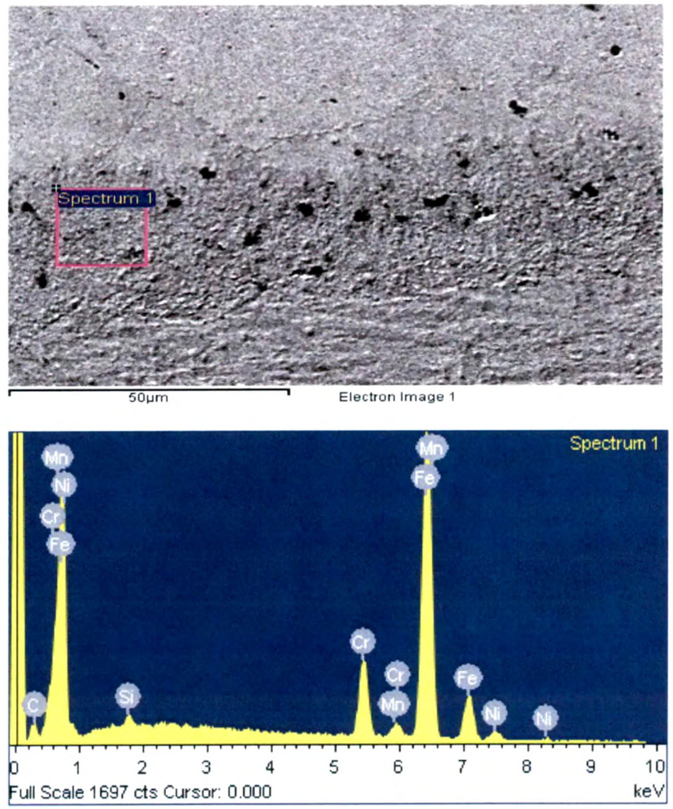


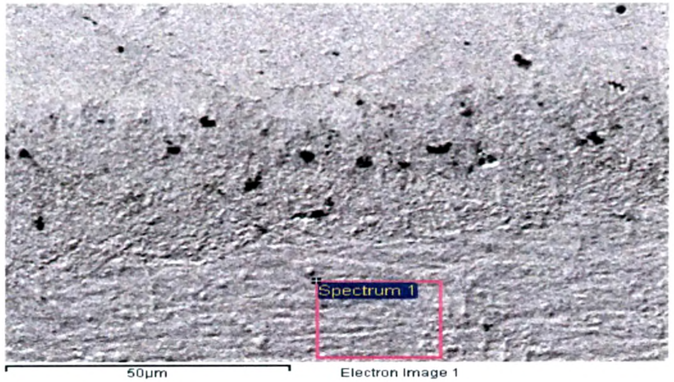

**Fig. 4.49 EDAX analysis at interface of 309 L cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.18 EDAX analysis at base metal near to interface of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.45 EDAX analysis of base metal near to interface of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.90 | 8.20 |
| Si K | 0.74 | 1.36 |
| Cr K | 1.72 | 1.72 |
| Fe K | 95.64 | 88.73 |
| Total | 100 | |
| | | |
| | | |
| | | |



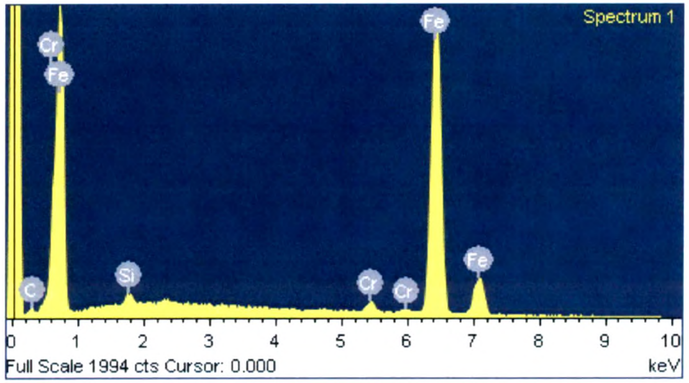



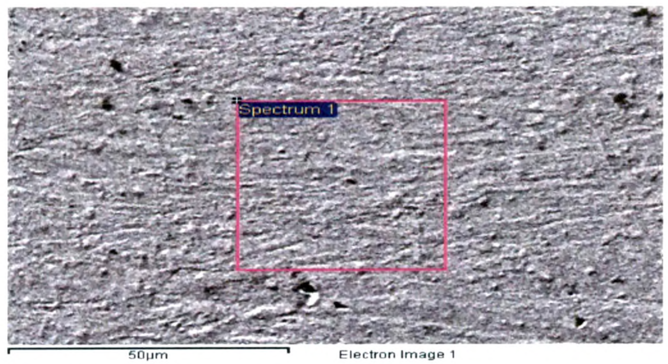

**Fig. 4.50 EDAX analysis of base metal near interface of 309 L cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.19 EDAX analysis at base metal of 309 L cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.46 EDAX analysis base metal of 309L Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 2.13 | 9.11 |
| Si K | 0.70 | 1.28 |
| Cr K | 1.36 | 1.34 |
| Fe K | 95.82 | 88.27 |
| Total | 100 | |
| | | |
| | | |
| | | |



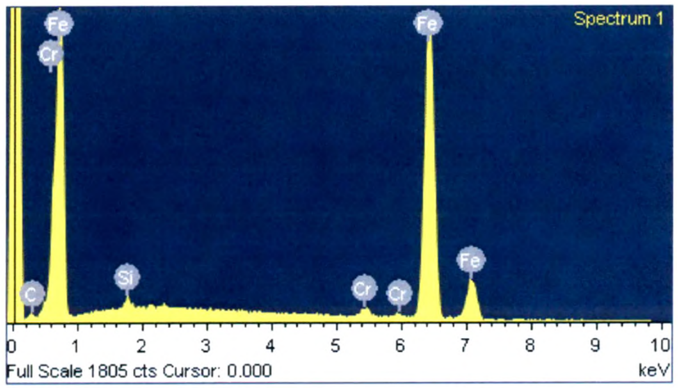




**Fig. 4.51 EDAX analysis of clad region of 309 LNb cladded weld overlay developed with 180 mm/ min welding speed**

### 4.2.2.20 EDAX analysis of clad region near to interface of 309 L Nb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.47 EDAX analysis of clad region near to interface of 309LNb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 2.81 | 11.67 |
| Si K | 0.64 | 1.14 |
| Cr K | 17.19 | 16.53 |
| Mn K | 1.20 | 1.09 |
| Fe K | 69.30 | 62.02 |
| Ni K | 8.86 | 7.54 |
| Total | 100 | |
| | | |

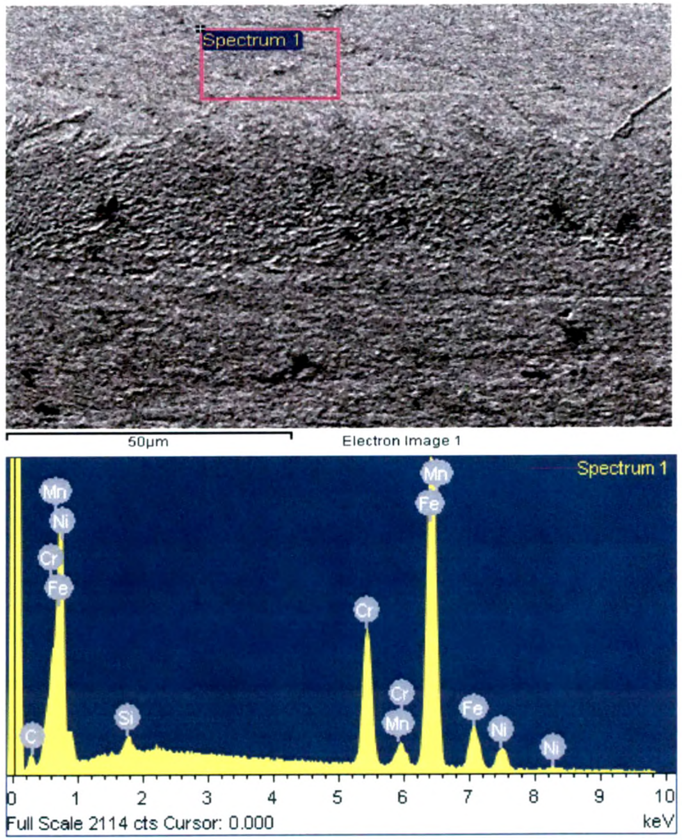



**Fig. 4.52 EDAX analysis base metal of 309 L cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.21 EDAX analysis at interface of 309 L Nb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.48 EDAX analysis at interface of 309L Nb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 4.28 | 17.04 |
| Si K | 0.59 | 1.00 |
| Cr K | 11.81 | 10.85 |
| Mn K | 0.69 | 0.60 |
| Fe K | 78.32 | 67.01 |
| Total | 100 | |
| | | |
| | | |

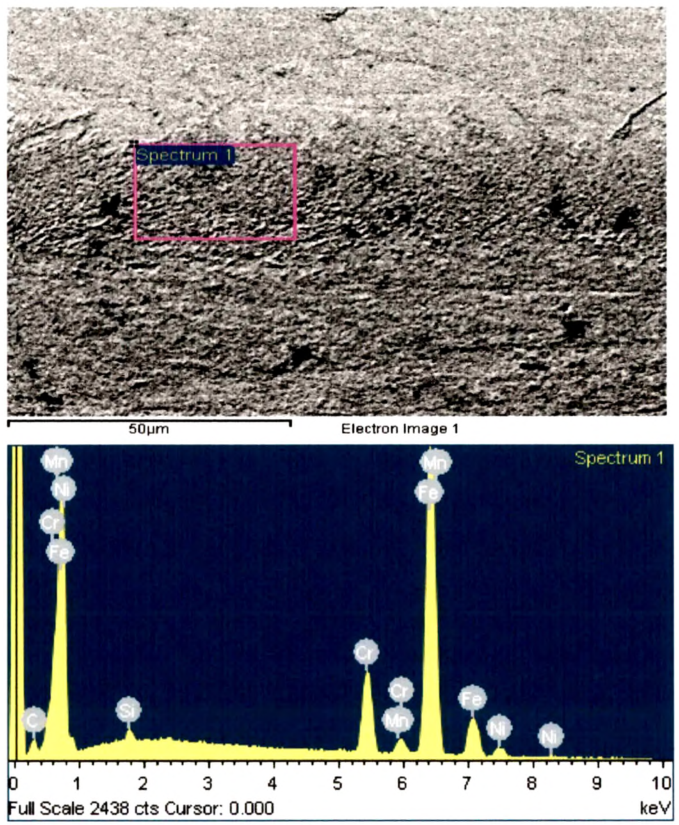


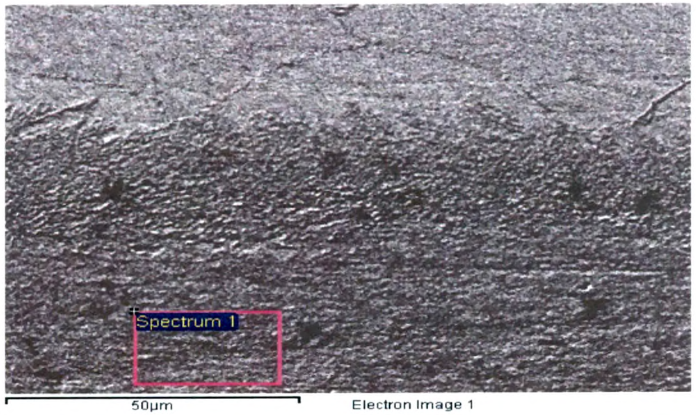

**Fig. 4.53 EDAX analysis at interface of 309 LNb cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.22 EDAX analysis at base metal near to interface of 309 L Nb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.49 EDAX analysis of base metal near to interface of 309L Nb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 2.08 | 8.94 |
| Si K | 0.56 | 1.03 |
| Cr K | 1.64 | 1.62 |
| Mn K | 0.62 | 0.58 |
| Fe K | 95.10 | 87.83 |
| Total | 100 | |
| | | |
| | | |



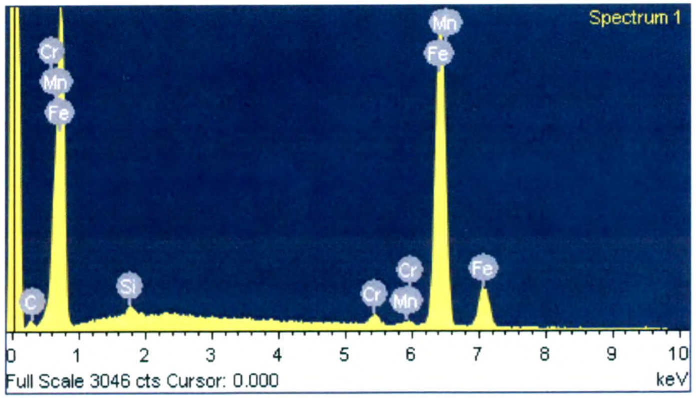



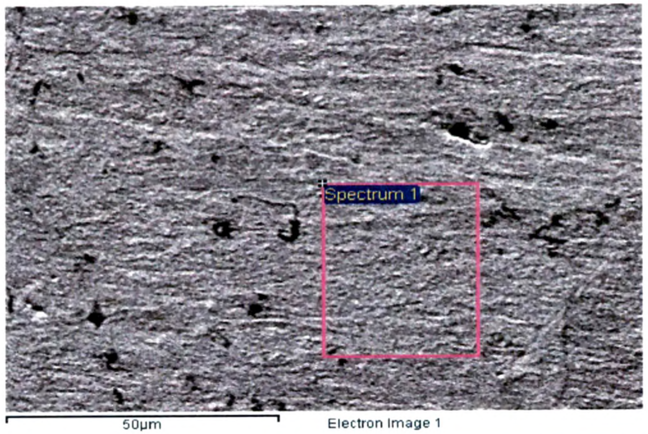

**Fig. 4.54 EDAX analysis of base metal near interface of 309 L Nb cladded weld overlay developed with 180 mm/ min welding speed**

## 4.2.2.23 EDAX analysis at base metal of 309 LNb cladded weld overlay at 180 mm /min. welding speed

Spectrum processing: No peaks omitted

**Table-4.50 EDAX analysis base metal of 309LNb Cladded weld overlay at 180 mm /min. welding speed**

| Element | Weight% | Atomic% |
|---|---|---|
| C K | 1.99 | 8.56 |
| Si K | 0.59 | 1.09 |
| Cr K | 1.48 | 1.47 |
| Fe K | 95.94 | 88.88 |
| Total | 100 | |
| | | |
| | | |
| | | |



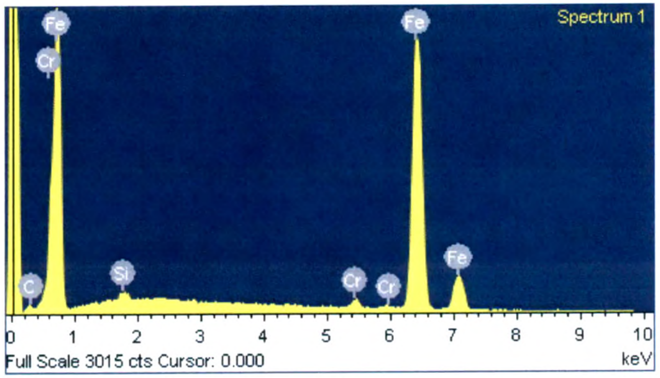




**Fig. 4.55 EDAX analysis of base metal ne of 309 L Nb cladded weld overlay developed with 180 mm/ min welding speed**

**Table-4.51 Percentage elements present at different location of weld overlay**

| Elements | Weld overlay strip | Location | | | |
|---|---|---|---|---|---|
| | | Clad region near interface | interface region | base mental near to interface | base metal |
| Carbon(%) | 309L | 1.42 | 4.10 | 1.90 | 2.13 |
| | 309L Nb | 1.39 | 4.02 | 1.92 | 2.16 |
| Iron(%) | 309L | 69.96 | 79.16 | 95.64 | 95.82 |
| | 309L Nb | 70.57 | 78.60 | 95.10 | 95.77 |
| Chromium(%) | 309L | 18.14 | 10.88 | 1.72 | 1.36 |
| | 309L Nb | 17.34 | 11.81 | 1.64 | 1.48 |

Results of SEM & EDAX analysis shows that % of carbon is increase at interface region of both weld overlays after PWHT due to the migration from base metal near to interface as well as from clad region near to interface which may from FeC and small amount of chromium carbide but not $Cr_{23}C_6$ (volume fraction is not matching with $Cr_{23}C_6$ ). This may lead to increase the hardness at interface region as compared to clad & base metal after PWHT for both weld overlay.

## 4.2.3 Effect of Welding Speed on Ferrite Content of the weld overlays

**Table- 4.52 : Variation of ferrite content at different welding speed**

| Welding speed (mm/min.) | Amount of ferrite Content | |
|---|---|---|
| | 309 L Cladded surface | 309 LNb cladded surface |
| 160 | 5.4 | 5.5 |
| 180 | 3.7 | 4.6 |
| 200 | 3.3 | 4.3 |

Table - 4.52 shows the variation of ferrite content at cladded region of both weld overlays developed with different welding speeds. It was found that the ferrite content decrease with increase in the welding speed from 160 to 200 mm / min. This is because with increasing welding speed, the cooling rate is also increases which provide less time for nucleation and growth of ferrite during solidification[82].

## .4.2.4 Effect of Welding Speed on Hardness Value of the weld overlays

**Table- 4.53: Micro harness at different location of weld overlays in as welded condition**

| Exp. No | Samples | Location | | |
|---|---|---|---|---|
| | | base metal | Interface | Clad |
| 1 | 309L - 160WS | 206 | 278 | 242 |
| 2 | 309L - 180WS | 208 | 289 | 260 |
| 3 | 309L - 200WS | 210 | 312 | 271 |
| 4 | 309LNb - 160WS | 206 | 249 | 222 |
| 5 | 309LNb - 180WS | 208 | 266 | 235 |
| 6 | 309LNb - 200WS | 210 | 281 | 254 |

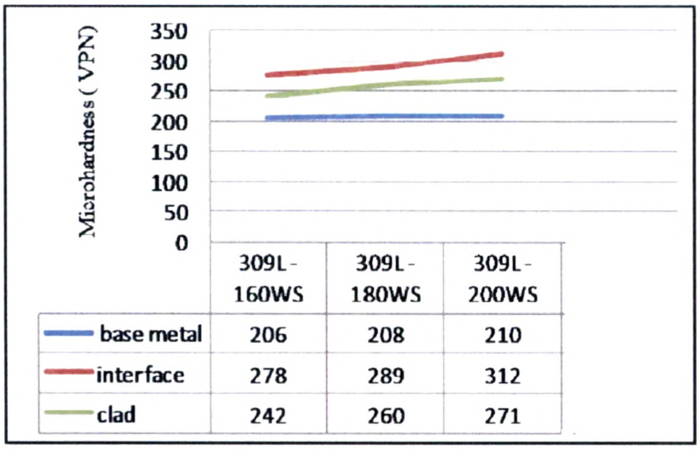



**Fig-4.56 Effect of welding speed on Hardness Value of 309 L cladded weld overlay**

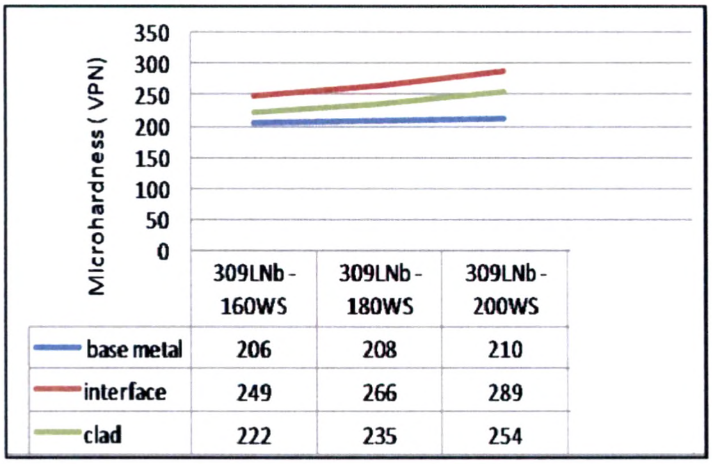



**Fig-4.57 Effect of welding speed on Hardness Value of 309 L Nb cladded weld overlay**

Fig -4.56 & 4.57 shows effect of welding speed on hardness value of 309 L & 309 L Nb austenitic stainless steel cladded weld overlay respectively. There were considerable increases in the hardness value with increase in the welding speed from 160 mm /min to 200 mm / min. in as welded condition. This is because as welding speed increase, the amount of heat input was decrease which result in decrease the ferrite content. There is a moderate increase in hardness at the weld interface region, which can be attributed to the formation of a low-carbon martensite for all weld overlays developed at different welding speeds[83].

## 4.2.5 Effect of welding speed on corrosion behaviour of weld overlays

### 4.2.5.1 Effect of welding speed on General Corrosion susceptibility of weld overlays in 0.1 N $HNO_3$ solution

#### 4.2.5.1.1 Effect of Welding Speed on corrosion behaviour of Base metal in 0.1 $HNO_3$ solution

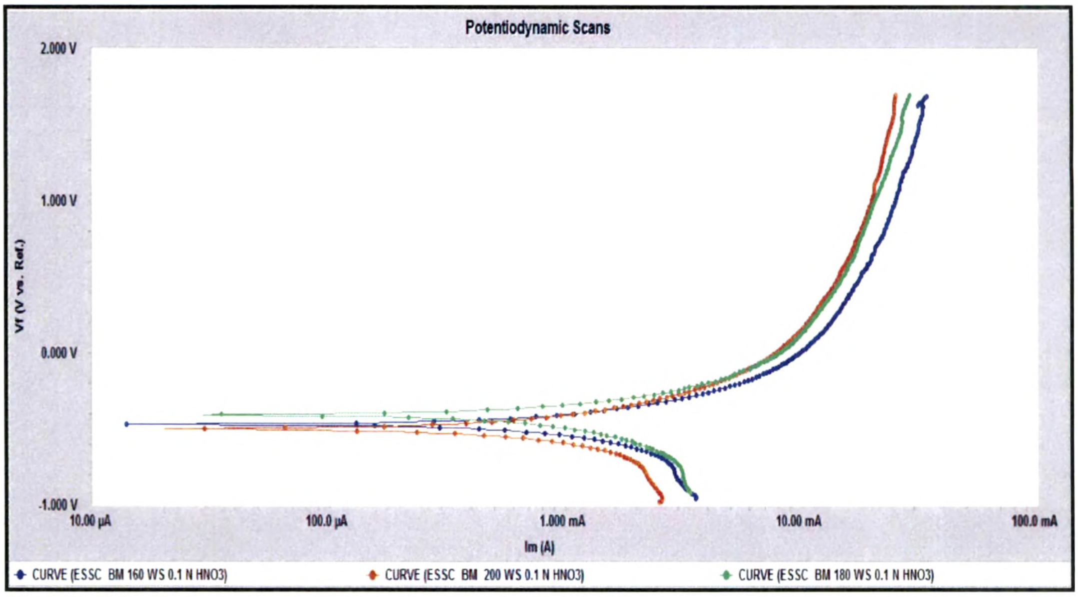



**Fig. 4.58 : Potentiodynamic scans of Base Metal at different WS in 0.1N $HNO_3$ solution**

**Table No-4.54: Electrochemical Parameters of Potentiodynamic studies on Base Metal in 0.1N $HNO_3$ solution**

| Sr. No | Samples | $i_{Corr}$ | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Base Metal 160 WS | 609.0 | -465 | 228.9 |
| 2 | Base Metal 180 WS | 567.0 | -404.0 | 213.0 |
| 3 | Base Metal 200 WS | 518.0 | -496.0 | 194.6 |

Fig. 4.58 shows the results of Potentiodynamic studies on Base Metal in 0.1N $HNO_3$ solution. By comparing corrosion behavior of base metal which was overlaid at different welding speeds in 0.1N $HNO_3$ solution, it shows that (i) corrosion rate decreases with

increase in the welding speed (ii) all other samples also exhibit similar kind of corrosion resistance at different welding speeds [84].

**4.2.5.1.2 Effect of Welding Speed on corrosion behaviour of 309 L cladded weld overlay in N $HNO_3$ Solution**

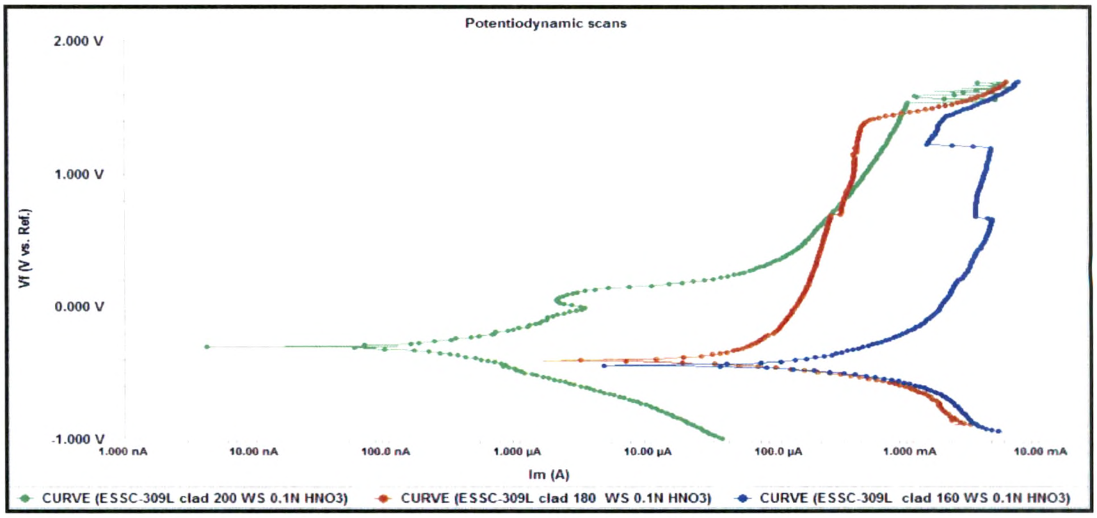



**Fig. 4.59 : Potentiodynamic scans of 309L cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution**

**Table No- 4.55: Electrochemical Parameters of Potentio-dynamic studies of 309 L cladded weld overlay in 0.1N $HNO_3$Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Clad 160 WS | 361.3 | -374.0 | 135.5 |
| 2 | ESSC-309L Clad 180 WS | 48.5 | -440 .0 | 81.24 |
| 3 | ESSC-309L Clad 200 WS | 0.35 | -402.0 | 13.41 |

Fig. 4.59 shows the results of Potentiodynamic studies on 309 L cladded weld overlays in 0.1N $HNO_3$ solution. By comparing corrosion behavior of 309L cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution it shows that (i) All weld overlays show passivation behavior during several potential scan cycles (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 180 mm / min. welding speed. (iii) Weld overlay developed at

180 & 200 mm / min. welding speed exhibit similar kind of corrosion rate (iv) corrosion rate decreases with increasing weld speed from 160 to 200 mm / min [84].

**4.2.5.1.3 Effect of Welding Speed on corrosion behaviour interface of 309 L cladded weld overlay in N $HNO_3$ Solution**

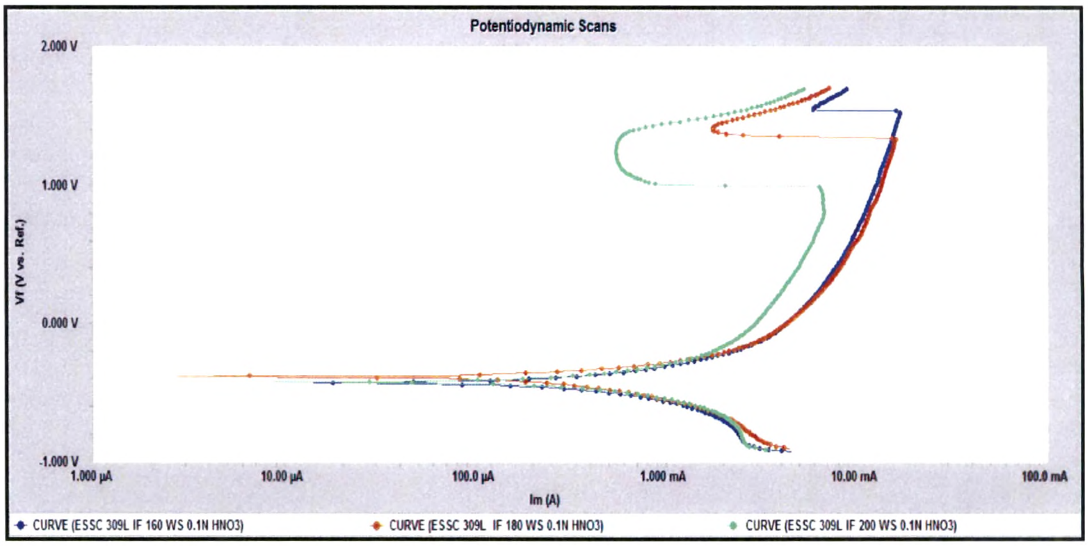



**Fig. 4.60: Potentiodynamic scans of interface of 309L cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution**

**Table No- 4.56 : Electrochemical Parameters of Potentio-dynamic studies interface of 309 L cladded weld overlay in 0.1N $HNO_3$Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC- 309L IF 160 WS | 431.2 | -428 | 161.7 |
| 2 | ESSC- 309L IF 180 WS | 254.0 | -383 | 95.31 |
| 3 | ESSC- 309L IF 200 WS | 245.0 | -423 | 92.1 |

Fig. 4.60 shows the results of Potentiodynamic studies on interface of 309 L cladded weld overlays in 0.1N $HNO_3$ solution. By comparing corrosion behavior of interface of 309L cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution it shows that (i) interface of weld overlays developed at different welding speed shows passivation behavior during several potential scan cycles (ii) weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 200 mm / min. welding speed.

**4.2.5.1.4. Effect of Welding Speed on corrosion behaviour of 309 L Nb cladded weld overlay in 0.1 $HNO_3$ solution**

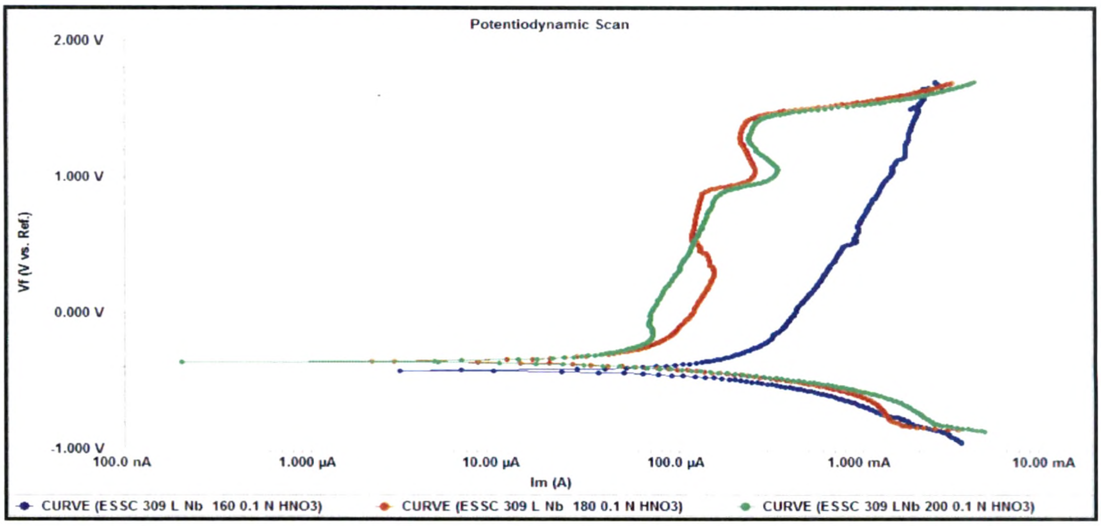



**Fig. 4.61: Potentiodynamic scans of 309L Nb cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution**

**Table No-4.57: Electrochemical Parameters of Potentiodynamic studies of 309 LNb cladded weld overlays in 0.1N $HNO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb Clad 160 WS | 393.0 | -424.0 | 147.3 |
| 2 | ESSC-309L Nb Clad 180 WS | 257.6 | -354.0 | 96.62 |
| 3 | ESSC-309L Nb Clad 200 WS | 242.1 | -359.0 | 90.80 |

Fig. 4.61 shows the results of Potentiodynamic studies on 309 L Nb cladded weld overlays in 0.1N $HNO_3$ solution. By comparing corrosion behavior of 309L Nb cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution it shows that (i) all weld overlays exhibit passive behavior in 0.1N $HNO_3$ solution (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 180 mm / min. welding speed (iii) but the weld overlay developed at 180 & 200 mm / min. welding speed exhibit similar kind of corrosion rate (iv) corrosion rate decreases with increasing weld speed from 160 to 200 mm / min [84].

#### 4.2.5.1.5 Effect of Welding Speed on corrosion behaviour interface of 309 LNb cladded weld overlay in N $HNO_3$ Solution

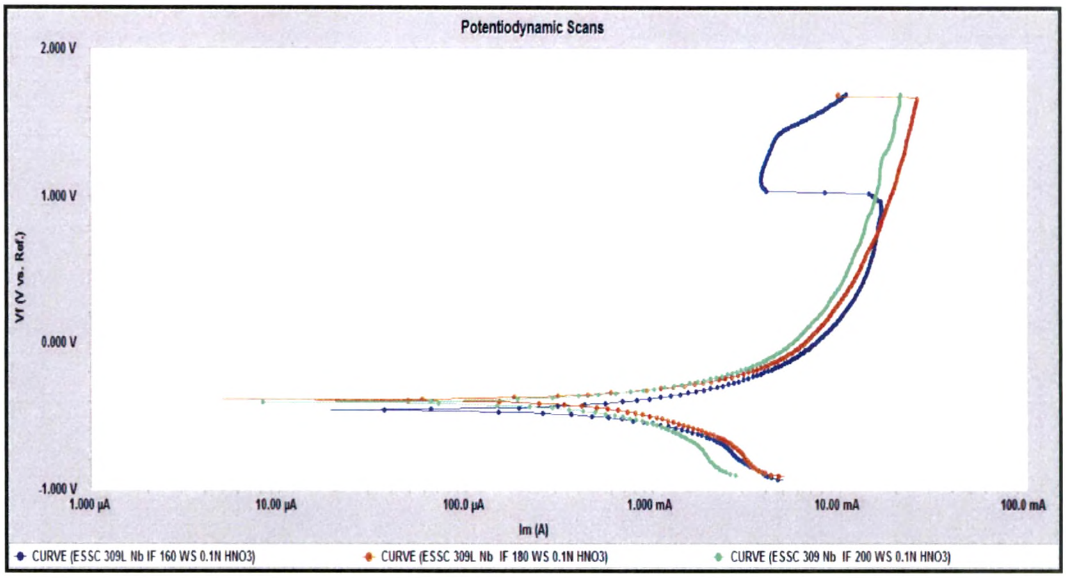



**Fig.4.62 : Potentiodynamic scans of interface of 309L Nb cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution**

**Table No- 4.58: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L Nb cladded weld overlay in 0.1N $HNO_3$Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb IF 160 WS | **564.0** | **-458** | **211.6** |
| 2 | ESSC-309L Nb IF 180 WS | **436.0** | **-386** | **163.6** |
| 3 | ESSC-309L Nb IF 200 WS | 441.0 | -406 | 166.7 |

Fig. 4.62 shows the results of Potentiodynamic studies on interface of 309 L cladded weld overlays in 0.1N $HNO_3$ solution. By comparing corrosion behavior of interface of 309L cladded weld overlays at different welding speed in 0.1N $HNO_3$ solution it shows that (i) interface of weld overlays developed at different welding speed show passivation behavior during several potential scan cycles (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 180 mm / min. welding speed. (iv) corrosion rate decreases with increasing weld speed from 160 to 200 mm / min.

### 4.2.5.2 Effect of welding speed on General Corrosion susceptibility of weld overlays in 0.1 N HCl solution

#### 4.2.5.2.1 Effect of Welding Speed on corrosion behaviour of Base metal in 0.1 HCl Solution

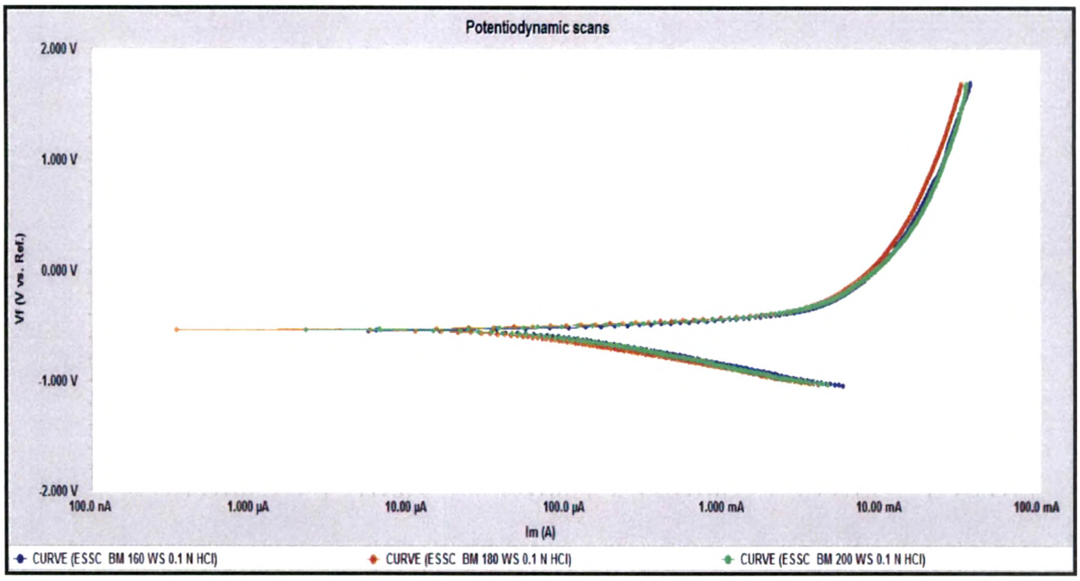



**Fig. 4.63: Potentiodynamic scans of Base metal at different welding speed in 0.1N HCl solution**

**Table No-4.59: Electrochemical Parameters of Potentiodynamic study of Base Metal in 0.1N HCl**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-Base Metal -160 WS | 91.8 | -509 | 34.5 |
| 2 | ESSC-Base Metal- 180 WS | 60.5 | -535 | 22.73 |
| 3 | ESSC-Base Metal -200 WS | 81.5 | -536 | 30.63 |

Fig. 4.63 shows the results of Potentiodynamic studies on Base Metal in 0.1N HCl solution. Base metal does not show any passivation behavior even after several potential scan cycles. By comparing corrosion behavior of Base Metal at different welding speed, it exhibit similar kind of corrosion resistance at all welding speed but base metal of weld

overlay developed at 180 mm / min. exhibit good corrosion resistance then that of 160 mm/ min. & 200 mm/ min welding speed.

#### 4.2.5.2.2 Effect of Welding Speed on corrosion behaviour of 309 L cladded weld overlay in 0.1 HCl Solution

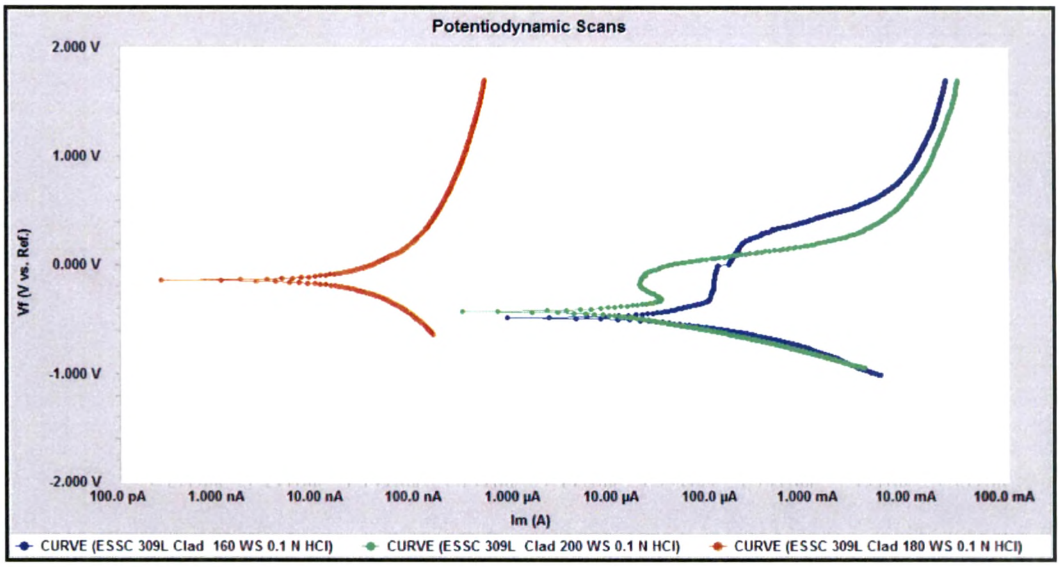



**Fig. 4.64: Potentiodynamic scans of 309L cladded weld overlays at different WS in 0.1N HCl Solution**

**Table No- 4.60: Electrochemical Parameters of Potentiodynamic study of 309 L cladded weld overlay in 0.1N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Clad 160 WS | 26.7 | -486 | 10.03 |
| 2 | ESSC-309L Clad 180 WS | 75 nA | -137 | 0.0282 |
| 3 | ESSC-309L Clad 200 WS | 7.56 | -427 | 2.843 |

Fig. 4.64 shows the results of Potentiodynamic studies on 309 L cladded weld overlays in 0.1N HCl solution. Except weld overlay developed at 160 mm /min. welding speed, All other weld overlays show passivation behavior during several potential scan cycles. By comparing corrosion behavior of weld overlays at different welding speed, it indicates that (i) weld overlay developed with 180 mm/ min. welding speed, exhibit good corrosion resistance while weld overlays developed with 160 mm/ min. & 200 mm/ min welding

speed, exhibit lower corrosion resistance but the values of corrosion rate are well within the acceptable limit (ii) weld overlay developed at 180 & 200 mm / min. welding speed exhibit similar kind of corrosion rate.

#### 4.2.5.2.3 Effect of Welding Speed on corrosion behaviour interface of 309 L cladded weld overlay in 0.1 N HCl Solution

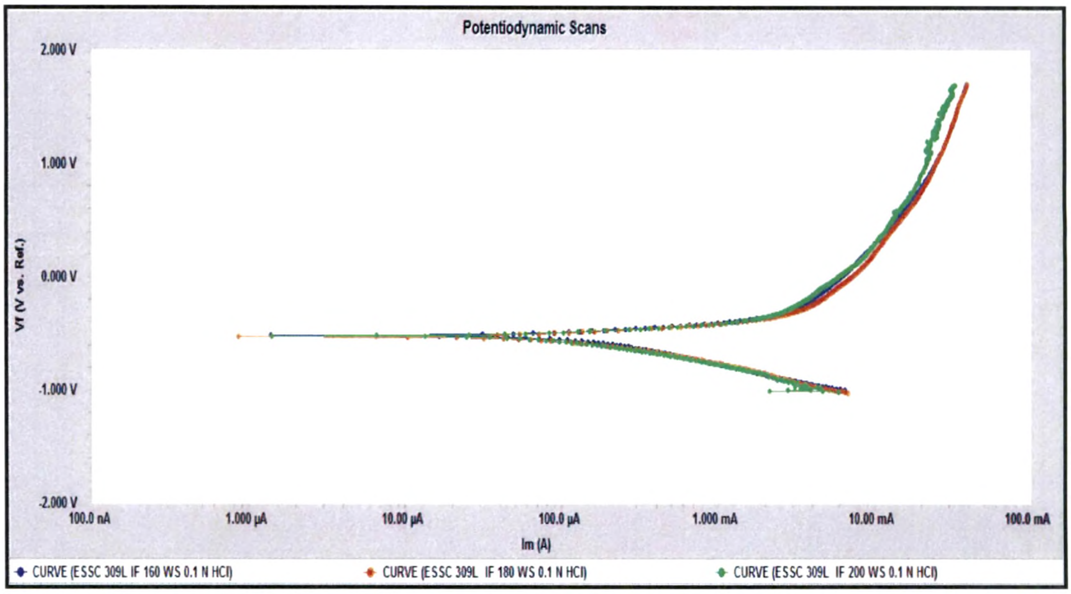



**Fig. 4.65 Potentiodynamic scans of interface of 309L cladded weld overlays at different welding speed in 0.1N HCl solution**

**Table No- 4.61: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L cladded weld overlay in 0.1N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L IF 160 WS | 48.5 | -523 | 18.22 |
| 2 | ESSC-309L IF 180 WS | 39.0 | -528 | 14.60 |
| 3 | ESSC-309L IF 200 WS | 39.3 | -521 | 14.77 |

Fig. 4.65 shows the results of Potentiodynamic studies on interface of 309 LNb cladded weld overlays in 0.1N HCl solution. By comparing corrosion behavior of interface of 309L Nb cladded weld overlays at different welding speed in 0.1N HCl solution it shows that (i) interface regions does not show any passivation behavior during several potential

scan cycles (ii) interface of weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compare to weld overlay developed at the 160 & 200 mm / min. welding speed. (iii) interface of weld overlay developed at 180 & 200 mm / min. welding speed exhibit similar kind of corrosion rate.

#### 4.2.5.2.4 Effect of Welding Speed on corrosion behaviour of 309 L Nb cladded weld overlay in 0.1 HCl Solution

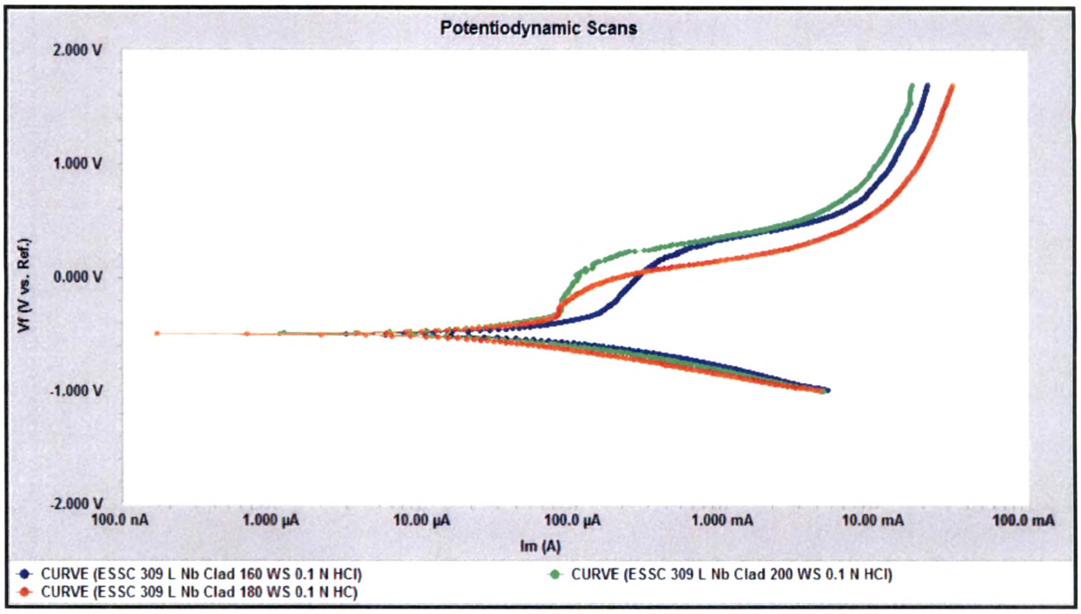



**Fig. 4.66 Potentiodynamic scans of 309LNb cladded weld overlays at different WS in 0.1N HCl Solution**

**Table No- 4.62 : Electrochemical Parameters of Potentio-dynamic study of 309 LNb cladded weld overlay in 0.1N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb Clad 160 WS | 39.6 | -493 | 14.9 |
| 2 | ESSC-309L Nb Clad 180 WS | 7.53 | -494 | 2.829 |
| 3 | ESSC-309L Nb Clad 200 WS | 20.9 | -491 | 7.872 |

Fig. 4.66 shows the results of Potentiodynamic studies on 309 L Nb cladded weld overlays in 0.1N HCl solution. All weld overlays show passivation behavior during several potential scan cycles. By comparing corrosion behavior of weld overlays at different welding speed, it

indicates that (i) weld overlay developed with 180 mm/ min & 200 mm/ min. welding speed, exhibit good corrosion resistance with compared to weld overlay developed at 160 mm/ min. welding speed, but the values of corrosion rate are well within the acceptable limit. (ii) corrosion rate decreases with increasing the welding speed from 160 mm/ min to 200 mm/ min.

**4.2.5.2.5 Effect of Welding Speed on corrosion behaviour interface of 309 LNb cladded weld overlay in 0.1 N HCl Solution**

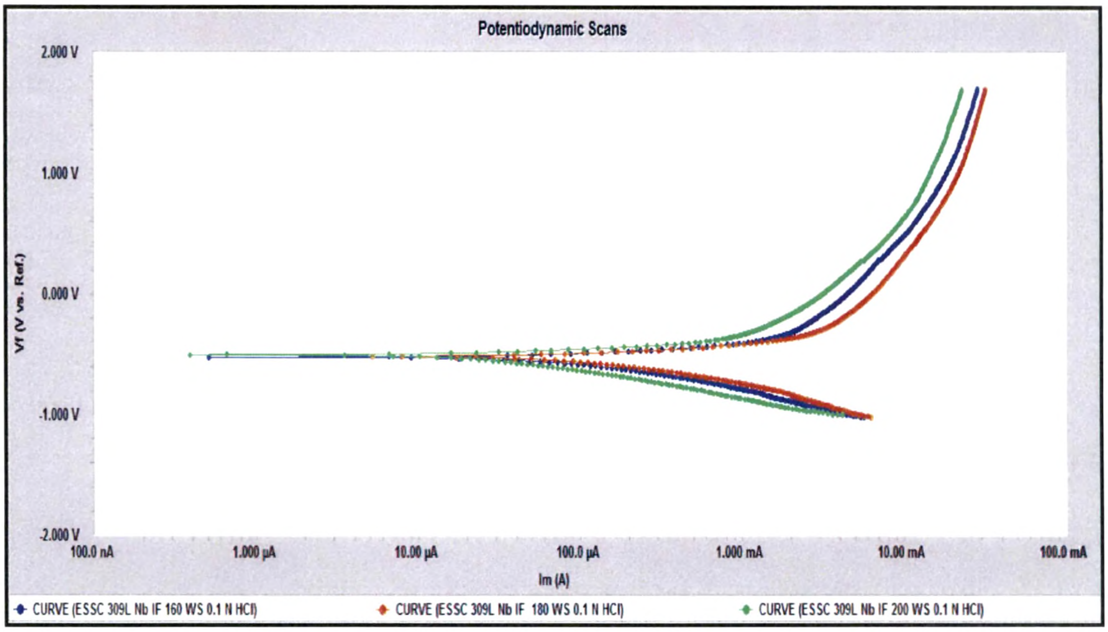



**Fig. 4.67 : Potentiodynamic scans of interface of 309L Nb cladded weld overlays at different welding speed in 0.1N HCl solution**

**Table No- 4.63: Electrochemical Parameters of Potentio-dynamic studies interface of 309 LNb cladded weld overlay in 0.1N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | IF 309L Nb 160 WS | 69.6 | -518 | 26.15 |
| 2 | IF 309L Nb 180 WS | 50.60 | -513 | 19.01 |
| 3 | IF 309L Nb 200 WS | 49.30 | -521 | 17.70 |

Fig. 4.67 shows the results of Potentiodynamic studies on interface of 309 LNb cladded weld overlays in 0.1N HCl solution. By comparing corrosion behavior of interface of

309L Nb cladded weld overlays at different welding speed in 0.1N HCl solution it shows that (i) interface of all weld overlays does not show any passivation behavior during several potential scan cycles (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 180 mm / min. welding speed. (iii) weld overlay developed at 160 & 180 mm / min. welding speed exhibit similar kind of corrosion rate.

## 4.2.5.3 Effect of welding speed on General Corrosion susceptibility of weld overlays in 0.1 N $H_2S0_4$ solution

### 4.2.5.3.1 Effect of Welding Speed on corrosion behaviour of Base metal in 0.1 N $H_2S0_4$ Solution:

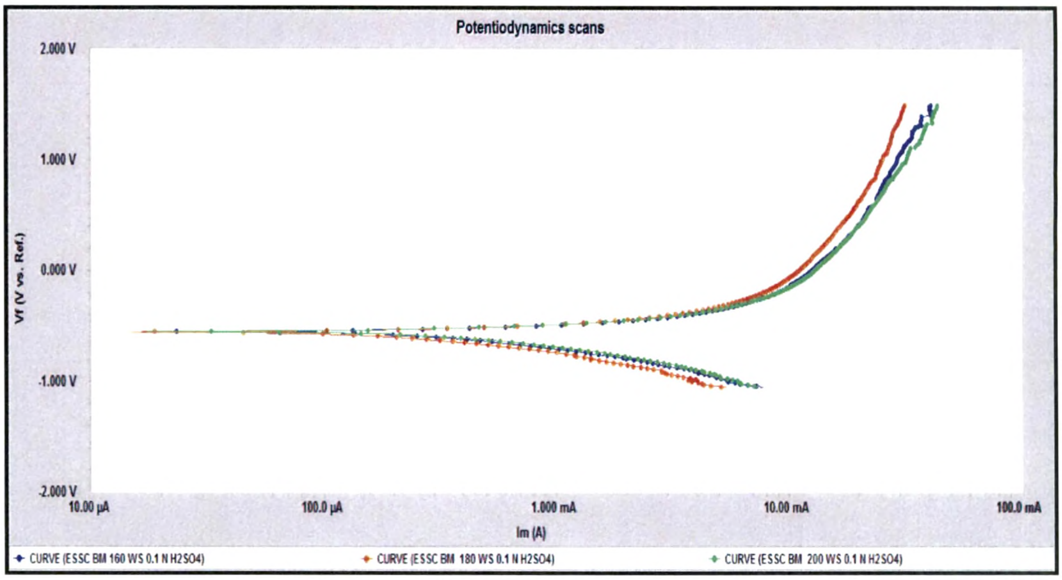



**Fig. 4.68 : Potentiodynamic scans of Base Metal at different WS in 0.1N $H_2S0_4$ solution**

**Table No-4.64: Electrochemical Parameters of Potentiodynamic studies on Base Metal in 0.1N $H_2S0_4$ solution**

| Sr. No | Samples | $i_{Corr}$ | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-Base Metal 160 WS | 295.0 | -551.0 | 539.2 |
| 2 | ESSC-Base Metal 180 WS | 247.0 | -554.0 | 451.7 |
| 3 | ESSC-Base Metal 200 WS | 349.0 | -547.0 | 637.1 |

Fig. 4.68 shows the results of Potentiodynamic studies on base metal of different weld overlays in 0.1N $H_2SO_4$ solution.By comparing corrosion behavior of base metal which were overlaid at different welding speed in 0.1N $H_2SO_4$ solution, it shows that (i) base metal of weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compare to weld overlay developed at the 160 & 200 mm / min. welding speed (iii) corrosion resistance of weld overlay developed at 160 & 200 mm / min. welding speed were similar[85].

**4.2.5.3.2 Effect of Welding Speed on corrosion behaviour of 309 L cladded weld overlay in N $H_2S0_4$ Solution**

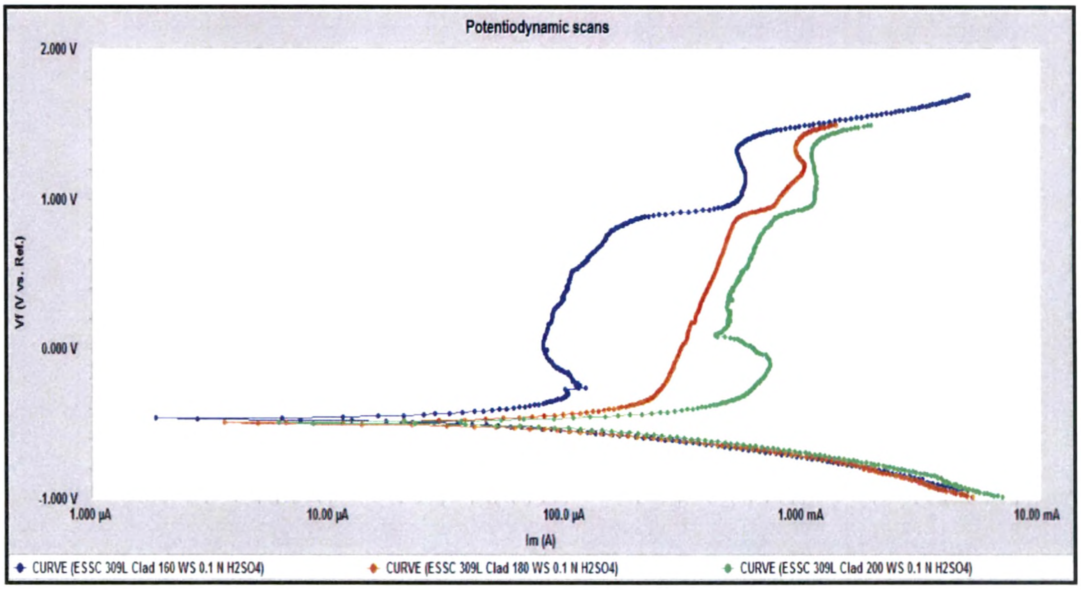



**Fig. 4.69 : Potentiodynamic scans of 309L cladded weld overlays at different welding speed in 0.1N $H_2S0_4$ solution**

**Table No- 4.65 : Electrochemical Parameters of Potentio-dynamic studies of 309 L cladded weld overlay in 0.1N $HNO_3$Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Clad 160 WS | 85.80 | -462 | 156.8 |
| 2 | ESSC-309L Clad 180 WS | 56.10 | -493 | 102.5 |
| 3 | ESSC-309L Clad 200 WS | 97.30 | -489 | 177.9 |

Fig. 4.69 shows the results of Potentiodynamic studies 309L cladded weld overlays which were developed at different welding speed in 0.1N $H_2SO_4$ solution. By comparing corrosion behavior of 309L cladded weld overlays at different welding speed in 0.1N $H_2SO_4$ solution, it shows that (i) all weld overlays exhibit passive behavior (ii) weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 200 mm / min. welding speed (iii) weld overlay developed at 160 & 200 mm / min. welding speed has similar corrosion behavior [85].

**4.2.5.3.3 Effect of Welding Speed on corrosion behaviour interface of 309 L cladded weld overlay in N $H_2S0_4$ Solution**

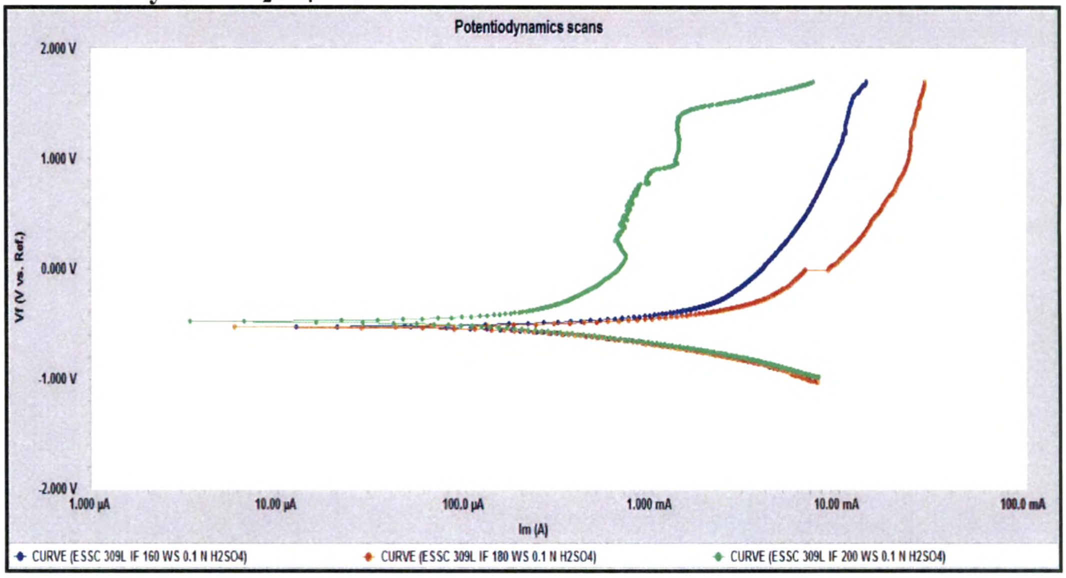



**Fig. 4.70 : Potentiodynamic scans of interface of 309L cladded weld overlays at different welding speed in 0.1N $H_2S0_4$ solution**

**Table No- 4.66: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L cladded weld overlay in 0.1N $H_2S0_4$ Solution**

| Sr. No | Amples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC- 309L IF 160 WS | 240.0 | -522.0 | 439.6 |
| 2 | ESSC- 309L IF 180 WS | 174.0 | -529.0 | 318.9 |
| 3 | ESSC- 309L IF 200 WS | 155.4 | -478.0 | 284.0 |

Fig. 4.70 shows the results of Potentiodynamic studies interface region of 309L cladded weld overlays which were developed at different welding speed in 0.1N $H_2SO_4$ solution. By comparing corrosion behavior of interface region of 309L cladded weld overlays at different developed welding speed in 0.1N $H_2SO_4$ solution shows that (i) only interface region of weld overlay developed at180 mm / min welding speed exhibit passive behavior while other two interface region does not exhibit any passivity (ii) interface region of weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 200 mm / min. welding speed (iii) weld overlay developed at 180 & 200 mm / min. welding speed has similar corrosion behavior.

**4.2.5.3.4 Effect of Welding Speed on corrosion behaviour of 309 L Nb cladded weld overlay in 0.1N $H_2S0_4$ solution**

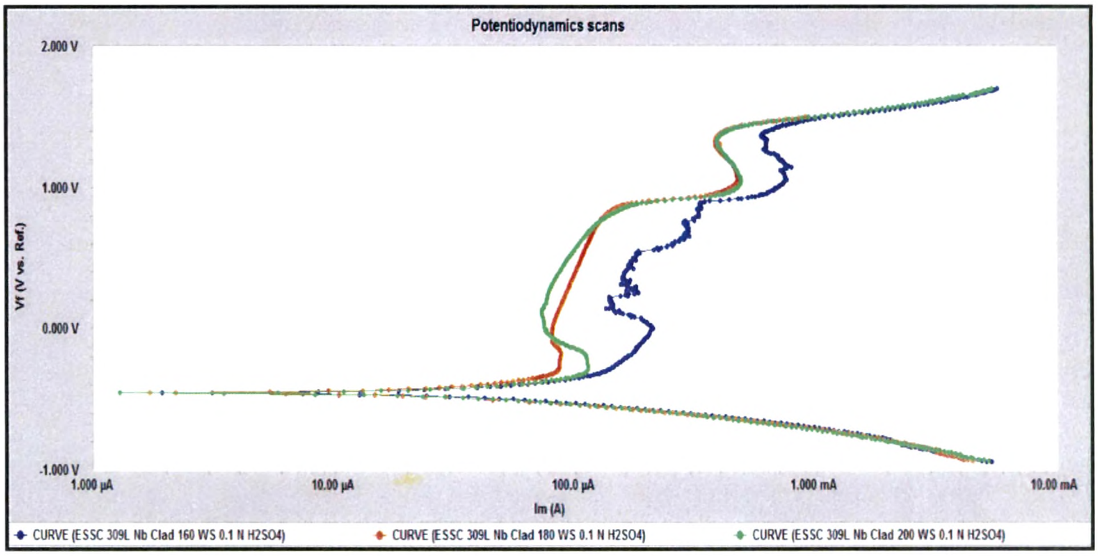



**Fig. 4.71: Potentiodynamic scans of 309L Nb cladded weld overlays at different welding speed in 0.1N $H_2S0_4$ solution**

**Table No-4.67: Electrochemical Parameters of Potentiodynamic studies of 309 LNb cladded weld overlays in 0.1N $H_2S0_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb Clad 160 WS | 72.60 | -452 | 132.6 |
| 2 | ESSC-309L Nb Clad 180 WS | 51.40 | -451 | 95.64 |
| 3 | ESSC-309L Nb Clad 200 WS | 52.8 | -454 | 96.40 |

Fig. 4.71 shows the results of Potentiodynamic studies 309L Nb cladded weld overlays which were developed at different welding speed in 0.1N $H_2SO_4$ solution. By comparing corrosion behavior of 309L Nb cladded weld overlays at different welding speed in 0.1N $H_2SO_4$ solution it shows that (i) all weld overlays exhibit passive behavior (ii) weld overlay developed at 180 mm /min. welding speed has best corrosion resistance compare to weld overlay developed at the 160 & 200 mm / min. welding speed iii) corrosion resistance of weld overlay developed at all welding speed exhibit similar in nature [85].

#### 4.2.5.3.5 Effect of Welding Speed on corrosion behaviour interface of 309 LNb cladded weld overlay in 0.1 N $H_2S0_4$ Solution

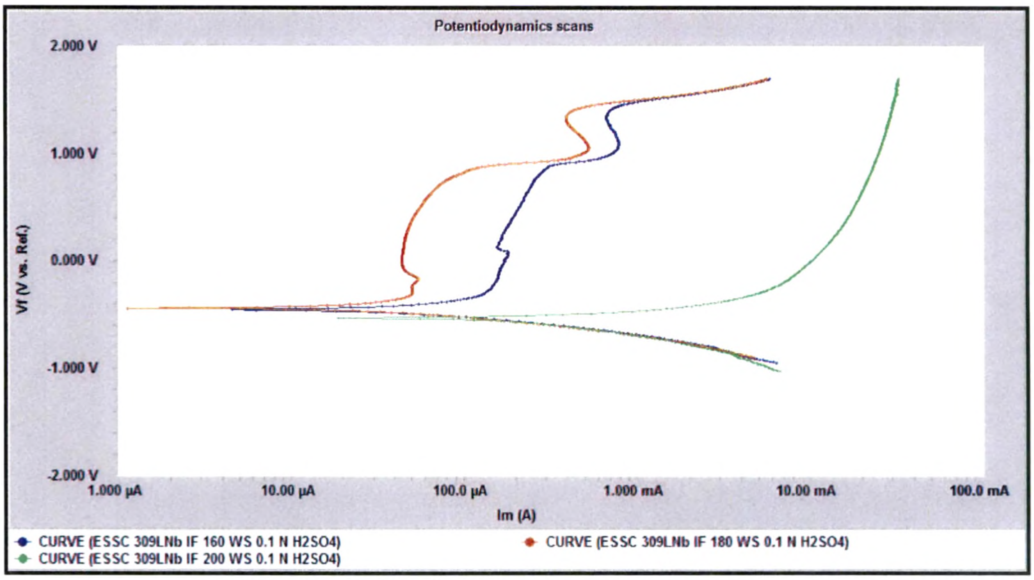



**Fig. 4.72: Potentiodynamic scans of interface of 309L Nb cladded weld overlays at different welding speed in 0.1N $H_2S0_4$ solution**

**Table No- 4.68: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L Nb cladded weld overlay in 0.1N $H_2S0_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb IF 160 WS | 66.40 | -452.0 | 122.8 |
| 2 | ESSC-309L Nb IF 180 WS | 61.0 | -531.0 | 113.1 |
| 3 | ESSC-309L Nb IF 200 WS | 75.2 | -541.0 | 137.4 |

Fig. 4.72 shows the results of Potentiodynamic studies interface region of 309L Nb cladded weld overlays which were developed at different welding speed in 0.1N $H_2SO_4$ solution. By comparing corrosion behavior of interface region of 309L Nb cladded weld overlays at different developed welding speed in 0.1N $H_2SO_4$ solution shows that (i) interface region of weld overlay developed at160 & 180 mm / min welding speed exhibit passive behavior while at interface region of weld overlay developed at 200 mm / min welding speed does not exhibit passive behaviour (ii) interface region of weld overlay developed at 180 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 200 mm / min. welding speed.

## 4.2.5.4 Effect of welding speed on General Corrosion susceptibility of weld overlays in 3.5 % NaCl Solution:

### 4.2.5.4.1 Effect of welding speed on General Corrosion susceptibility of weld overlays in 3.5 % NaCl Solution:

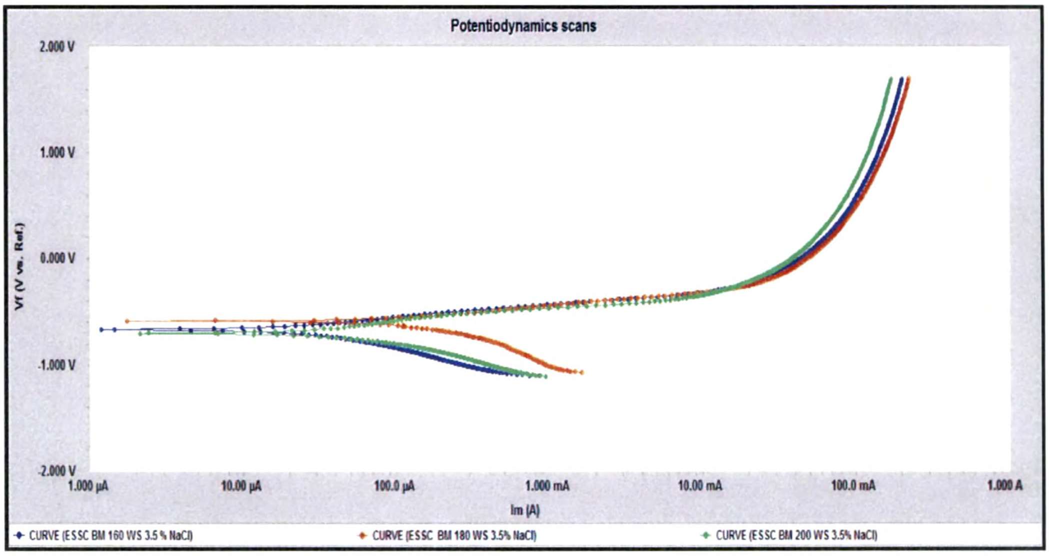



**Fig. 4.73: Potentiodynamic scans of Base Metal at different WS in 3.5 % NaCl solution**

**Table No-4.69: Electrochemical Parameters of Potentiodynamic studies on Base Metal in 3.5 % NaCl solution**

| Sr. No | Samples | $i_{Corr}$ | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-Base Metal 160 WS | 157.4 | -668 | 289.6 |
| 2 | **ESSC-Base Metal 180 WS** | 148 | -584 | 272.3 |
| 3 | ESSC-Base Metal 200 WS | 176.1 | -699 | 324.1 |

Fig. 4.73 shows the results of Potentiodynamic studies on Base Metal in 3. 5 % NaCl solution. Base metal does not show any passivation behavior even after several potential scan cycles. By comparing corrosion behavior of Base Metal at different welding speed, it exhibit similar kind of corrosion resistance at all welding speed but base metal of weld overlay developed at 180 mm / min. exhibit good corrosion resistance then that of 160 mm/ min. & 200 mm/ min welding speed [86].

### 4.2.5.4.2 Effect of Welding Speed on corrosion behaviour of 309 L cladded weld overlay in 3.5 % NaCl Solution

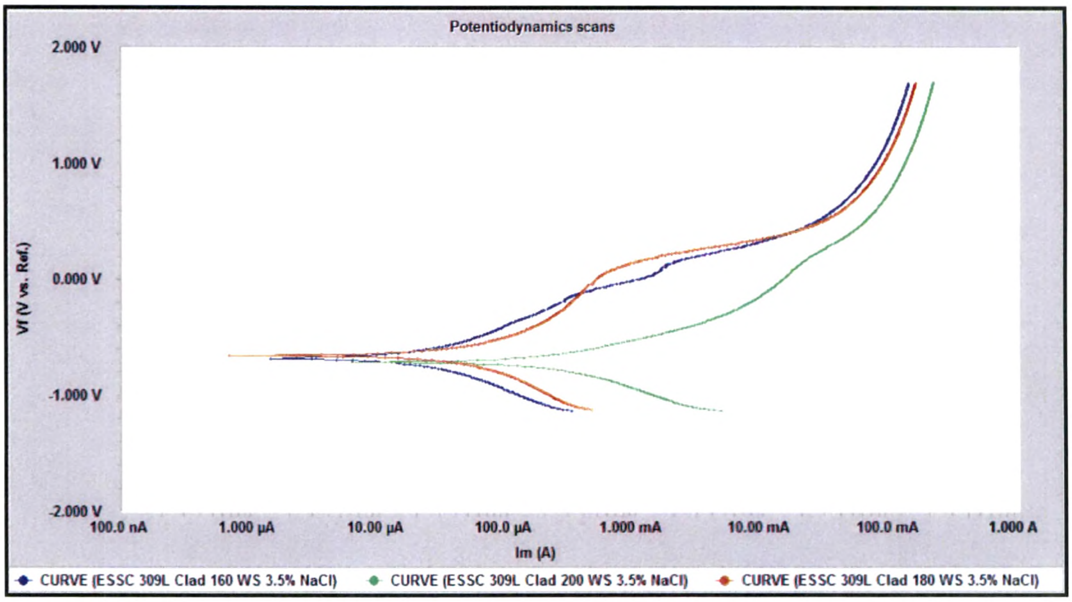



**Fig. 4.74 : Potentiodynamic scans of 309L cladded weld overlays at different welding speed in 3.5 % NaCl solution**

**Table No- 4.70 : Electrochemical Parameters of Potentio-dynamic studies of 309 L cladded weld overlay in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Clad 160 WS | 102.2 | -676 | 186.8 |
| 2 | ESSC-309L Clad 180 WS | 73.61 | -709 | 132.5 |
| 3 | ESSC-309L Clad 200 WS | 121.61 | -651 | 222.7 |

Fig. 4.74 shows the results of Potentiodynamic studies 309L cladded weld overlays which were developed at different welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of 309L cladded weld overlays at different welding speed in 3.5 % NaCl solution, it shows that (i) all weld overlays do not exhibit passive behavior (ii) weld overlay developed at 160 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 180 & 200 mm / min. welding speed [86].

**4.2.5.4.3 Effect of Welding Speed on corrosion behaviour interface of 309 L cladded weld overlay in 3.5 % NaCl Solution**

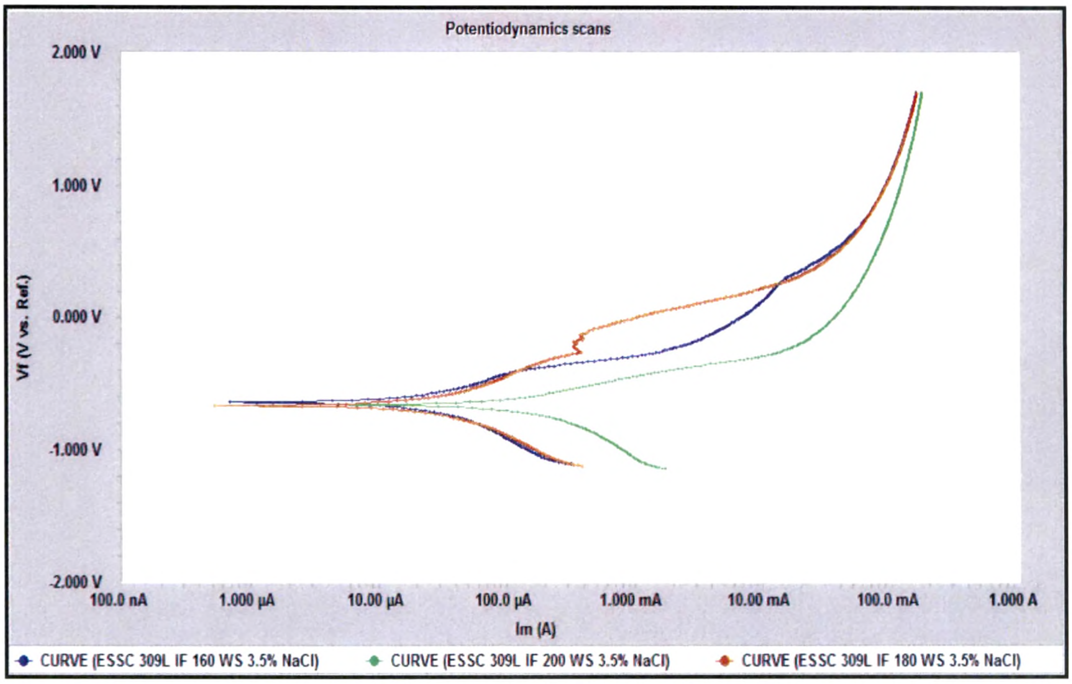



**Fig. 4.75: Potentiodynamic scans of interface of 309L cladded weld overlays at different welding speed in 3.5 % NaCl solution**

**Table No- 4.71: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L cladded weld overlay in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC- 309L IF 160 WS | 122.2 | -639 | 224.9 |
| 2 | ESSC- 309L IF 180 WS | 94.9 | -660 | 174.7 |
| 3 | ESSC- 309L IF 200 WS | 134.07 | -663 | 246.7 |

Fig. 4.75 shows the results of Potentiodynamic studies interface region of 309L cladded weld overlays which were developed at different welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of interface region of 309L cladded weld overlays at different welding speed in 3.5 % NaCl solution, it shows that (i) all weld overlays does not exhibit passive behavior (ii) weld overlay developed at 160 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 180 & 200 mm / min. welding speed.

#### 4.2.5.4.4 Effect of Welding Speed on corrosion behaviour of 309 L Nb cladded weld overlay in 3.5 % NaCl solution

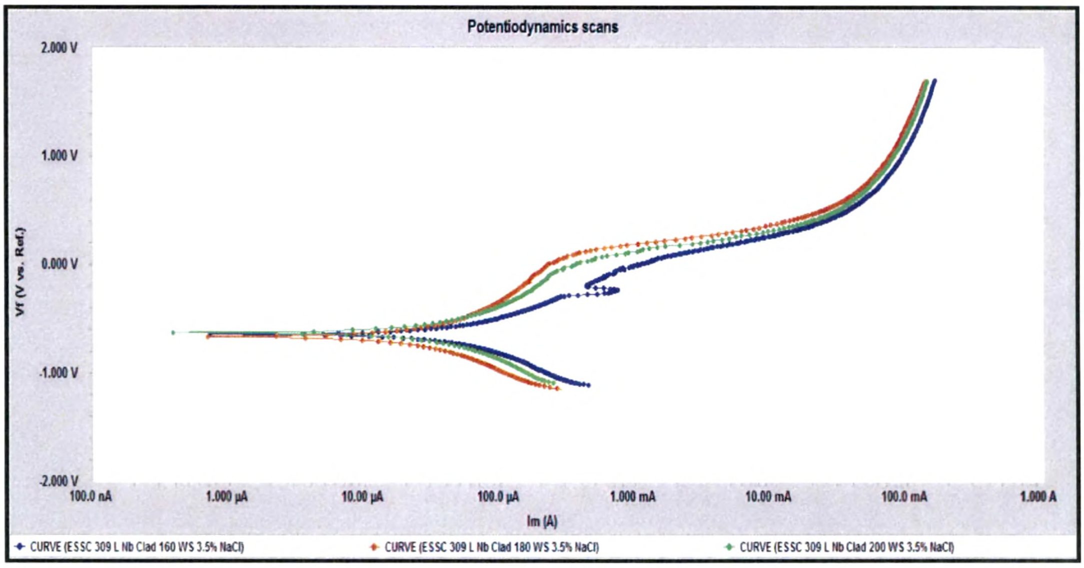



**Fig. 4.76: Potentiodynamic scans of 309L Nb cladded weld overlays at different welding speed in 3.5 % NaCl solution**

**Table No-4.72 : Electrochemical Parameters of Potentiodynamic studies of 309 LNb cladded weld overlays in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb Clad 160 WS | 82.70 | -640 | 152.2 |
| 2 | ESSC-309L Nb Clad 180 WS | 57.40 | -661 | 104.9 |
| 3 | ESSC-309L Nb Clad 200 WS | 105.7 | -623 | 194.6 |

Fig. 4.76 shows the results of Potentiodynamic studies 309L Nb cladded weld overlays which were developed at different welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of 309L Nb cladded weld overlays at different welding speed in 3.5 % NaCl solution, it shows that (i) all weld overlays does not exhibit passive behavior (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compared to weld overlay developed at the 160 & 180 mm / min. welding speed (iii) corrosion rate is decreases with increasing the welding speed from 160 mm/ min to 200 mm/ min [86].

**4.2.5.4.5 Effect of Welding Speed on corrosion behaviour interface of 309 LNb cladded weld overlay in 3.5 % NaCl Solution**

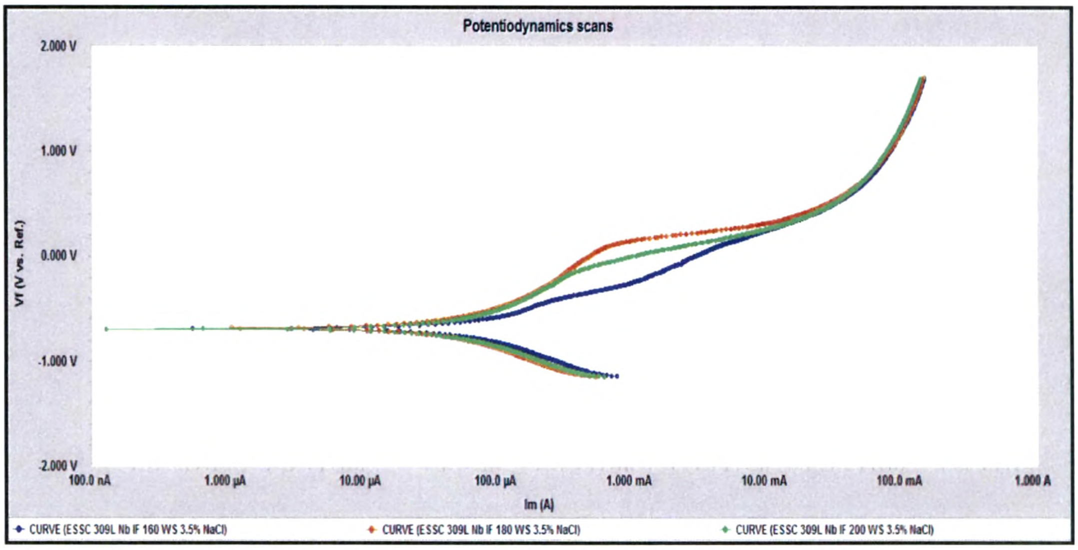



**Fig. 4.77: Potentiodynamic scans of interface of 309L Nb cladded weld overlays at different welding speed in 3.5 % NaCl solution**

**Table No- 4.73: Electrochemical Parameters of Potentio-dynamic studies interface of 309 L Nb cladded weld overlay in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC-309L Nb IF 160 WS | 107.0 | -688 | 195.1 |
| 2 | ESSC-309L Nb IF 180 WS | 86.00 | -681 | 157.3 |
| 3 | ESSC-309L Nb IF 200 WS | 115.0 | -692 | 211.7 |

Fig. 4.77 shows the results of Potentiodynamic studies interface region of 309L Nb cladded weld overlays which were developed at different welding speed in 3.5 % NaCl

solution. By comparing corrosion behavior of interface region of 309L Nb cladded weld overlays at different welding speed in 3.5 % NaCl solution, it shows that (i) all weld overlays does not exhibit passive behavior (ii) weld overlay developed at 200 mm / min. welding speed has best corrosion resistance compare to weld overlay developed at the 160 & 180 mm / min. welding speed (iii) corrosion rate is decreases with increasing the welding speed from 160 mm/ min to 200 mm/ min.

### 4.2.6 Effect of welding speed on pitting Corrosion susceptibility of the weld overlays

#### 4.2.6.1 Effect of Welding Speed on Pitting corrosion behaviour of Base metal of cladded weld overlay in 6% $FeCl_3$ Solution

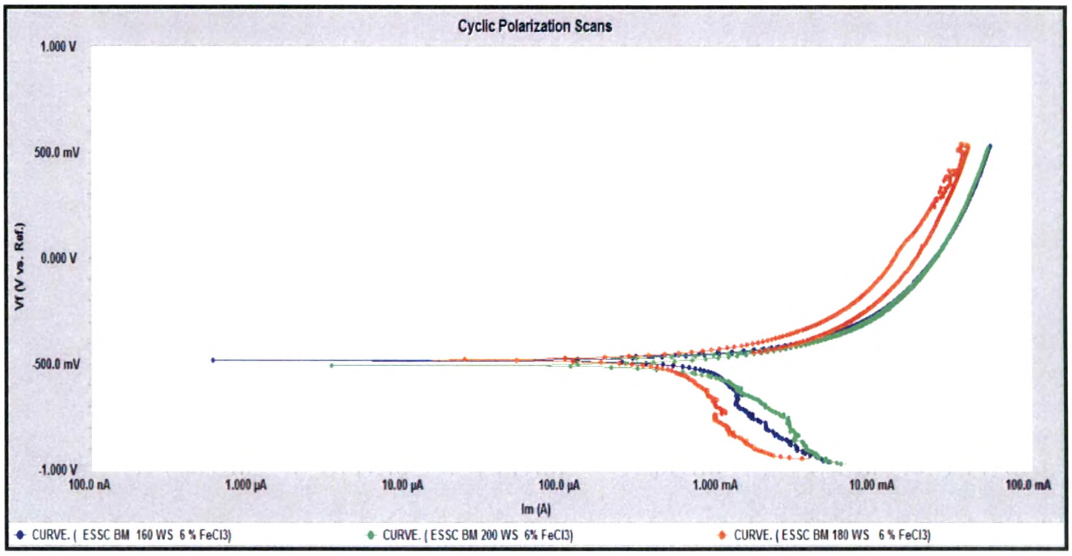



**Fig. 4.78 : Cyclic polarization scans of base metal at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.74: Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | $E_{rp}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-BM 160 WS | 1420 | -481 | -488.0 | 2127 |
| 2 | ESSC-BM 180 WS | 886 | -479 | -529.6 | 1330 |
| 3 | ESSC-BM 200 WS | 1790 | -505 | -502.5 | 2687 |

Fig. 4.78 show the Cyclic polarization scans of base metal at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of base metal, it shows that all

scans exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for 160,180 & 200 mm / minute welding speeds which implies that pitting will occur and damaged passive film will not repaired .The results is increase in pitting corrosion susceptibility[87].

**4.2.6.2 Effect of Welding Speed on Pitting corrosion behaviours of 309 L cladded weld overlays in 6% $FeCl_3$ Solution**

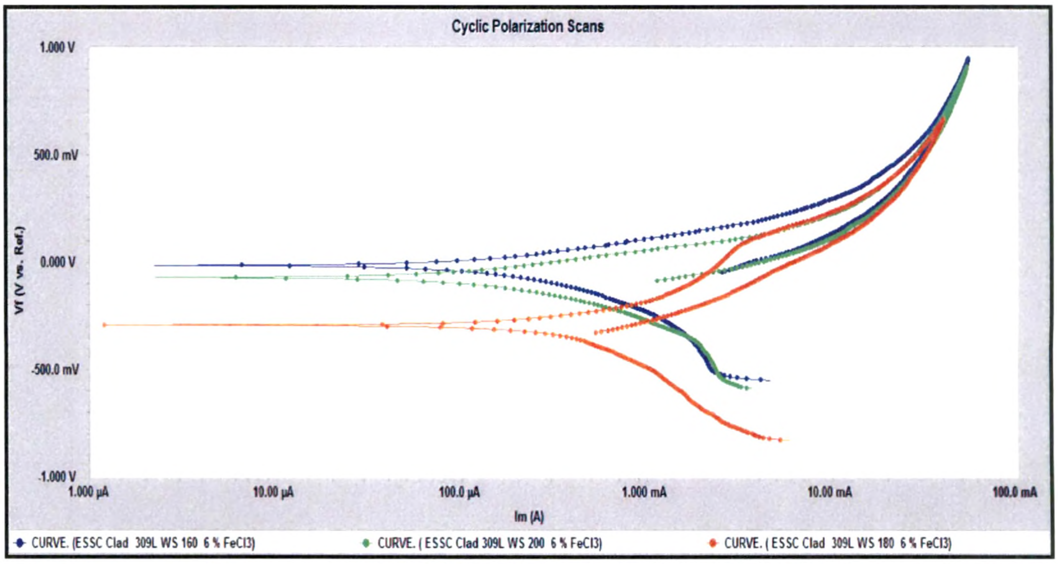



**Fig. 4.79 : cyclic polarization scans of 309L cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.75: Electrochemical Parameters of cyclic polarization Scan of 309L cladded weld overlays in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$\ (µA) | $E_{Corr}$ (mV) | $E_{rp}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC -309L Clad 160 WS | 309.0 | -13.00 | -195.3 | 463.0 |
| 2 | ESSC- 309L Clad 180 WS | 135.0 | -291.00 | -350.4 | 203.2 |
| 3 | ESSC-309L Clad 200 WS | 264.0 | -70.80 | -136.2 | 395.5 |

Fig. 4.79 show the Cyclic polarization scans of 309L cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of cladded region, it shows that all scans exhibit positive hysteresis which indicates that the reverse

scan current density which is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for 160,180 & for 200 mm / minute welding speeds which implies that pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility [87].

#### 4.2.6.3 Effect of Welding Speed on Pitting corrosion behaviours of 309 L Nb cladded weld overlays in 6% $FeCl_3$ Solution

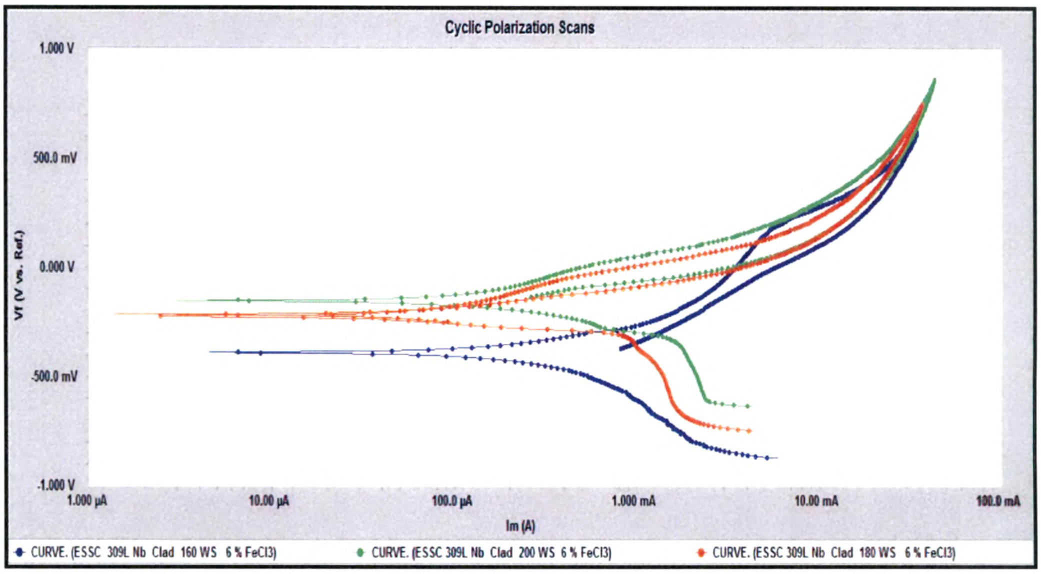



**Fig. 4.80 : cyclic polarization scans of 309LNb Cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.76: Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC -309LNb Clad 160 WS | 184.0 | -388.0 | -478.6 | 275.9 |
| 2 | ESSC- 309L Nb Clad 180 WS | 47.10 | -222.0 | -192.8 | 70.62 |
| 3 | ESSC-309L Nb Clad 200 WS | 103.0 | -153.0 | -167.3 | 155.0 |

Fig. 4.80 show the Cyclic polarization scans of 309L Nb cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of cladded region, it shows that cladded region of 180 mm / min welding speed exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan while cladded region developed with 160 & 200 mm / min welding

speeds exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for 160 & 200 mm / minute welding speeds which implies that pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility while $E_{rp} > E_{corr}$ for 180 mm / minute welding speed which indicate that the pitting will occur but damage passive film will get repaired & protecting further pitting corrosion susceptibility[87].

**4.2.6.4 Effect of Welding Speed on Pitting corrosion behaviours of Interface 309 L cladded weld overlays in 6% $FeCl_3$ Solution**

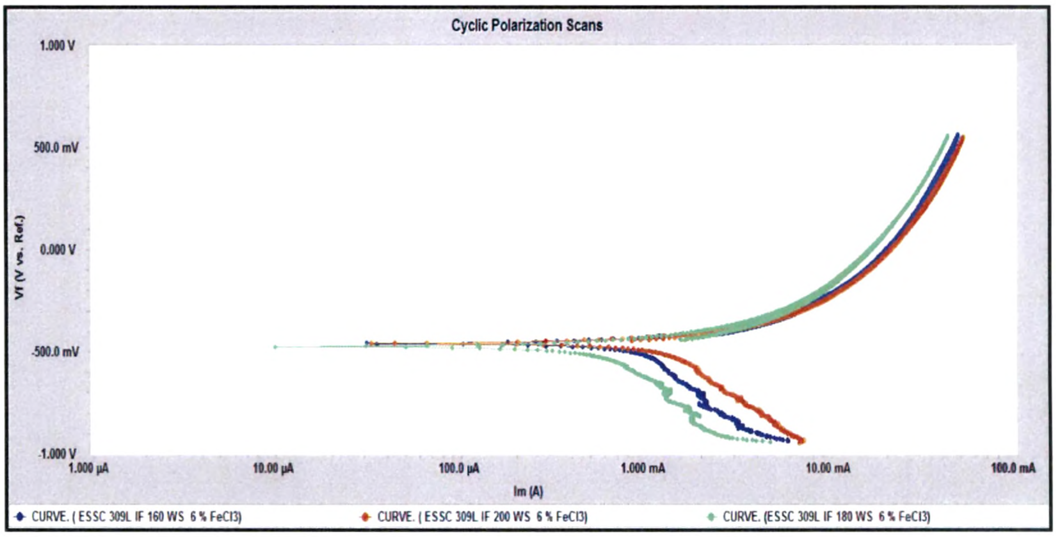



**Fig. 4.81 : cyclic polarization scans of Interface 309L cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.77 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | $E_{rp}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC- 309L IF 160 WS | 489.0 | -434.0 | -470.03 | 893.0 |
| 2 | ESSC- 309L IF 180 WS | 434.0 | -433.0 | -488.68 | 793.1 |
| 3 | ESSC- 309L IF 200 WS | 267.0 | -461.0 | -498.6 | 488.6 |

Fig. 4.81 shows the Cyclic polarization scans interface region of 309L cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of interface region, it shows that cladded region of at all welding speeds

exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for all welding speeds which implies that pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility.

### 4.2.6.5 Effect of Welding Speed on Pitting corrosion behaviours of interface 309 L Nb cladded weld overlays in 6% $FeCl_3$ Solution

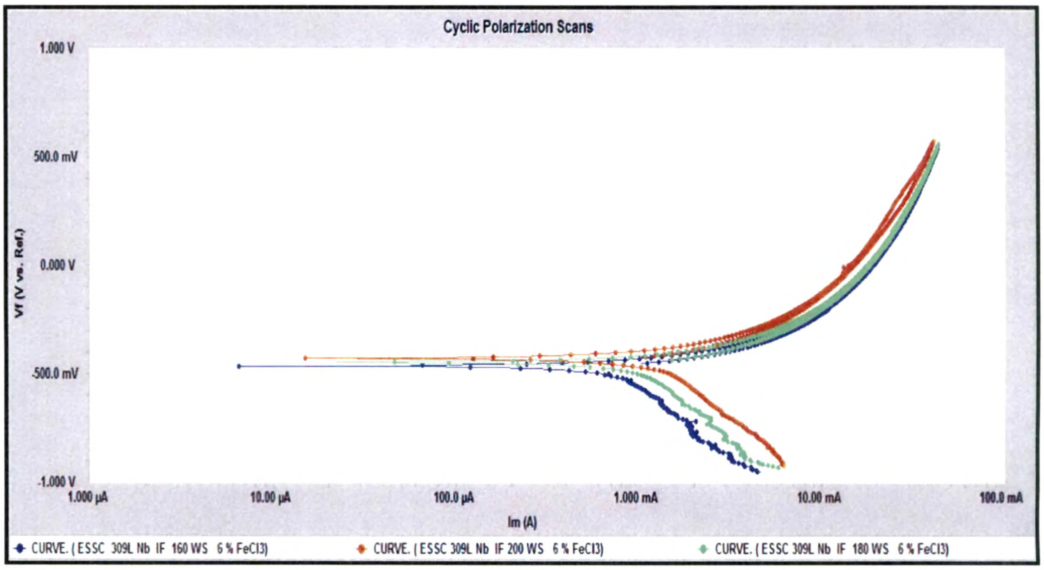



**Fig. 4.82 : cyclic polarization scans of interface 309LNb Cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.78: Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | $E_{rp}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC- 309L Nb IF 160 WS | 352.0 | -465.0 | -480.0 | 352.0 |
| 2 | ESSC- 309L Nb IF 180 WS | 305.0 | -445.0 | -463.3 | 305.0 |
| 3 | ESSC- 309L Nb IF 200 WS | 460.0 | -427.0 | -451.6 | 460.0 |

Fig. 4.82 shows the Cyclic polarization scans interface region of 309L Nb cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of interface region, it shows that cladded region of at all welding speeds

exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{pit} < E_{corr}$ for all welding speeds which implies that pitting will occur and damaged passive film will get not repaired that results in increase in pitting corrosion susceptibility.

## 4.2.7 Effect of welding speed on Degree of sensitization of the weld overlays

### 4.2.7.1 Effect of Welding Speed on corrosion behaviour of cladded region of 309 L Cladded weld overlay in 0.1 H2SO4 + 0.01 M NaCl Solution

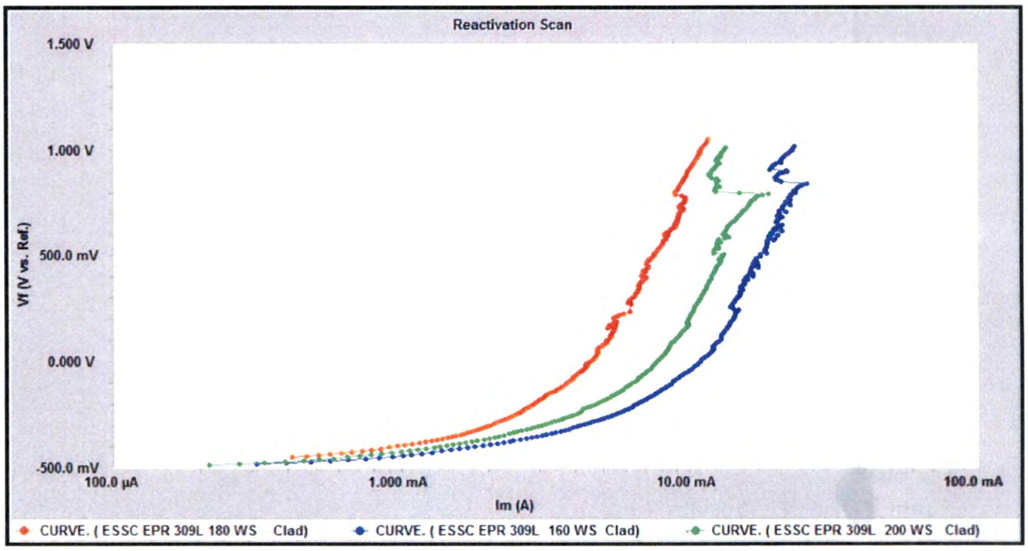



**Fig. 4.83 EPR scans of 309L cladded weld overlays at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.79 : Peak Current density of EPR scans ofcladded region of 309L cladded weld overlays at as welded condition**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 160 WS | $2.72 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Clad 180 WS | $1.16 \times 10^{-2}$ |
| 3 | ESSC-EPR 309L Clad 200 WS | $1.86 \times 10^{-2}$ |

Fig. 4.83 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309L cladded weld overlay which were developed at different welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization get decreased with increasing the welding speed from 160 to 180 mm /min welding speed then after it get increased at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

**4.2.7.2 Effect of Welding Speed on corrosion behaviour of interface region of 309 L Cladded weld overlay in 0.1 H2SO4 + 0.01 M NaCl Solution**

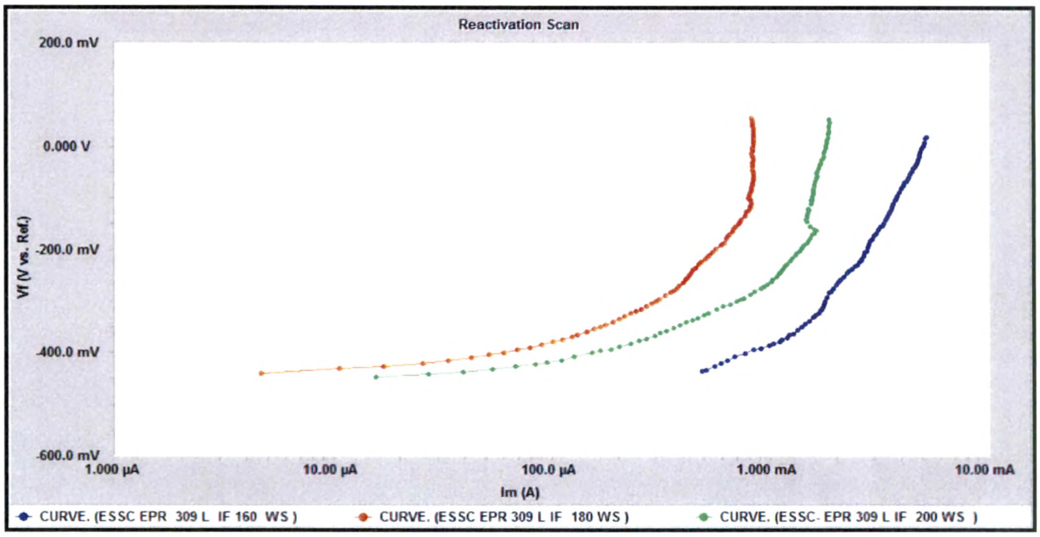



**Fig. 4.84 EPR scans of interface of 309L cladded weld overlays at different welding speed in 0.1 $H_2SO_4$+ 0.01 M NaCl Solution**

**Table-4.80: Peak Current density of EPR scans of interfce region of 309L cladded weld overlays at as welded condition**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 160 WS | $3.86 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L IF 180 WS | $2.71 \times 10^{-2}$ |
| 3 | ESSC-EPR 309L IF 200 WS | $9.16 \times 10^{-2}$ |

Fig. 4.84 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface of 309L cladded weld overlay which were developed at different welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decrease with increasing the welding speed from 160 to 180 mm /min welding speed then after it gets increased at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

**4.2.7.3 Effect of Welding Speed on corrosion behaviour of cladded region of 309 L Nb Cladded weld overlay in 0.1 H2SO4 + 0.01 M NaCl Solution**

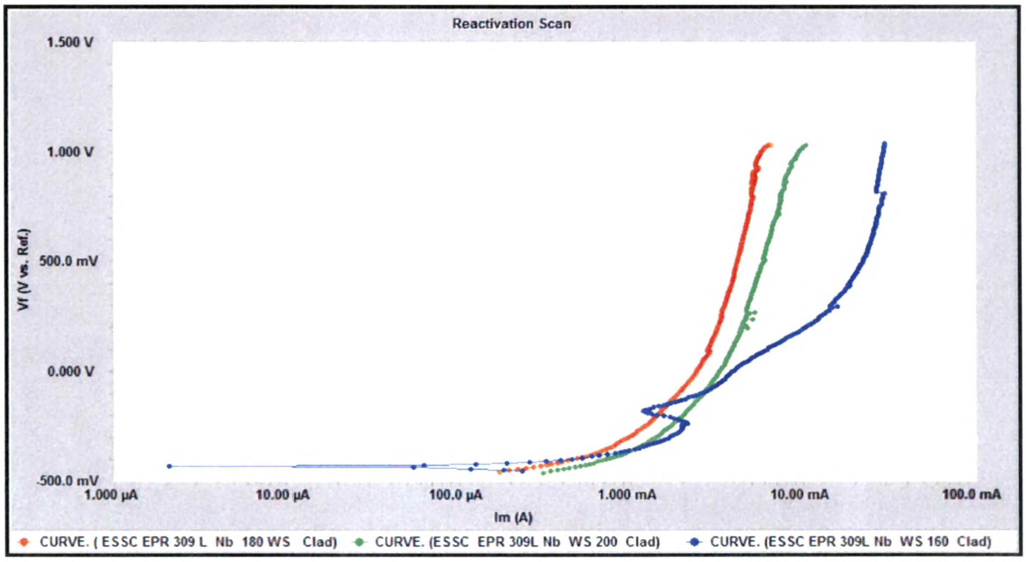



**Fig. 4.85 EPR scans of 309LNb cladded weld overlays at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.81 : Peak Current density of EPR scans ofcladded region of 309L Nb cladded weld overlays at as welded condition**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Nb Clad 160 WS | $1.52 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 180 WS | $1.04 \times 10^{-2}$ |
| 3 | ESSC-EPR 309L Nb Clad 200 WS | $1.22 \times 10^{-2}$ |

Fig. 4.85 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309L Nb cladded weld overlay which were developed at different welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decreased with increasing the welding speed from 160 to 180 mm /min welding speed then after it get increased at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

**4.2.7.4 Effect of Welding Speed on corrosion behaviour of interface region of 309 L Nb Cladded weld overlay in 0.1 H2SO4 + 0.01 M NaCl Solution**

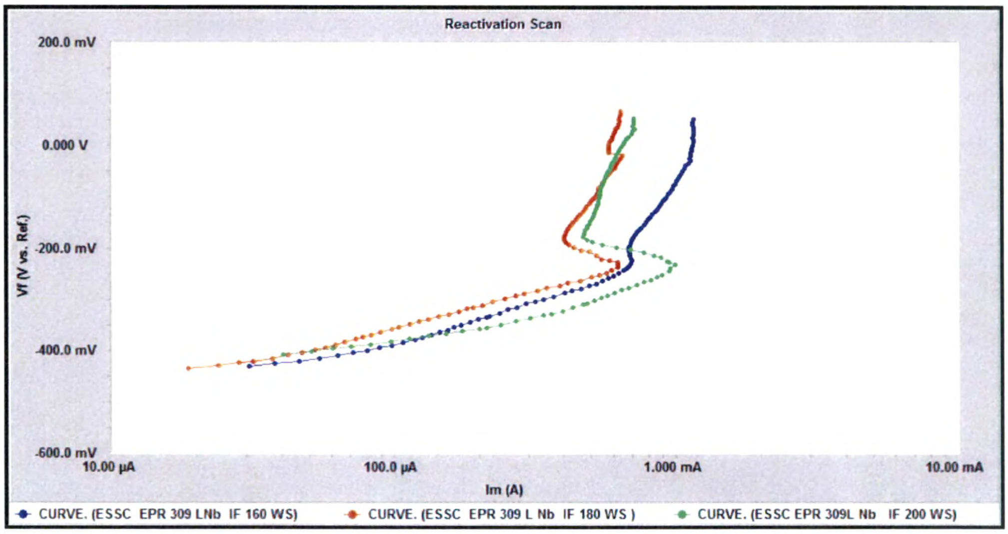



**Fig. 4.86 EPR scans of interface of 309LNb cladded weld overlays at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.82 : Peak Current density of EPR scans of interfce region of 309L Nb cladded weld overlays at as welded condition**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Nb IF 160 WS | 3.91 x $10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 180 WS | 1.81 x $10^{-2}$ |
| 3 | ESSC-EPR 309L Nb IF 200 WS | 6.55 x $10^{-2}$ |

Fig. 4.86 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface of 309LNb cladded weld overlay which were developed at different welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decreased with increasing the welding speed from 160 to 180 mm /min welding speed then after it get increased at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

# 4.3 Result of Niobium Addition on Micro-structural changes, ferrite content, Micro-hardness and Corrosion behaviour of Weld Overlays

## 4.3.1 Effect of Niobium addition on Microstructure changes of the weld overlays

### 4.3.1.1 Effect of Niobium addition on Microstructure changes at cladded region:

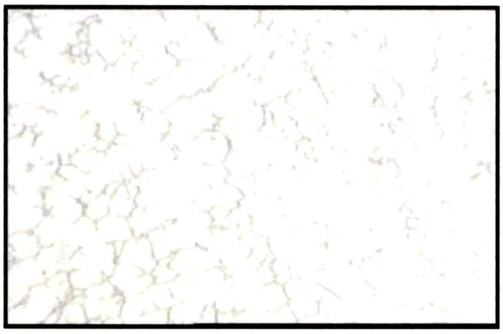


**Fig. 4.87 (a) Cladded region of 309 L Clad 160 WS**

**Fig. 4.87 (b) Cladded region of 309 L Nb Clad 160 WS**

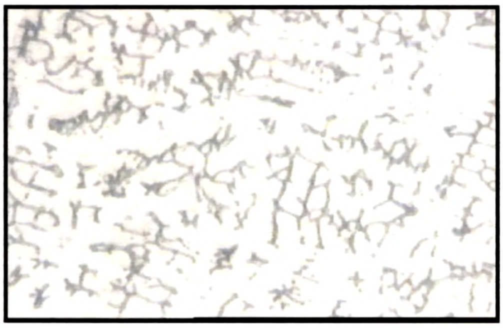


**Fig. 4.88 (a) Cladded region of 309 L Clad 180 WS**

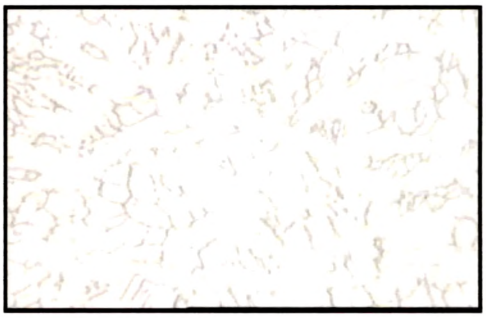


**Fig. 4.88 (b) Cladded region of 309 L Nb Clad 180 WS**

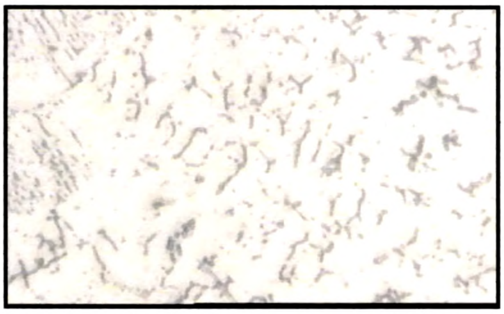


**Fig. 4.89 (a) Cladded region of 309 L Clad 200 WS**

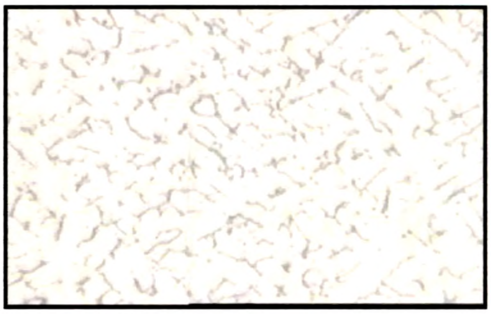


**Fig. 4.89 (b) Cladded region of 309 L Nb Clad 200 WS**

The microstructure of the cladded region of weld overlay developed with 309L & 309L Nb at different welding speed is shown in Fig. 4.87(a) to 4.89 (a) & Fig. 4.87 (b) to 4.89 (b) respectively in as welded condition. The Aquaregia etchant used reveals predominantly the ferrite distribution in the austenite matrix. In bulk cladding, the modes of solidification were primary ferritic in both 309 L & 309 Nb types weld overlays at all welding speeds. It shows at the end of primary ferrite solidification, a peritectic-eutectic reaction results in the formation of austenite along the ferrite cell & dendrite boundaries which is also known as skeletal or vermicular ferrite [88]. There were no any micro-structural changes observed but in case of 309 L Nb cladded weld overlay ,little bit higher amount of ferrite as compared to 309L cladded weld overlay as Nb is strong ferrite forming elements.

**4.3.1.2 Effect of Alloying Elements on Microstructure changes at interface region:**

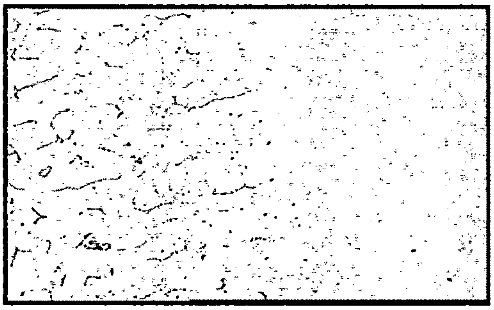


**Fig.4.90 (a) Interface region of 309 L Clad 160 WS**

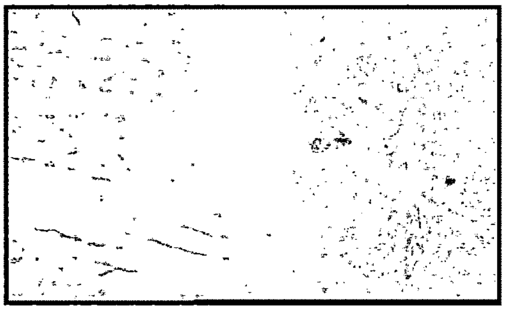


**Fig. 4.90 (b) Interface region of 309 L Nb Clad 160 WS**

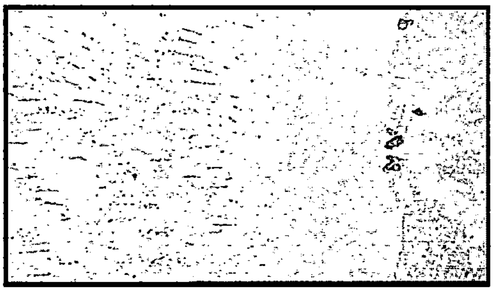


**Fig. 4.91 (a) Interface region of 309 L Clad 180 WS**

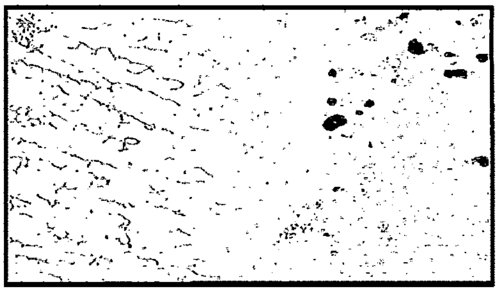


**Fig.4..91(b) Interface region of 309 L Nb Clad 180 WS**

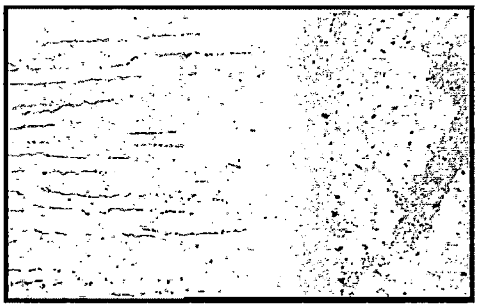


**Fig.4.92(a) Interface region of 309 L Clad 200 WS**

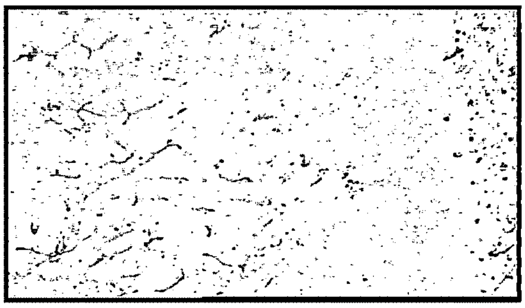


**Fig.4.92(b) Interface region of 309 L Nb Clad 200 WS**

The microstructure of the interface region of weld overlay developed with 309L & 309L Nb at different welding speed is shown in Fig. 4.90(a) to 4.92 (a) & Fig. 4.90 (b) to 4.92 (b) respectively in as welded condition. At interface region there were significant composition gradients produced due to a combination of dilution and other factors which have a profound effect on the micro-structural development. The dilution level in the bulk weld metal under ESSC conditions is known to be not more than about 8 to 10% ,but at interface the degree of dilution will be much higher which result in the formation of a stagnant fluid layer in the weld pool adjacent to the base metal. The transition from the low alloy content (Cr, Mo) in the base metal to the high alloy content (Cr, Ni, Nb) in the bulk weld metal occurs in this transition zone. The layer originally had the same composition as the base metal, but develops higher chromium and nickel contents as a result of diffusion from the cladding due to the concentration gradients [89]. The stagnation layer has also been called the unmixed zone. It may be seen from Table - 4.39 that Cr contents over 9.06 % and Ni contents around 9.35 % could develop in the transition zone during cladding The composition in the layer is such that during cooling following overlaying this region transforms to martensite. There were no any micro-structural changes observed but in case of 309 L Nb cladded weld overlay ,little bit higher amount of ferrite as compared to 309L cladded weld overlay as Nb is strong ferrite forming elements.

### 4.3.2 Effect of Noibium additions on Ferrite Content of weld overlay

**Table- 4.83 : Effect of Nb addition on the amount of ferrite content**

| Welding speed (mm/min.) | Amount of ferrite Content | |
|---|---|---|
| | 309 L Cladded surface | 309 LNb cladded surface |
| 160 | 5.4 | 5.5 |
| 180 | 3.7 | 4.6 |
| 200 | 3.3 | 4.3 |

Table-4.83 shows the effect of Nb addition on the amount of ferrite content in clad region of 309 L & 309L Nb cladded weld overlays. It reveals that 309L Nb cladded weld overlay exhibit higher amount of ferrite than309 L cladded weld overlay at all welding speed because Nb is strong ferrite former element.

### 4.3.3 Effect of Alloying Elements on Hardness Value weld overlays

**Table- 4.84 : Effect of Nb addition on the Micro hardness value**

| Welding speed (mm/min.) | Micro hardness (VPN) | |
|---|---|---|
| | 309 L Cladded surface | 309 LNb cladded surface |
| 160 | 242 | 222 |
| 180 | 260 | 235 |
| 200 | 271 | 254 |

Table-4.84 shows the effect of Nb addition on the hardness value in clad region of 309 L & 309L Nb cladded weld overlays. It reveals that 309L Nb cladded weld overlay exhibit lower value of hardness than309 L cladded weld overlay at all welding speed because Nb is strong ferrite former element which lead to increase in the amount of ferrite content.

## 4.3.4 Effect of Niobium addition on Corrosion Behaviour of weld Overlays

### 4.3.4.1 Effect of Niobium addition on General Corrosion susceptibility:

#### 4.3.4.1.1 Effect of Niobium addition ccorrosion behaviour of f 309 L and 309 L Nb cladded weld overlays in 0.1 N $HHO_3$ Solution

##### 4.3.4.1.1.1 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$ Solution

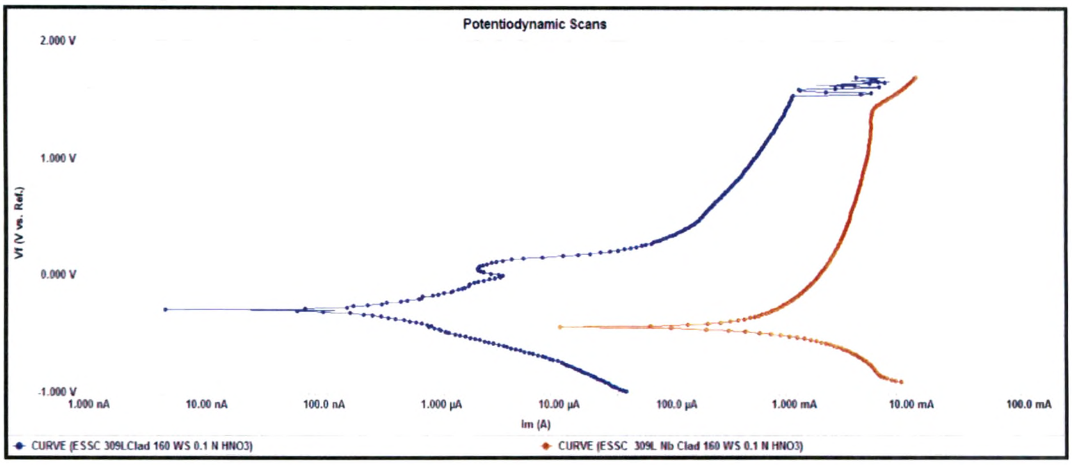



**Fig.4.93 Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table-4.85 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 160 WS | 74.2 | -374.0 | 135.5 |
| 2 | Clad 309L Nb 160 WS | 80.60 | -424.0 | 147.3 |

Fig. 4.93 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behaviour of both weld overlays at cladded region, it

shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L cladded weld overlay passivited much earlier than 309 L Nb cladded weld overlay due to which it has good corrosion resistance as compared to 309 L Nb cladded weld overlay

**4.3.4.1.1.2 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N $HHO_3$ Solution**

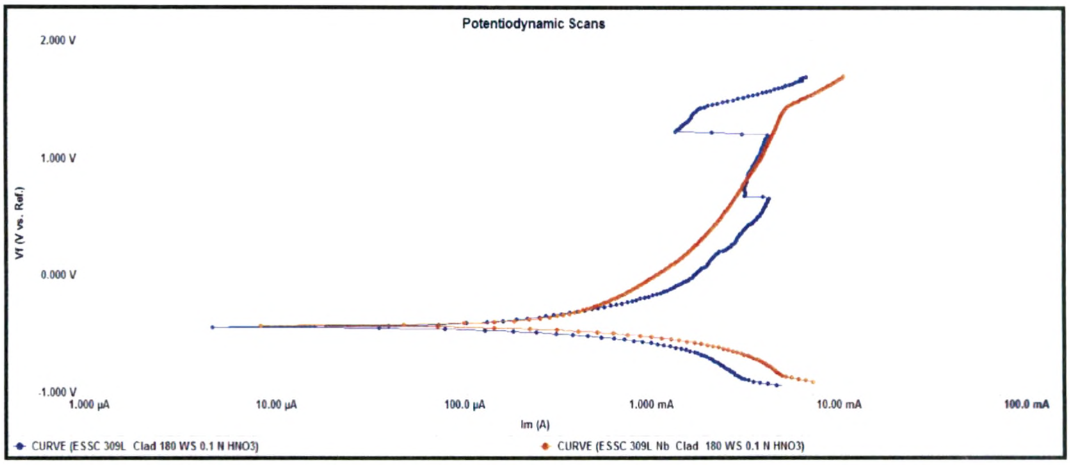



**Fig. 4.94 Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table- 4.86 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 180 WS | 48.5 | -440 .0 | 18.24 |
| 2 | Clad 309L Nb 180 WS | 52.90 | -354.0 | 96.62 |

Fig. 4.94 shows the results of potentiodynamic scans of cladded region of 309 L & 309L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all sample exhibit active potentials in given environment,(ii) 309 L cladded weld overlay exhibit passivation behaviour due to which it has good

corrosion resistance as compared to 309 L Nb cladded weld overlay (iii) 309 L Nb cladded weld overlay does not exhibit any passivation behaviour due to which it has lower corrosion resistance as compared to 309 L cladded weld overlay.

**4.3.4.1.1.3 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 0.1 N $HHO_3$ Solution**

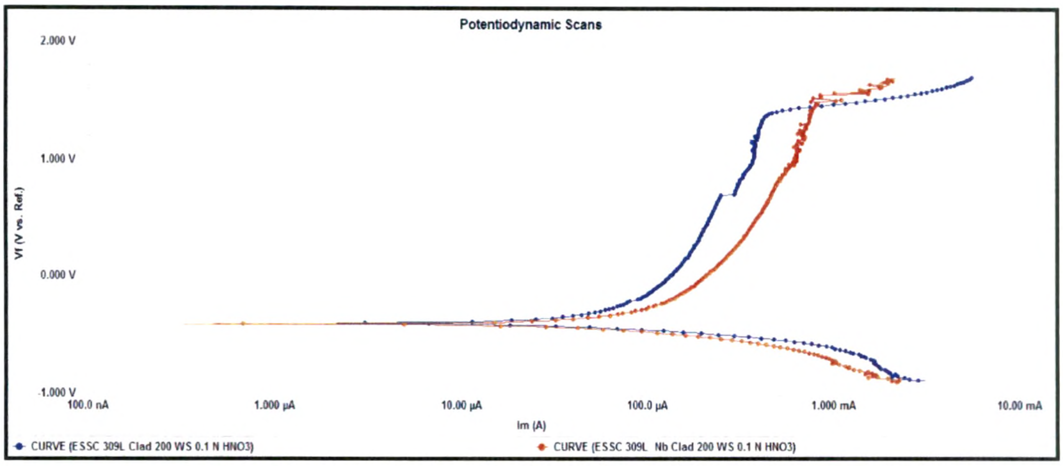



**Fig. 4.95 Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table-4.87 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 200 WS | 35.7 | -402.0 | 13.41 |
| 2 | Clad 309L Nb 200 WS | 49.70 | -359.0 | 90.80 |

Fig. 4.95 shows the results of potentiodynamic scans of cladded region of 309 L & 309L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all sample exhibit active potentials in given environment,(ii) 309 L cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compare to 309 L Nb cladded weld overlay (iii) 309 L Nb cladded weld

overlay does not exhibit any passivation behaviour due to which it has lower corrosion resistance as compare to 309 L cladded weld overlay.

**4.3.4.1.1.4 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 0.1 N $HHO_3$ Solution**

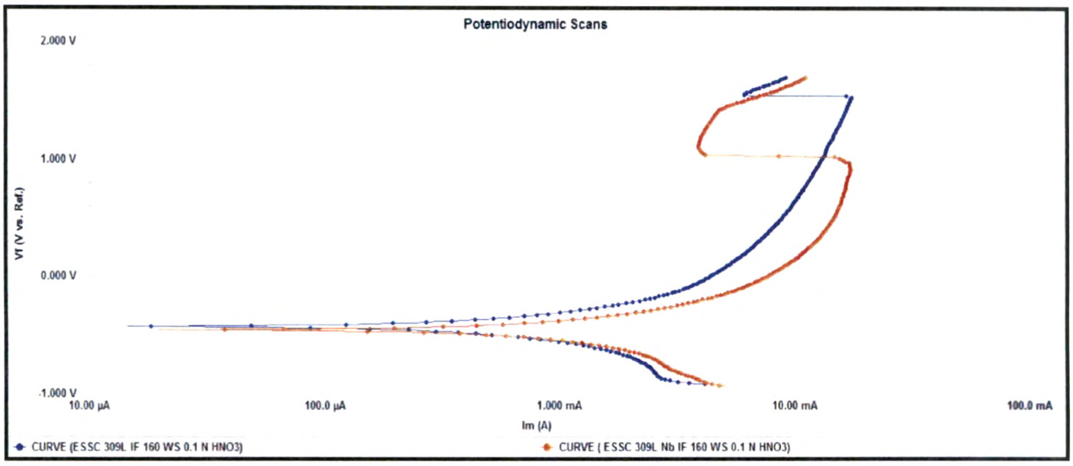



**Fig. 4.96 Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table-4.88 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 160 WS | 106.0 | -428 | 181.7 |
| 2 | ESSC Clad 309L Nb - IF 160 WS | 562.0 | -458 | 211.6 |

Fig. 4.96 shows the results of potentiodynamic scans of interface region of 309 L and 309l Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all sample exhibit active potentials in given environment,(ii) interface region of 309 L cladded weld overlay has good corrosion resistance as compared to interface region 309 L Nb cladded weld overlay .

#### 4.3.4.1.1.5 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N $HHO_3$ Solution

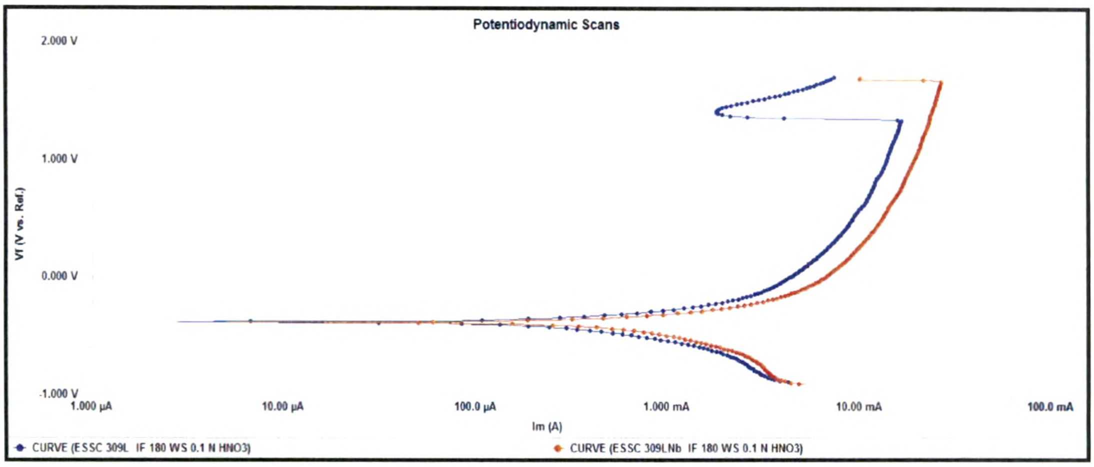



**Fig. 4.97 Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table-3.89 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 180 WS | 61.0 | -383 | 45.31 |
| 2 | ESSC Clad 309L Nb - IF 180 WS | 124.0 | -386 | 163.6 |

Fig. 4.97 shows the results of potentiodynamic scans of interface region of 309 L and 309L Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to interface region 309 L Nb cladded weld overlay .

### 4.3.4.1.1.6 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 0.1 N $HHO_3$ Solution

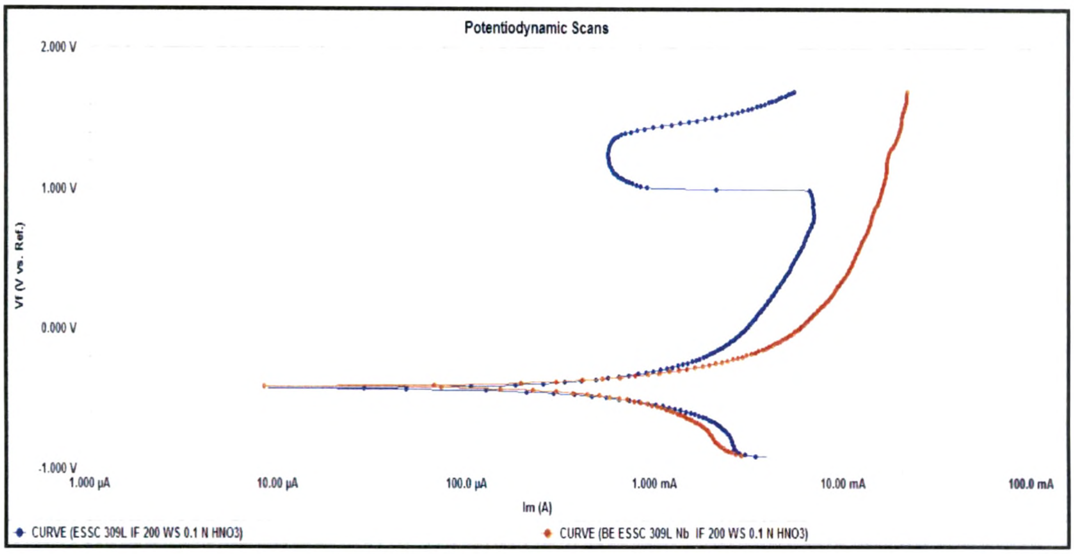



**Fig. 4.98 Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $HHO_3$Solution**

**Table-4.90 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $HHO_3$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 200 WS | **70.6** | **-423** | **128.1** |
| 2 | ESSC Clad 309L Nb - IF 200 WS | **90.3** | **-406** | **166.7** |

Fig. 4.98 shows the results of potentiodynamic scans of interface region of 309 L and 309L Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 N $HHO_3$ solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L cladded weld overlay exhibit passivation behaviour due to

which it has good corrosion resistance as compared to interface region 309 L Nb cladded weld overlay .

**Table- 4.91 : Effect of Nb addition on corrosion resistance of weld overlay at clad as well as at interface clad as well as at interface in 0.1 N $HNO_3$ solution**

| Sr. No | Samples | Corrosion Rate (mpy) | |
|---|---|---|---|
| | | 309 L cladded region | 309 L Nb cladded region |
| 1 | ESSC Clad 160 WS | 135.5 | 147.3 |
| 2 | ESSC Clad 180 WS | 18.24 | 96.62 |
| 3 | ESSC Clad 200 WS | 13.41 | 90.80 |
| 4 | ESSC IF 160 WS | 181.7 | 211.6 |
| 5 | ESSC IF 180 WS | 45.31 | 163.6 |
| 6 | ESSC IF 200 WS | 128.1 | 166.7 |

By comparing corrosion behavior of both weld overlays developed at different welding speed at clad as well as interface region in 0.1 N $HNO_3$ solution , it shows that 309 L cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to 309 L Nb cladded weld overlay in 0.1 N $HNO_3$ solution.

#### 4.3.4.1.2 Effect of Niobium addition corrosion behaviour of 309 L and 309 L Nb cladded weld overlay in 0.1 N $H_2SO_4$ Solution

##### 4.3.4.1.2.1 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 0.1 N $H_2SO_4$ Solution

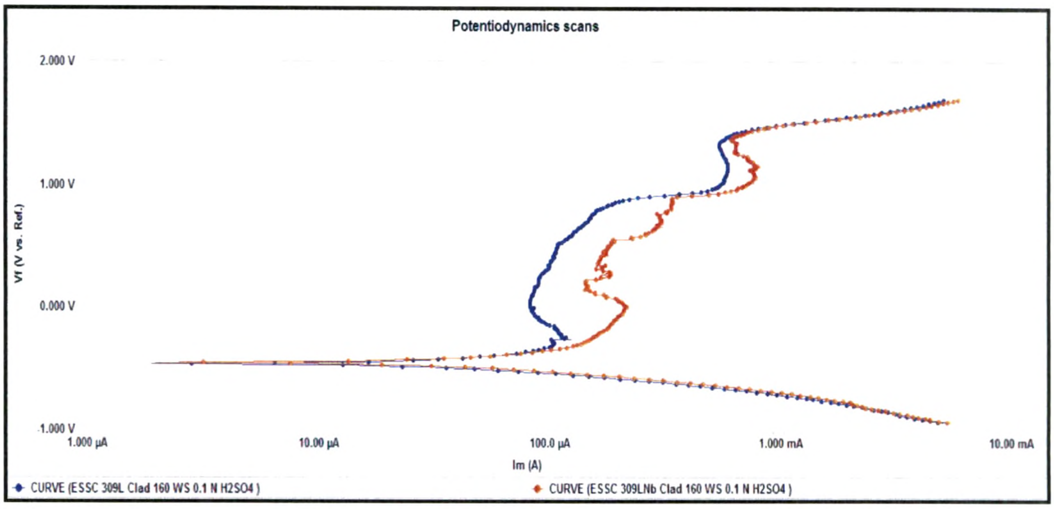



**Fig. 4.99 Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table-4.92 Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 160 WS | 85.80 | -462 | 156.8 |
| 2 | Clad 309L Nb 160 WS | 64.60 | -452 | 118.2 |

Fig. 4.99 shows the results of potentiodynamic scans of cladded region of 309 L and 309L Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb cladded weld overlay passivited much earlier than 309 L cladded weld

overlay and also form secondary passivation firm at latter part of anodic scan due to which it has good corrosion resistance as compared to 309 L cladded weld overlay.

#### 4.3.4.1.2.2 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N $H_2SO_4$ Solution

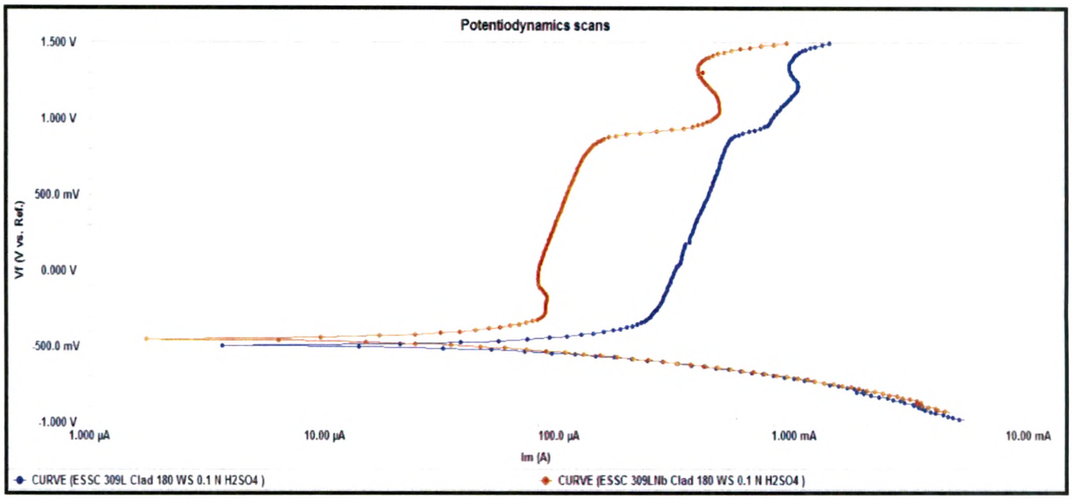



**Fig. 4.100 Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table-4.93 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 180 WS | 56.10 | -493 | 102.5 |
| 2 | Clad 309L Nb 180 WS | 53.40 | -451 | 97.64 |

Fig. 4.100 shows the results of potentiodynamic scans of cladded region of 309 L & 309LNb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb cladded weld overlay passivited much earlier than 309 L cladded weld overlay

and also form secondary passivation firm at latter part of anodic scan due to which it has good corrosion resistance as compare to 309 L cladded weld overlay.

**4.3.4.1.2.3 Comparison of corrosion behaviour of cladded region of 309 L and 309L Nb cladded weld overlay develop with 200 mm / min. Welding speed 0.1 N $H_2SO_4$ Solution**

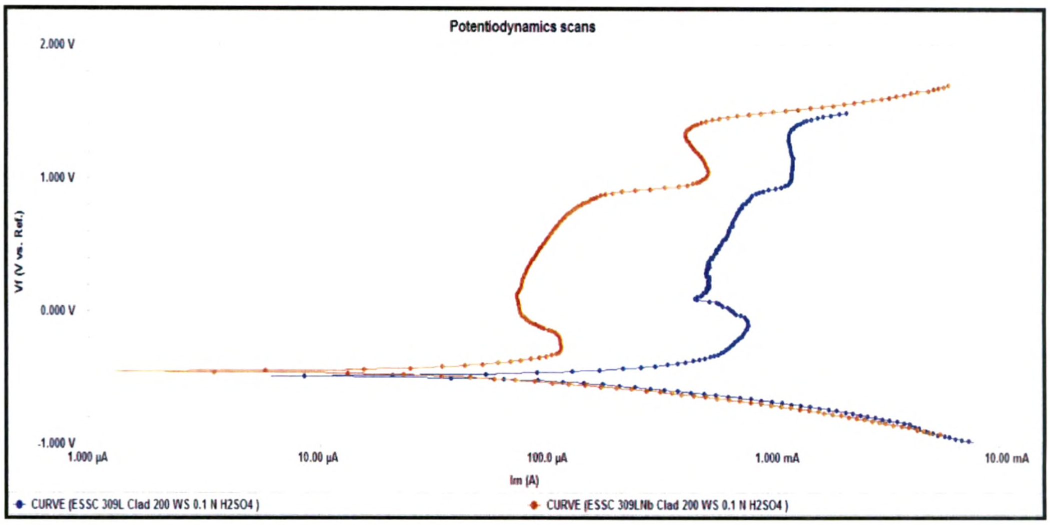



**Fig. 4.101 : Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table-4.94 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 200 WS | **97.30** | **-489** | **177.9** |
| 2 | Clad 309L Nb 200 WS | **72.60** | **-454** | **132.6** |

Fig. 4.101 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) both weld

overlay exhibit double passivation behaviour,(iii) anodic scan at cladded region of 309 L Nb cladded weld overlay was more smoother than 309 L cladded weld overlay which indicate that the film form at this region was more uniform in nature due to which it has good corrosion resistance as compared to cladded region of 309 L cladded weld overlay.

**4.3.4.1.2.4 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 0.1 N $H_2SO_4$ Solution**

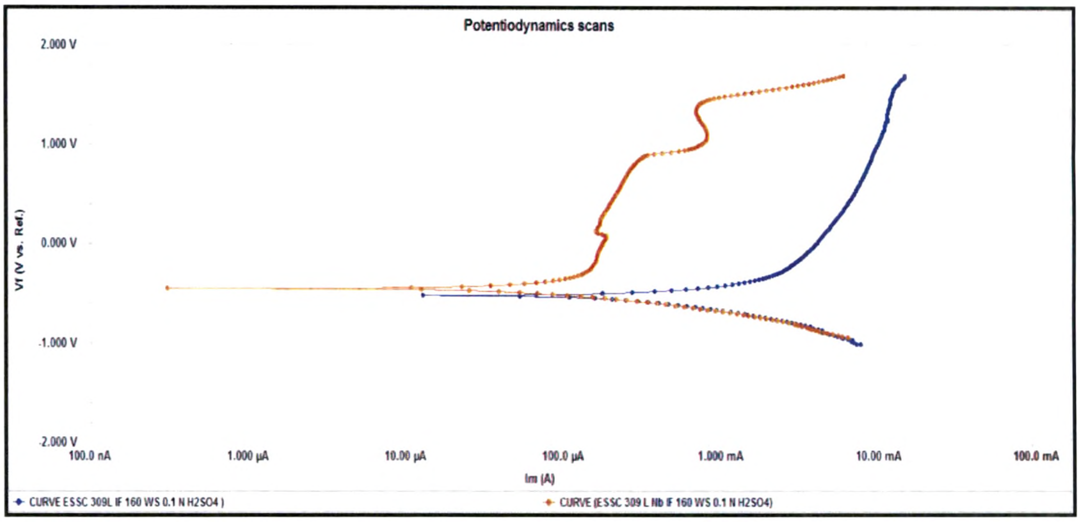



**Fig. 4.102 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table-4.95 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 160 WS | 240.0 | -522.0 | 439.6 |
| 2 | ESSC Clad 309L Nb - IF 160 WS | 66.40 | -452.0 | 122.8 |

Fig. 4.102 shows the results of potentiodynamic scans of interface region of 309 L and 309L Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at interface

region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to interface region 309 L cladded weld overlay .

**4.3.4.1.2.5 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N $H_2SO_4$ Solution**

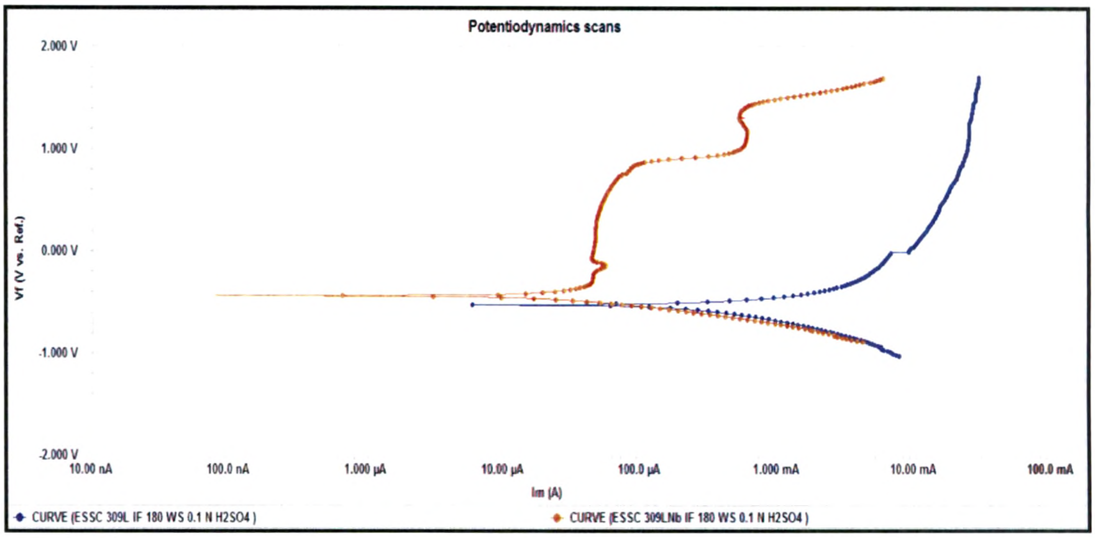



**Fig. 4.103 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table- 4.96 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 180 WS | 174.0 | -529.0 | 318.9 |
| 2 | ESSC Clad 309L Nb - IF 180 WS | 84.0 | -531.0 | 153.8 |

Fig. 4.103 shows the results of potentiodynamic scans of interface region of 309 L and 309L Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to interface region 309 L cladded weld overlay .

**4.3.4.1.2.6 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 0.1 N $H_2SO_4$ Solution**

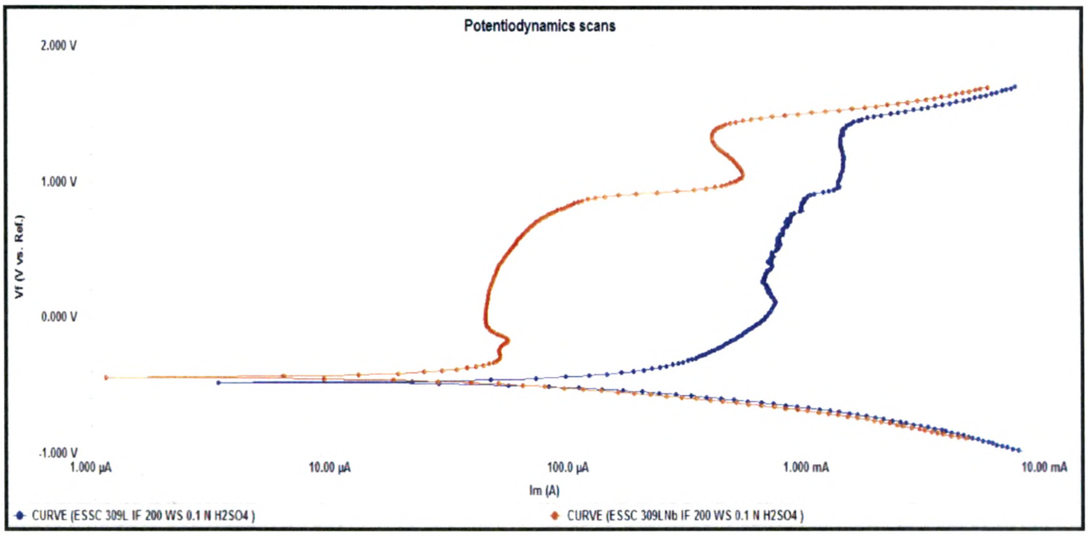



**Fig. 4.104 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $H_2SO_4$ solution**

**Table-4.97 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N $H_2SO_4$ Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 200 WS | 184.0 | -478.0 | 335.7 |
| 2 | ESSC Clad 309L Nb - IF 200 WS | 75.20 | -440.0 | 137.4 |

Fig. 4.104 shows the results of potentiodynamic scans of interface region of 309 L & 309l Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N $H_2SO_4$ solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to interface region 309 L cladded weld overlay .

**Table- 4.98 : Effect of Nb addition on corrosion resistance of weld overlay at clad as well as at interface clad as well as at interface in 0.1 N $H_2SO_4$ solution**

| Sr. No | Samples | Corrosion Rate (mpy) | |
|---|---|---|---|
| | | 309 L cladded region | 309 L Nb cladded region |
| 1 | ESSC Clad 160 WS | 156.8 | 118.2 |
| 2 | ESSC Clad 180 WS | 102.5 | 97.64 |
| 3 | ESSC Clad 200 WS | 177.9 | 132.6 |
| 4 | ESSC IF 160 WS | 439.6 | 122.8 |
| 5 | ESSC IF 180 WS | 318.9 | 153.8 |
| 6 | ESSC IF 200 WS | 355.7 | 137.4 |

By comparing corrosion behavior of both weld overlays developed at different welding speed at clad as well as at interface region in 0.1 N $H_2SO_4$ solution , it shows that passivation film of 309 L Nb cladded weld overlay was more uniform as compared to 309 L cladded weld overlay due to which it has good corrosion resistance than 309 L cladded weld overlay in 0.1 N $H_2SO_4$ solution.

**4.3.4.1.3 Effect of Niobium addition ccorrosion behaviour of 309 L and 309 L Nb cladded weld overlay in 0.1 N HCl Solution**

**4.3.4.1.3.1 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 0.1 N HCl Solution**

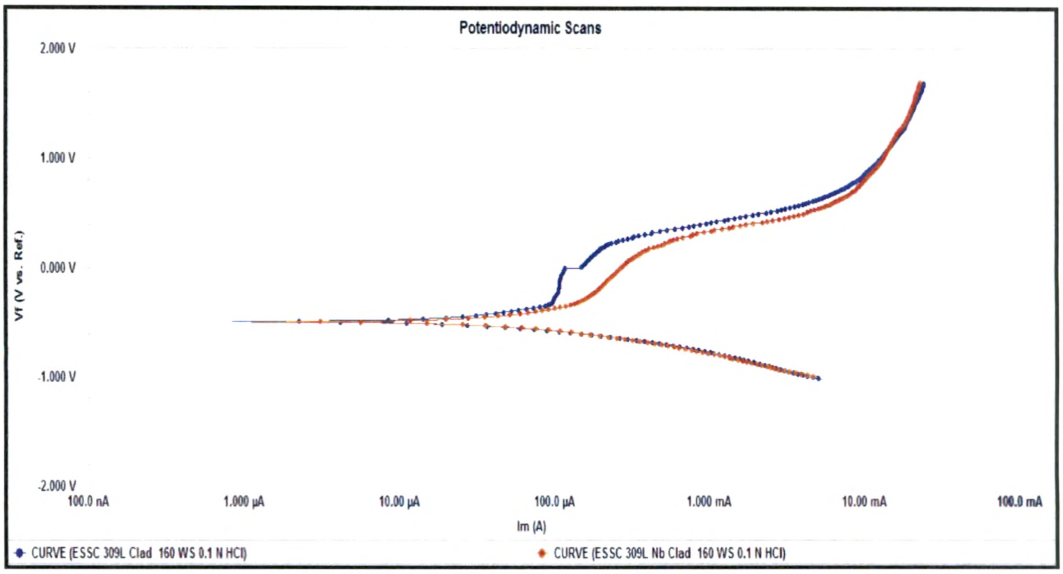



**Fig.4.105 : Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.99 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 160 WS | 26.7 | -486 | 10.03 |
| 2 | Clad 309L Nb 160 WS | 39.6 | -493 | 14.9 |

Fig. 4.105 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L &

309 L Nb cladded weld overlay exhibit similar kind of corrosion behaviour (iii) 309 L cladded weld overlay has slightly better passive firm as compare to 309 L Nb cladded weld overlay due to which it has good corrosion resistance than 309 L Nb cladded weld overlay.

#### 4.3.4.1.3.2 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N HCl Solution

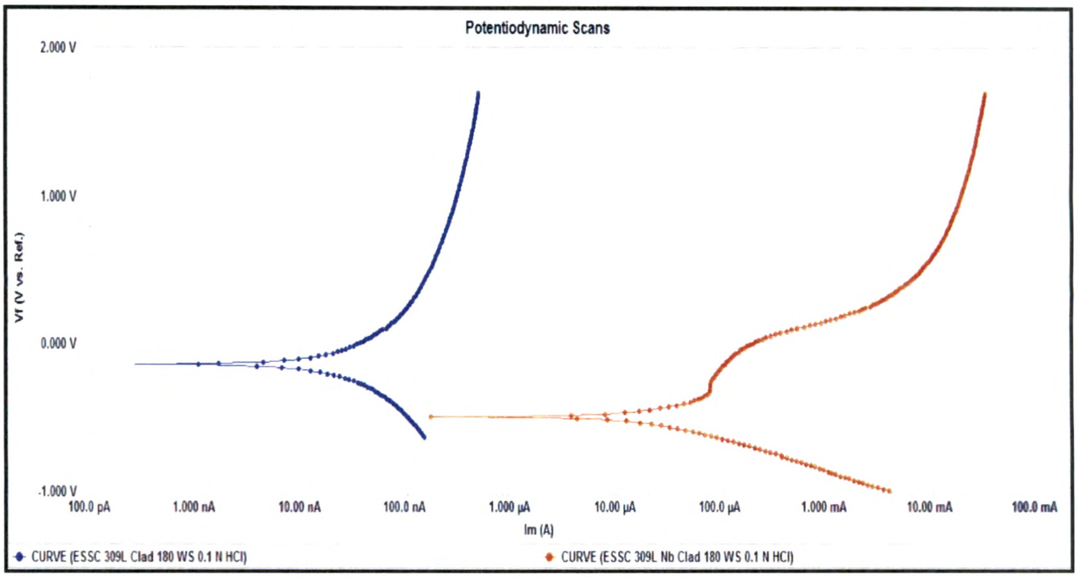



**Fig. 4.106 : Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.100 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 180 WS | 0.075 | -137 | 0.0282 |
| 2 | Clad 309L Nb 180 WS | 7.53 | -494 | 2.829 |

Fig. 4.106 shows the results of potentiodynamic scans of cladded region of 309 L & 309L Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at cladded

region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L cladded weld overlay has good corrosion resistance as compared to 309 L Nb cladded weld overlay.

**4.3.4.1.3.3 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 0.1 N HCl Solution**

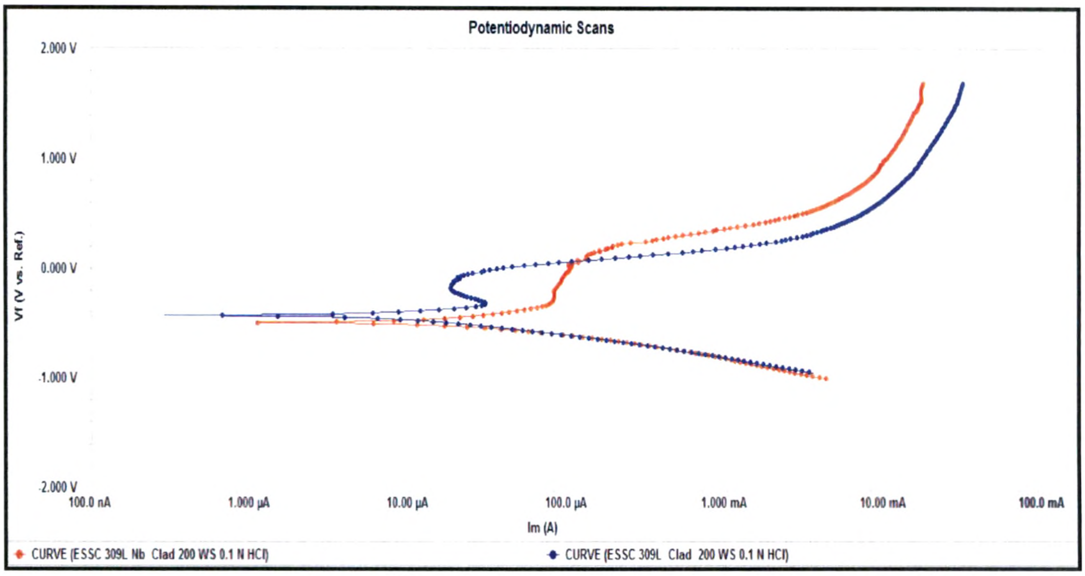



**Fig. 4.107 : Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.101 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 200 WS | 7.56 | -427 | 2.843 |
| 2 | Clad 309L Nb 200 WS | 20.9 | -491 | 7.872 |

Fig. 4.107 shows the results of potentiodynamic scans of cladded region of 309 L & 309L Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at cladded region, it

shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb cladded weld overlay exhibit good passivation film formation due to which it has good corrosion resistance as compared to 309 L cladded weld overlay (iii) 309 L cladded weld overlay also exhibit passivation behaviour due to which it also has good corrosion resistance but higher than that of 309 L Nb cladded weld overlay.

#### 4.3.4.1.3.4 Comparison of Corrosion behaviour of Interface region of 309 L and 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 0.1 N HCl Solution

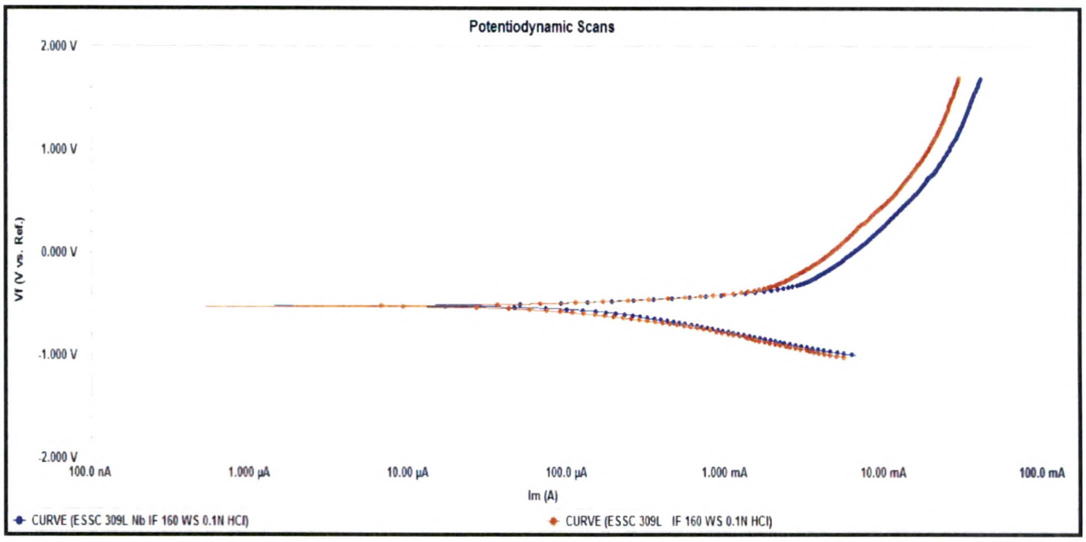



**Fig. 4.108 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.102 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 160 WS | 48.50 | -523 | 18.22 |
| 2 | ESSC Clad 309L Nb - IF 160 WS | 69.6 | -518 | 26.15 |

Fig. 4.108 shows the results of potentiodynamic scans of interface region of 309 L & 309L Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at interface

region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L cladded weld overlay has good corrosion resistance as compared to 309 L Nb cladded weld overlay.

**4.3.4.1.3.5 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 0.1 N HCl Solution**

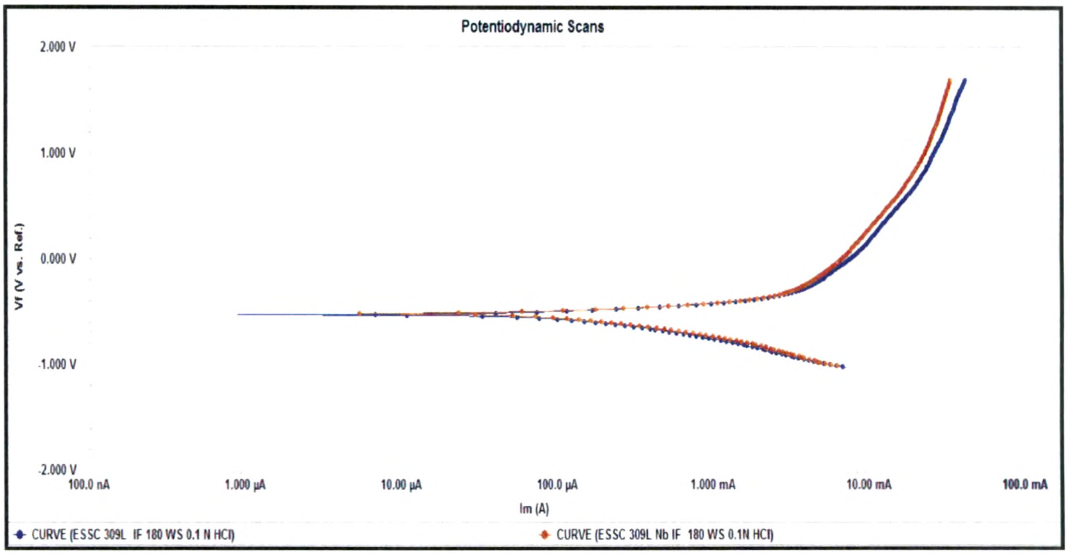



**Fig. 4.109 Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.103 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 180 WS | 42.50 | -528 | 15.97 |
| 2 | ESSC Clad 309L Nb - IF 180 WS | 50.60 | -513 | 19.01 |

Fig. 4.109 shows the results of potentiodynamic scans of interface region of 309 L & 309l Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L

cladded weld overlay has good corrosion resistance as compared to 309 L Nb cladded weld overlay.

**4.3.4.1.3.6 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 0.1 N HCl Solution**

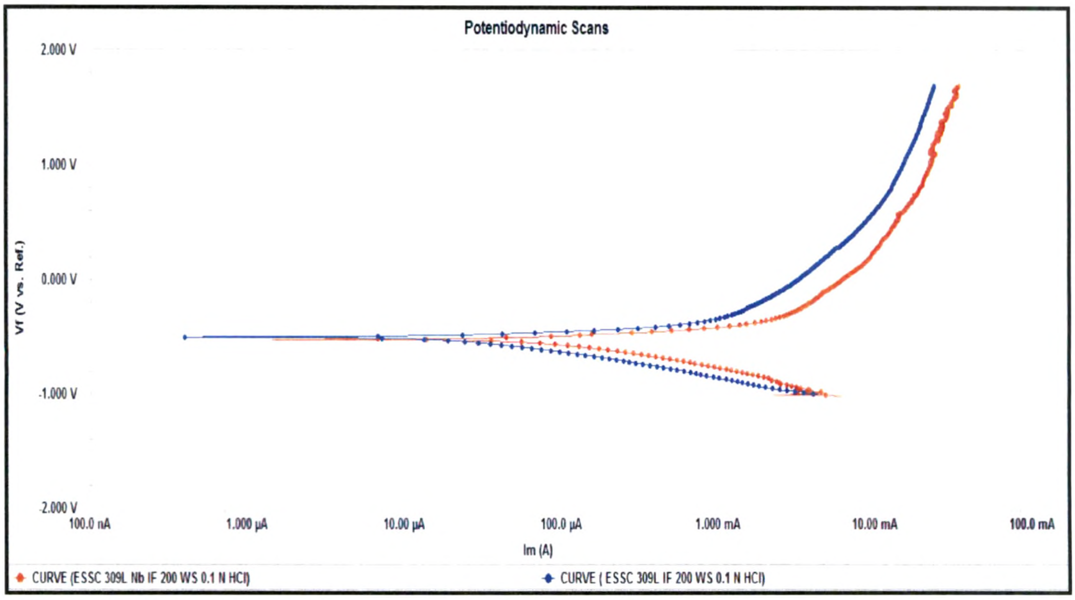



**Fig.4.110 Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N HCl solution**

**Table-4.104 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 0.1 N HCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 200 WS | 39.30 | -502 | 14.77 |
| 2 | ESSC Clad 309L Nb - IF 200 WS | 65.4 | -521 | 24.58 |

Fig. 4.110 shows the results of potentiodynamic scans of interface region of 309 L & 309l Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 N HCl solutions. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L

cladded weld overlay has good corrosion resistance as compared to 309 L Nb cladded weld overlay.

**Table- 4.105 : Effect of Nb addition on corrosion resistance of weld overlay at clad as well as at interface clad as well as at interface in 0.1 N HCl solution**

| Sr. No | Samples | Corrosion Rate (mpy) | |
|---|---|---|---|
| | | 309 L cladded region | 309 L Nb cladded region |
| 1 | ESSC Clad 160 WS | 10.03 | 14.9 |
| 2 | ESSC Clad 180 WS | 0.0282 | 2.829 |
| 3 | ESSC Clad 200 WS | 2.843 | 7.872 |
| 4 | ESSC IF 160 WS | 18.22 | 26.15 |
| 5 | ESSC IF 180 WS | 15.97 | 19.01 |
| 6 | ESSC IF 200 WS | 14.77 | 24.58 |

By comparing corrosion behavior of both weld overlays developed at different welding speed at clad as well as interface region in 0.1 N HCl solution , it shows that 309 L cladded weld overlay exhibit passivation behaviour due to which it has good corrosion resistance as compared to 309 L Nb cladded weld overlay in 0.1 N HCl solution.

**4.3.4.1.4 Effect of Niobium addition ccorrosion behaviour of 309 L and 309 L Nb cladded weld overlay in 3.5 % NaCl Solution**

**4.3.4.1.4.1Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 3.5 % NaCl Solution**

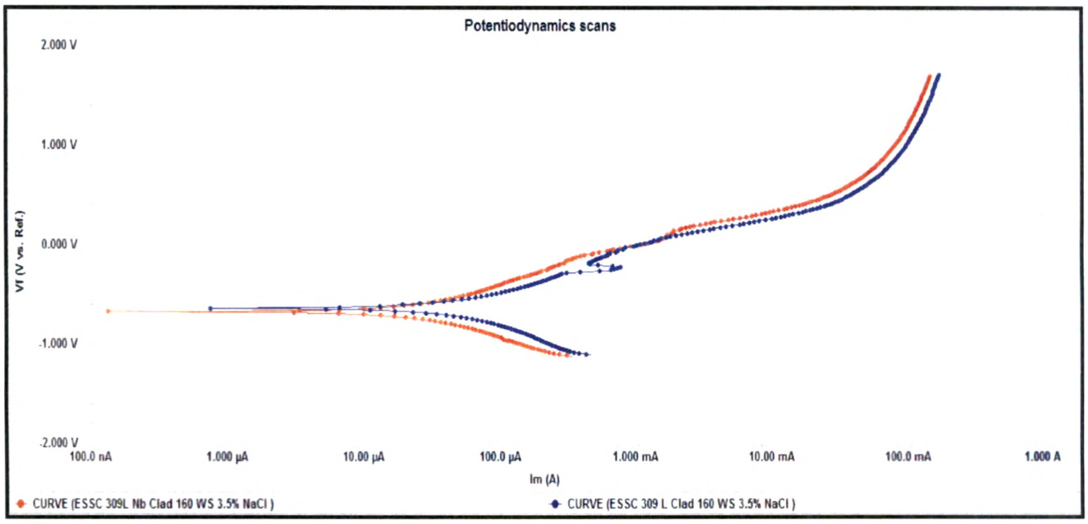



**Fig. 4.111: Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.106 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 160 WS | 85.80 | -462 | 156.8 |
| 2 | Clad 309L Nb 160 WS | 77.80 | -640 | 142.2 |

Fig. 4.111 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 160 mm / min. welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb

cladded weld overlay has good corrosion resistance as compared to 309 L cladded weld overlay [90].

**4.3.4.1.4.2 Comparison of Corrosion behaviour of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 3.5 % NaCl Solution**

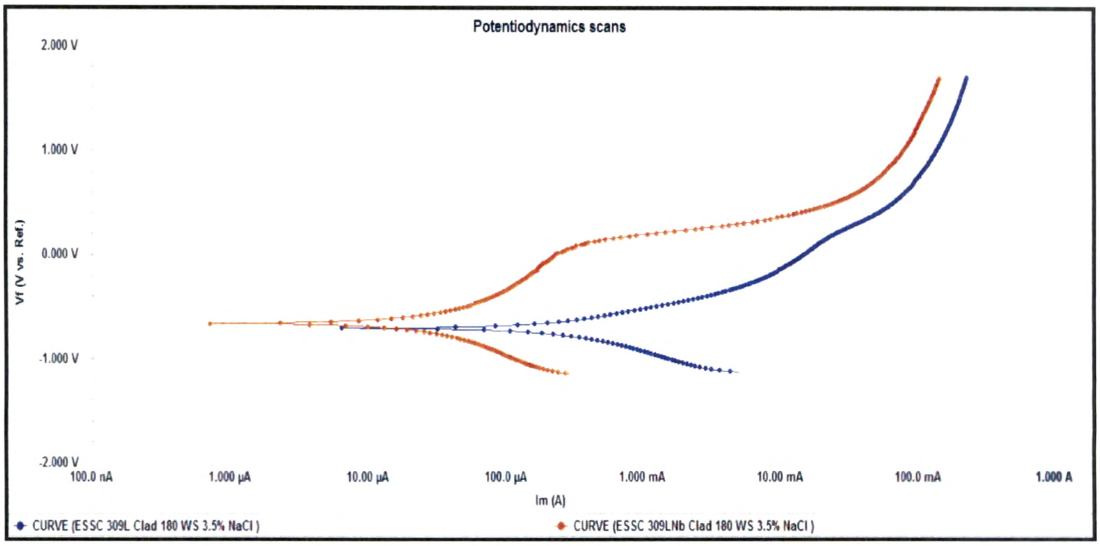



**Fig. 4.112 : Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.107 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 180 WS | **68.30** | **-660** | **134.5** |
| 2 | Clad 309L Nb 180 WS | **59.40** | **-661** | **97.5** |

Fig. 4.112 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 180 mm / min. welding speed in 3.5 % NaCl solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb

cladded weld overlay has good corrosion resistance as compared to 309 L cladded weld overlay due to passive film formation [90].

**4.3.4.1.4.3 Comparison of Corrosion behaviour of cladded region of 309 L and 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 3.5 % NaCl Solution**

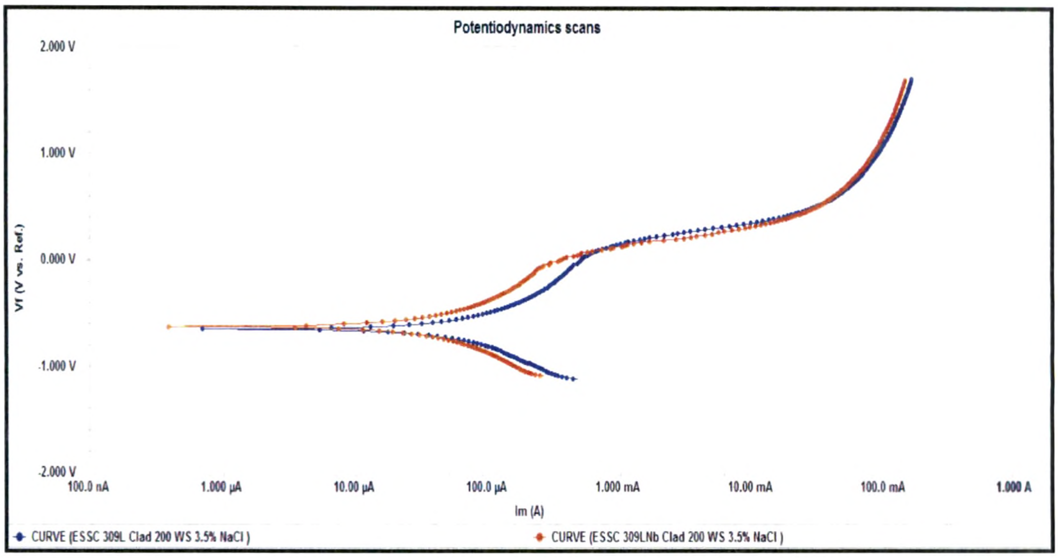



**Fig. 4.113: Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.108 : Electrochemical Parameters of Potentiodynamic scans of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | Clad 309L 200 WS | 121.0 | -651 | 222.7 |
| 2 | Clad 309L Nb 200 WS | 106.40 | -623 | 194.6 |

Fig. 4.113 shows the results of potentiodynamic scans of cladded region of 309 L & 309l Nb cladded weld overlay developed with 180 mm / min. welding speed in 3.5 % NaCl solutions. By comparing corrosion behavior of both weld overlays at cladded region, it shows that (i) all samples exhibit active potentials in given environment,(ii) 309 L Nb cladded weld overlay has good corrosion resistance as compared to 309 L cladded weld overlay [90].

**4.3.4.1.4.4 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed 3.5 % NaCl Solution**

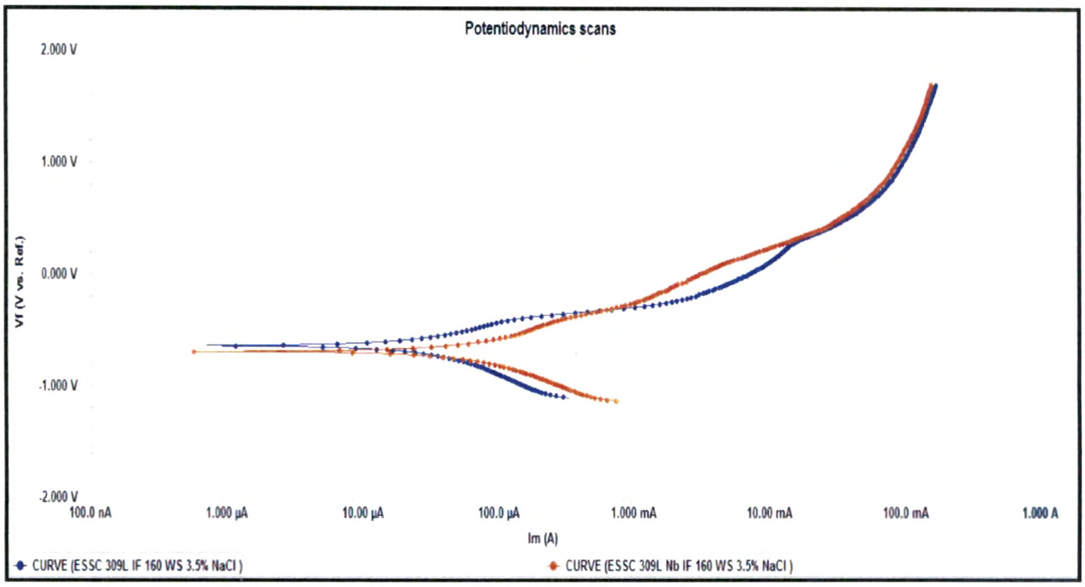



**Fig. 4.114 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.109 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 160 WS | 123.2 | -639 | 224.9 |
| 2 | ESSC Clad 309L Nb - IF 160 WS | 107.0 | -688 | 195.1 |

Fig. 4.114 shows the results of potentiodynamic scans of interface region of 309 L & 309L Nb cladded weld overlay developed with 160 mm / min. welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay has good corrosion resistance as compared to interface region of 309 L cladded weld overlay.

### 4.3.4.1.4.5 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed 3.5 % NaCl Solution

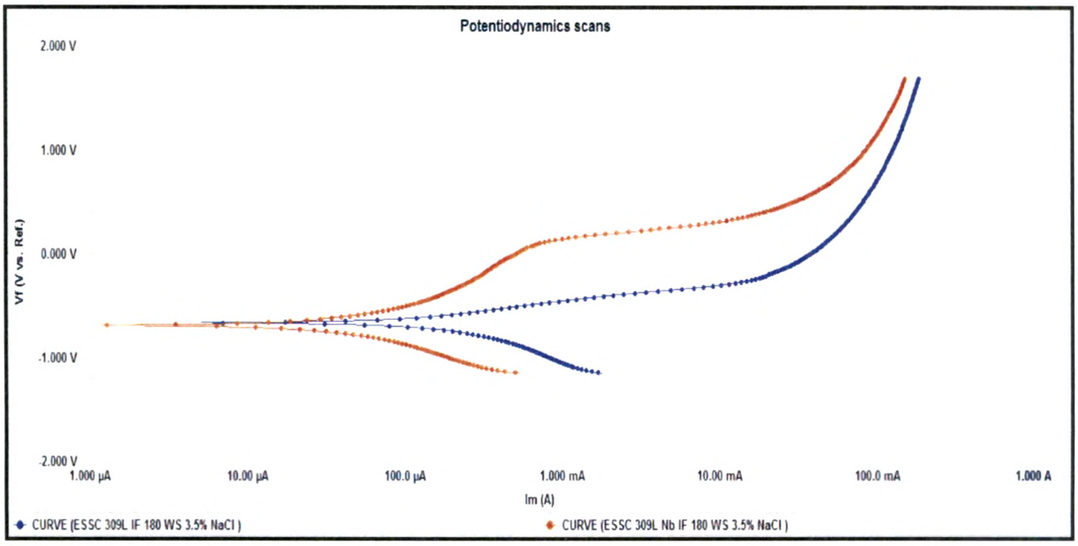



**Fig. 4.115 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.110: Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 180 WS | 97.00 | -709 | 174.7 |
| 2 | ESSC Clad 309L Nb - IF 180 WS | 86.50 | -681 | 157.3 |

Fig. 4.115 shows the results of potentiodynamic scans of interface region of 309 L & 309L Nb cladded weld overlay developed with 180 mm / min. welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay has good corrosion resistance as compared to interface region of 309 L cladded weld overlay.

#### 4.3.4.1.4.6 Comparison of Corrosion behaviour of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed 3.5 % NaCl Solution

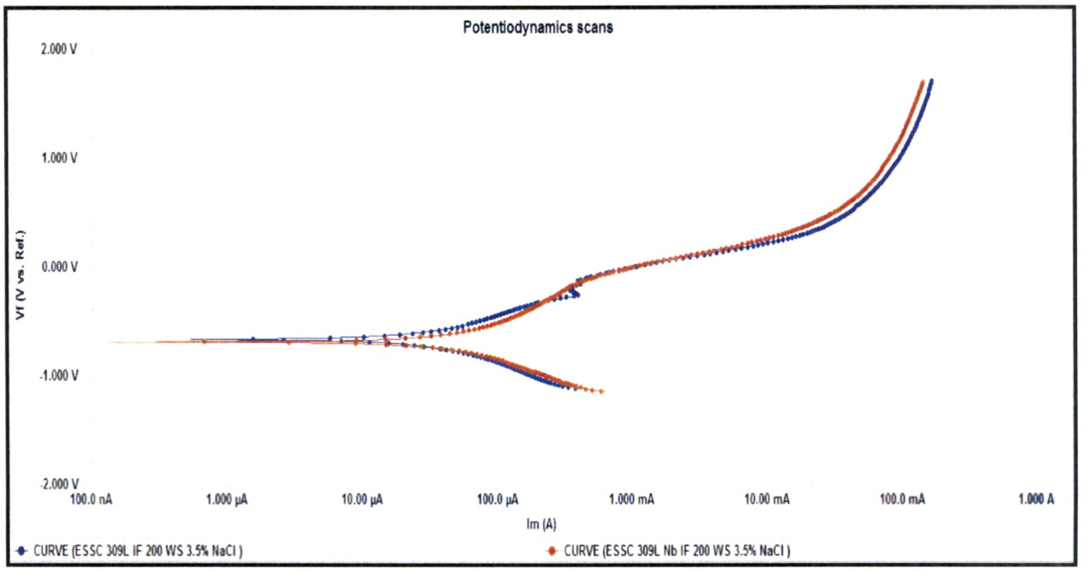



**Fig. 4.116 : Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 3.5 % NaCl solution**

**Table-4.111 : Electrochemical Parameters of Potentiodynamic scans of Interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 3.5 % NaCl Solution**

| Sr. No | Samples | $i_{Corr}$ (µA) | $E_{Corr}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|
| 1 | ESSC Clad 309L - IF 200 WS | 132.90 | -663 | 246.7 |
| 2 | ESSC Clad 309L Nb - IF 200 WS | 116.10 | -692 | 211.7 |

Fig. 4.116 shows the results of potentiodynamic scans of interface region of 309 L & 309L Nb cladded weld overlay developed with 200 mm / min. welding speed in 3.5 % NaCl solution. By comparing corrosion behavior of both weld overlays at interface region, it shows that (i) all samples exhibit active potentials in given environment,(ii) interface region of 309 L Nb cladded weld overlay has good corrosion resistance as compared to interface region of 309 L cladded weld overlay.

**Table- 4.112 : Effect of Nb addition on corrosion resistance of weld overlay at clad as well as at interface clad as well as at interface in 3.5 % NaCl solution**

| Sr. No | Samples | Corrosion Rate (mpy) | |
|---|---|---|---|
| | | 309 L cladded region | 309 L Nb cladded region |
| 1 | ESSC Clad 160 WS | 156.8 | 142.2 |
| 2 | ESSC Clad 180 WS | 204.5 | 104.9 |
| 3 | ESSC Clad 200 WS | 222.7 | 164.6 |
| 4 | ESSC IF 160 WS | 224.9 | 195.1 |
| 5 | ESSC IF 180 WS | 174.7 | 157.3 |
| 6 | ESSC IF 200 WS | 246.7 | 211.7 |

By comparing corrosion behavior of both weld overlays developed at different welding speed at clad as well as at interface region in 3.5 % NaCl solution , it shows that passivation film of 309 L Nb cladded weld overlay was more uniform as compared to 309 L cladded weld overlay due to which it has good corrosion resistance than 309 L cladded weld overlay in in 3.5 % NaCl solution.

### 4.3.4.2 Effect of Niobium addition on pitting Corrosion susceptibility of weld overlays

#### 4.3.4.2.1 Effect of Niobium addition on pitting Corrosion susceptibility of weld overlays in as welded conditions

##### 4.3.4.2.1.1 Comparison of pitting susceptibility of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 6 % $FeCl_3$ Solution

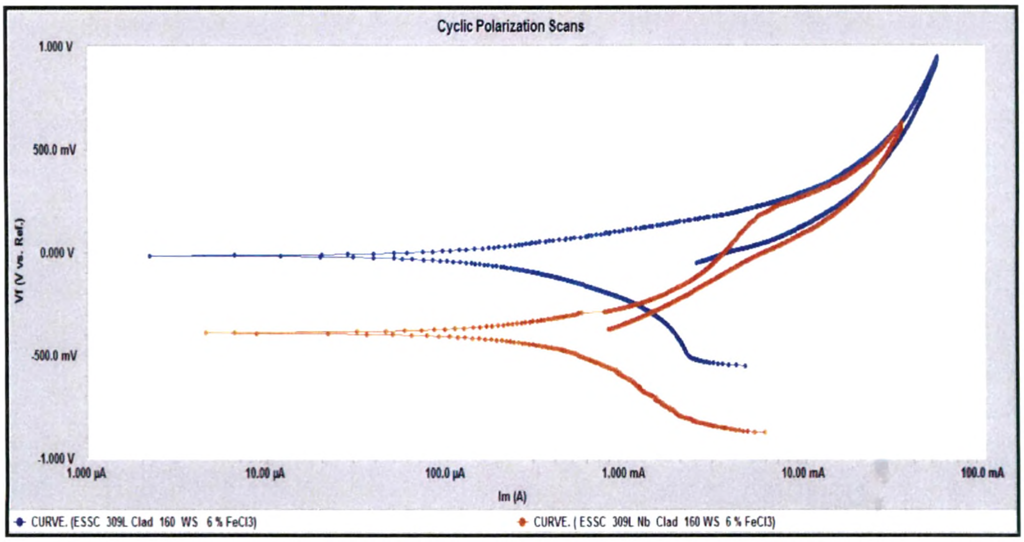



**Fig. 4.117 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at cladded region in 6 % $FeCl_3$ Solution**

**Table- 4.113 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 160 WS | 309.0 | -13.00 | -195.3 | 463.0 |
| 2 | ESSC- 309L Nb Clad 160 WS | 184.0 | -388.0 | -478.6 | 275.9 |

Fig. 4.117 shows the Cyclic polarization scans of 309L & 309L Nb cladded weld overlays developed at 160 mm /min. welding speed in 6% $FeCl_3$ Solution. Results show that cladded region of both weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility[91].

#### 4.3.4.2.1.2 Comparison of pitting susceptibility of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 6 % $FeCl_3$ Solution

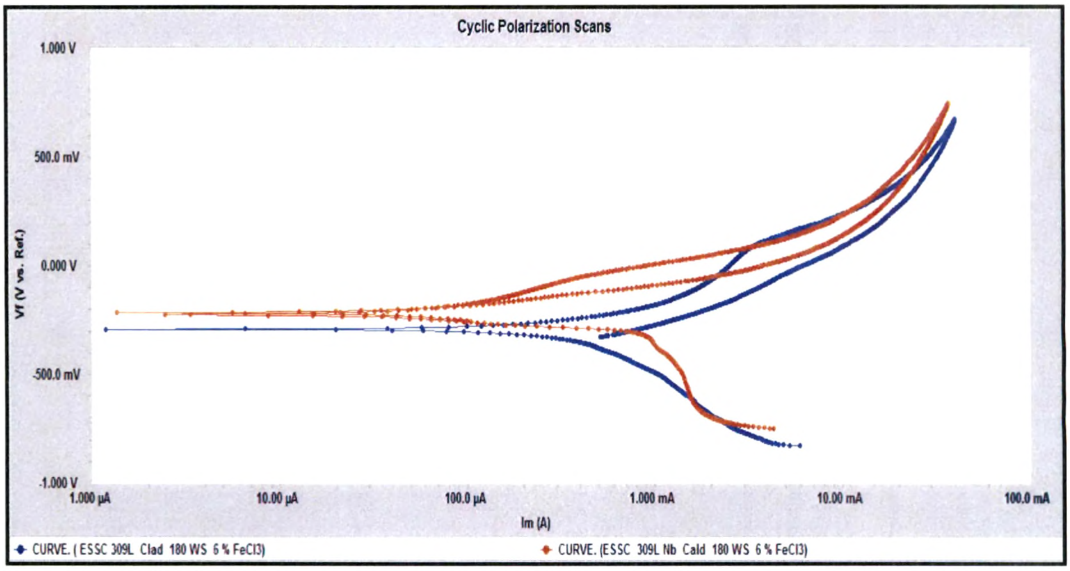



**Fig.4.118 Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at cladded region in 6 % $FeCl_3$ Solution**

**Table-4.114 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 180 WS | 135.0 | -291.00 | -350.4 | 203.2 |
| 2 | ESSC- 309L Nb Clad 180 WS | 47.10 | -222.0 | -192.8 | 70.62 |

Fig. 4.118 show the Cyclic polarization scans of 309L & 309L Nb cladded weld overlays developed at 180 mm /min. welding speed in 6% $FeCl_3$ Solution. Results show that cladded region of 309 L cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility. But in case of cladded region of 309 L Nb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here

$E_{rp} > E_{corr}$ that indicate pitting will occur but damaged passive film will get repaired that results in decrease in pitting corrosion susceptibility[91].

**4.3.4.2.1.3 Comparison of pitting susceptibility of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 6 % $FeCl_3$ Solution**

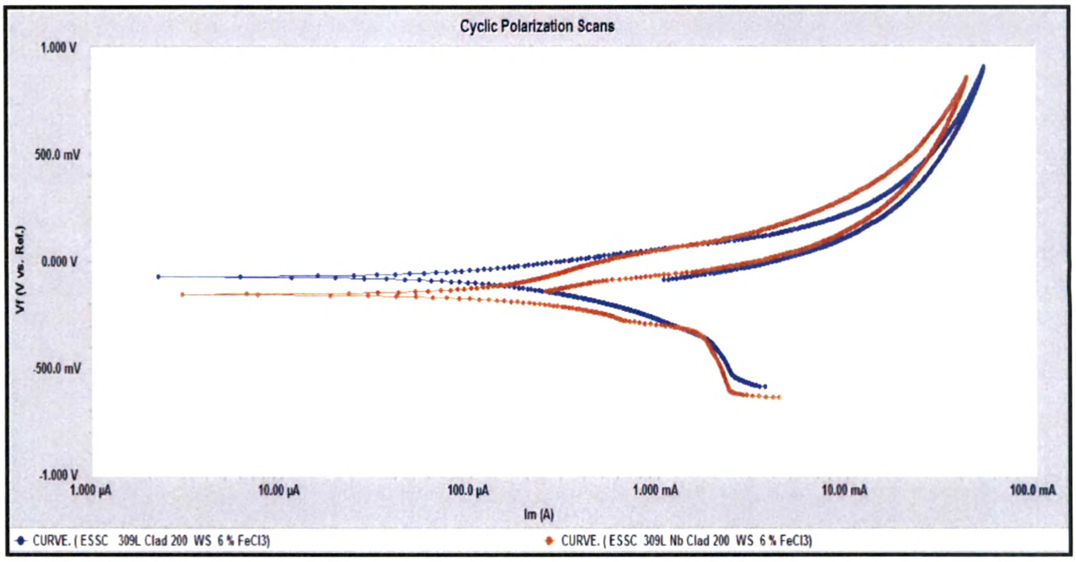



**Fig. 4.119 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at cladded region in 6 % $FeCl_3$ Solution**

**Table-4.115 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 200 `WS | 264.0 | -70.80 | -136.2 | 395.5 |
| 2 | ESSC- 309L Nb Clad 200 WS | 103.0 | -153.0 | -167.3 | 155.0 |

Fig.4.119 show the Cyclic polarization scans of 309L & 309L Nb cladded weld overlays developed at 200 mm /min. welding speed in 6% $FeCl_3$ Solution. Results show that cladded region of both weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan.

Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damaged passive film will get not repaired that results in increase in pitting corrosion susceptibility[91].

#### 4.3.4.2.1.4 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed in 6 % $FeCl_3$ Solution

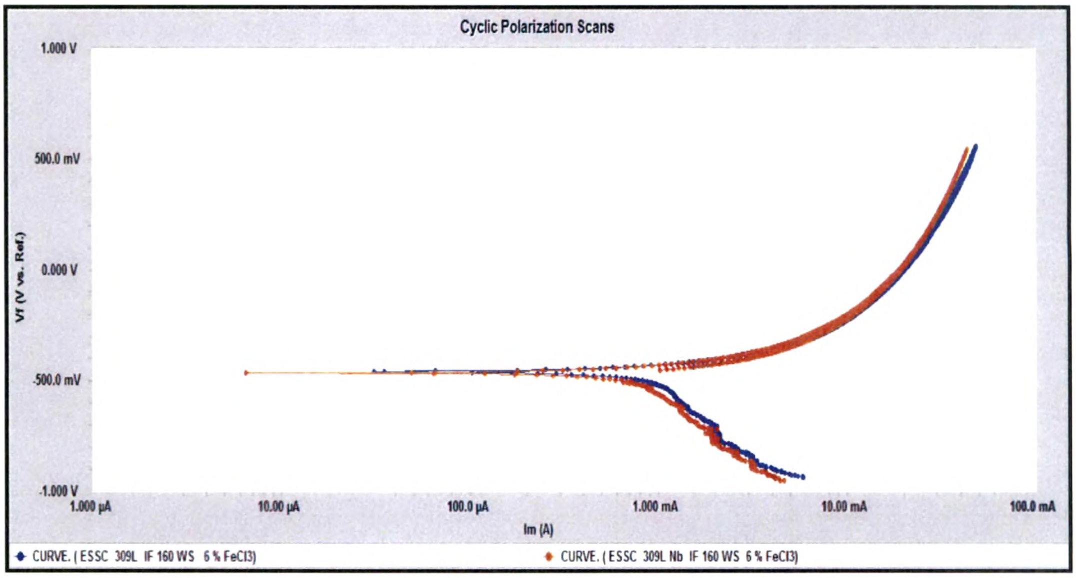



**Fig. 4.120 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at interface region in 6 % $FeCl_3$ Solution**

**Table- 4.116 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 160 WS | 489.0 | -434.0 | -470.03 | 893.0 |
| 2 | ESSC- 309L Nb IF 160 WS | 352.0 | -465.0 | -480.0 | 528.2 |

Fig. 4.120 show the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 160 mm /min. welding speed in 6% $FeCl_3$ Solution. Results show that interface region of 309 L & 309 L Nb cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur

and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility.

#### 4.3.4.2.1.5 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed in 6 % $FeCl_3$ Solution

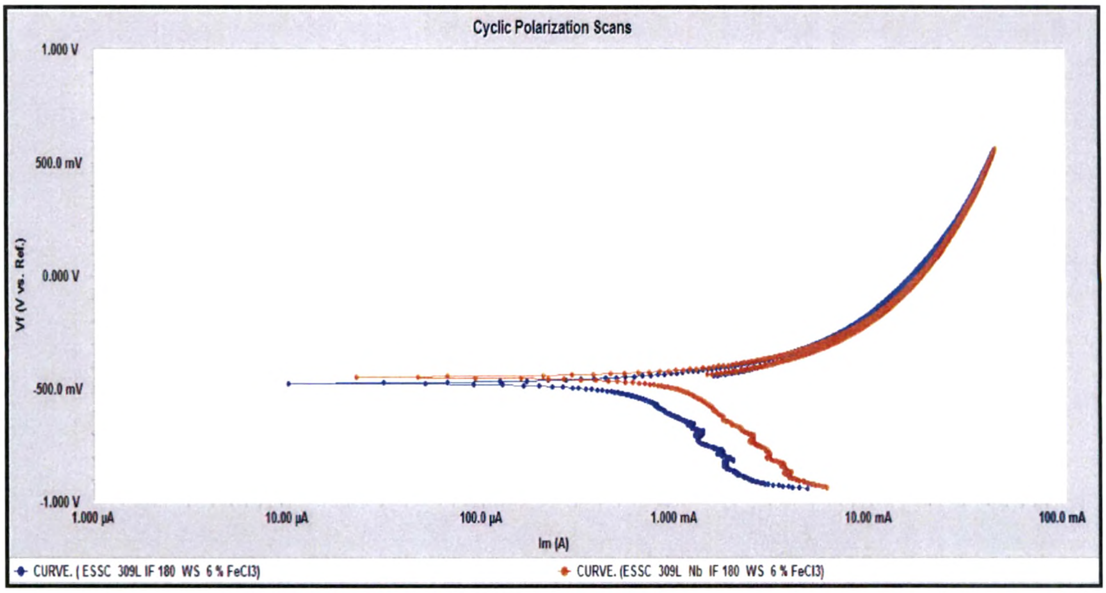



**Fig. 4. 121 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at interface region in 6 % $FeCl_3$ Solution**

**Table-4.117 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 180 WS | 434.0 | -433.0 | -488.68 | 793.1 |
| 2 | ESSC- 309L Nb IF 180 WS | 305.0 | -445.0 | -463.3 | 457.0 |

Fig. 4.121 show the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 180 mm /min. welding speed in 6% $FeCl_3$ Solution. Results show that interface region of 309L & 309 L Nb cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur

and damaged passive film will not repaired that results in increase in pitting corrosion susceptibility.

**4.3.4.2.1.6 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed in 6 % $FeCl_3$ Solution**

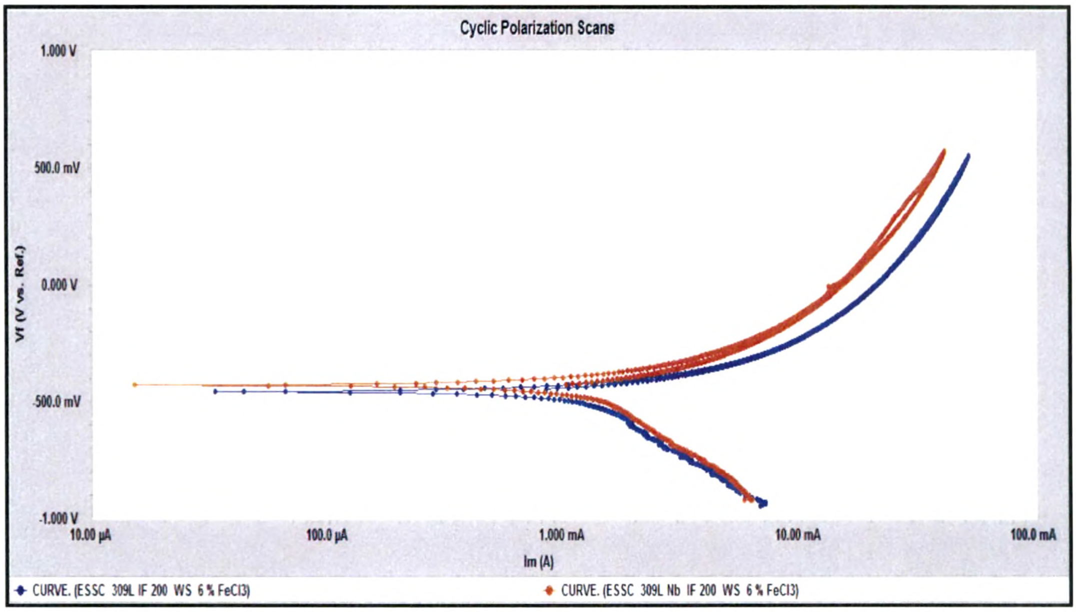



**Fig. 4.122 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at interface region in 6 % $FeCl_3$ Solution**

**Table-4.118 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 200 WS | 267.0 | -461.0 | -498.6 | 488.6 |
| 2 | ESSC- 309L Nb IF 200 WS | 460.0 | -427.0 | -451.6 | 690.4 |

Fig. 4.122 shows the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 200 mm /min. welding speed in 6% $FeCl_3$ Solution. Results shows that interface region of 309 L & 309 L Nb cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur

and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility.

### 4.3.4.2.2 Effect of Niobium addition on pitting Corrosion susceptibility of weld overlays in as welded conditions after PWHT

#### 4.3.4.2.2.1Comparison of pitting susceptibility of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution

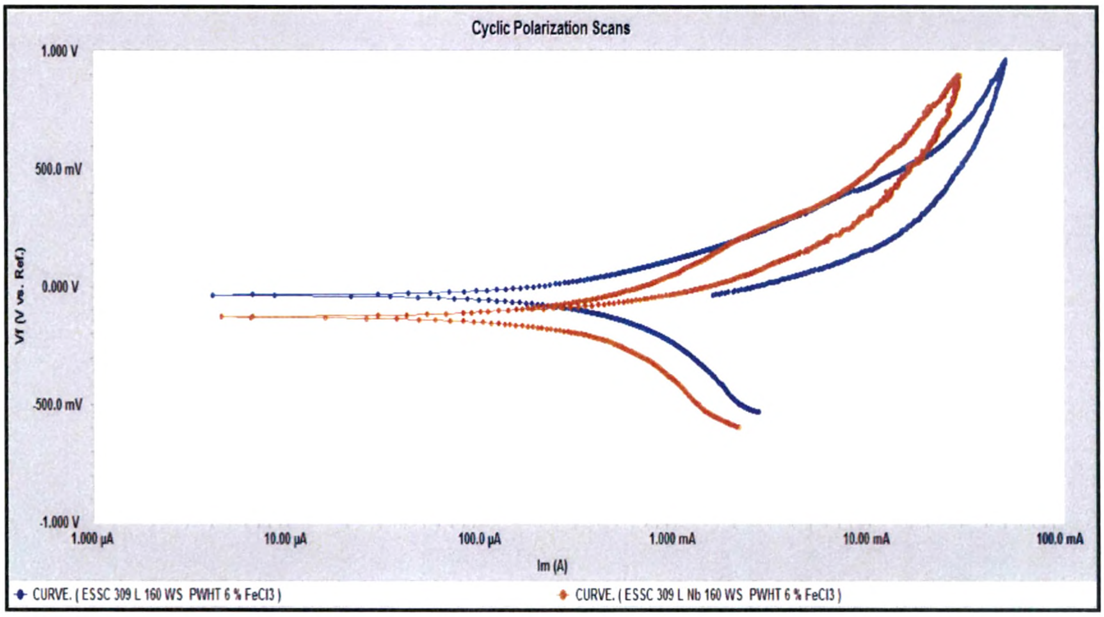



**Fig. 4.123 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at cladded region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.119 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 160 WS PWHT | 88.50 | -33.10 | -87.37 | 132.9 |
| 2 | ESSC- 309L Nb Clad 160 WS PWHT | 49.10 | -126.0 | -110.5 | 73.63 |

Fig. 4.123 show the Cyclic polarization scans of cladded region of 309L & 309L Nb cladded weld overlays developed at 160 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that cladded region of 309 L cladded weld overlays

exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility. But in case of cladded region of 309 L Nb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{ro} > E_{corr}$ that indicate pitting will occur but damaged passive film will get repaired that results in decrease in pitting corrosion susceptibility[92].

**4.3.4.2.2.2 Comparison of pitting susceptibility of cladded region of 309 L and 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution**

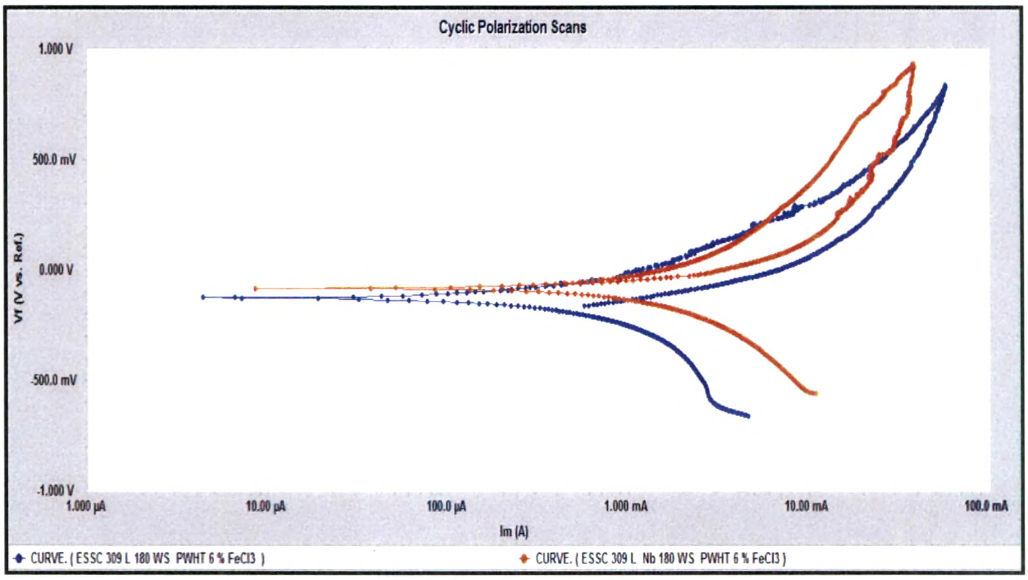



**Fig. 4.124 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at cladded region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.120 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 180 WS PWHT | 40.80 | -127.0 | -178.5 | 61.20 |
| 2 | ESSC- 309L Nb Clad 180 WS PWHT | 215.0 | -82.70 | -67.37 | 322.3 |

Fig. 4.124 show the Cyclic polarization scans of cladded region of 309L & 309L Nb cladded weld overlays developed at 180 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that cladded region of 309 L cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility. But in case of cladded region of 309 L Nb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{rp} > E_{corr}$ that indicate pitting will occur but damaged passive film will get repaired that results in decrease in pitting corrosion susceptibility[92].

**4.3.4.2.2.3 Comparison of pitting susceptibility of cladded region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution**

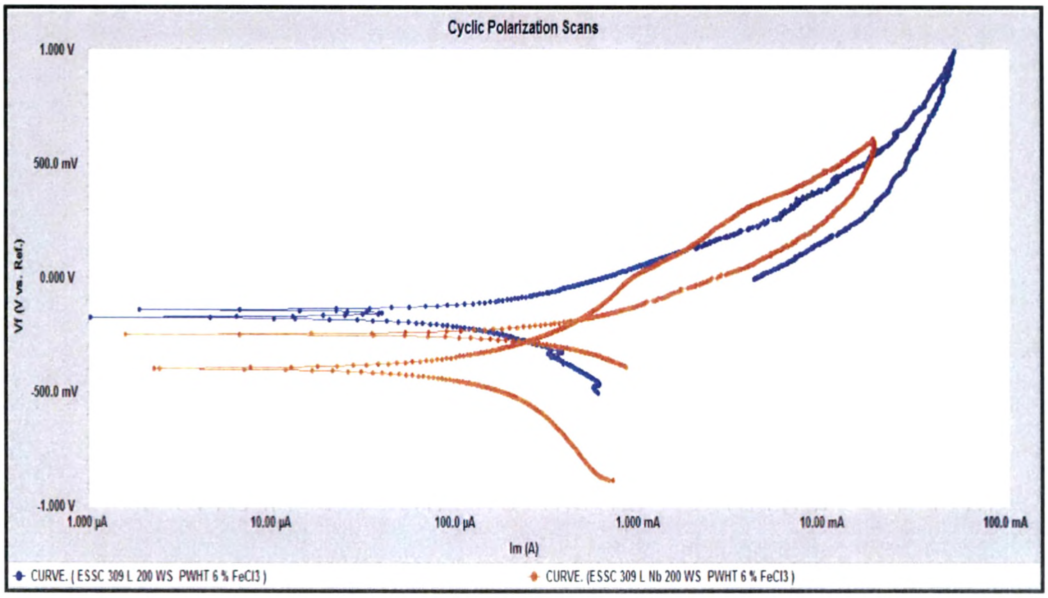



**Fig. 4.125 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at cladded region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.121 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L Clad 200 WS PWHT | 330.0 | -412.0 | -419.5 | 494.8 |
| 2 | ESSC- 309L Nb Clad 200 WS PWHT | 124.0 | -173.0 | -298.8 | 185.8 |

Fig.4.125 show the Cyclic polarization scans of cladded region of 309L & 309L Nb cladded weld overlays developed at 200 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that cladded region of both weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damaged passive film will not get repaired that results in increases pitting corrosion susceptibility [92].

#### 4.3.4.2.2.4 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution

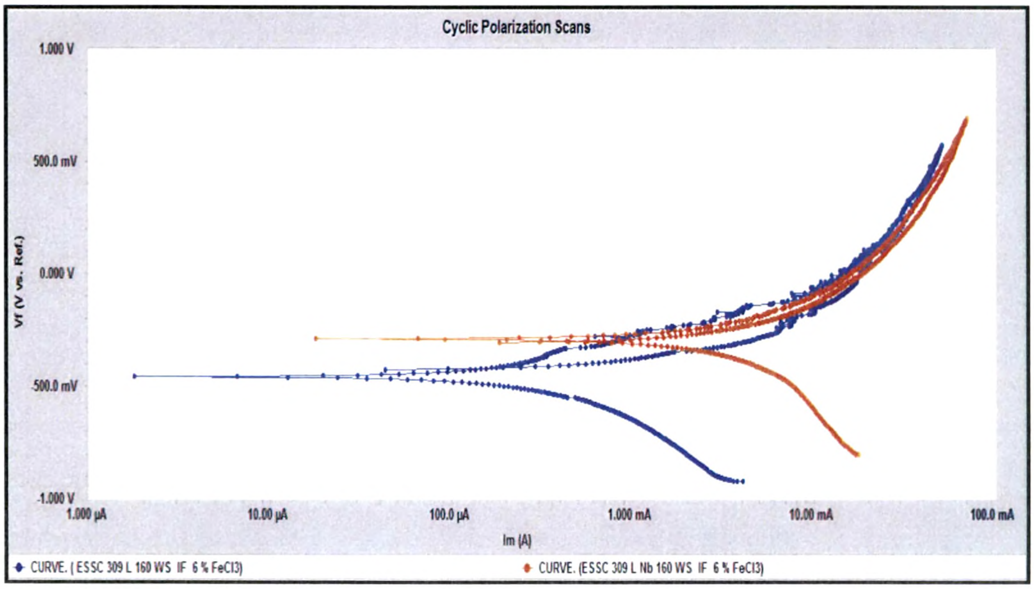



**Fig. 4.126 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 160 mm / min. welding speed at interface region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.122 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 160 WS PWHT | 112.0 | -456.0 | -467.1 | 167.9 |
| 2 | ESSC- 309L Nb IF 160 WS PWHT | 98.80 | -289.0 | -281.2 | 148.2 |

Fig. 4.126 shows the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 160 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that interface region of 309 L cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility. But in case of interface region of 309 LNb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{rp} > E_{corr}$ that indicate pitting will occur but damage passive film will repaired that results in decrease in pitting corrosion susceptibility.

**4.3.4.2.2.5 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution**

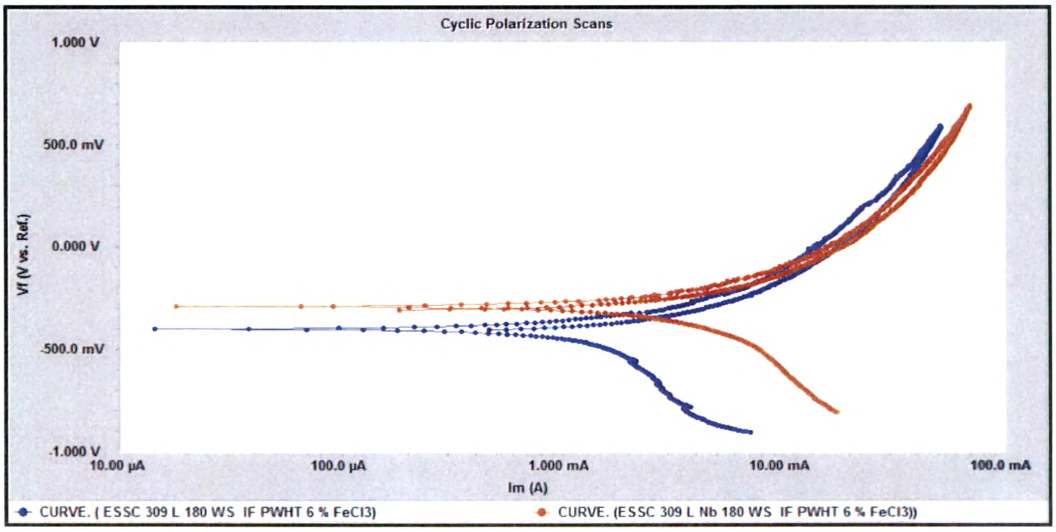



**Fig. 4.127 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 180 mm / min. welding speed at interface region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.123 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 180 WS PWHT | 617.0 | -400.0 | -412.7 | 925.5 |
| 2 | ESSC- 309L Nb IF 180 WS PWHT | 344.0 | -519.0 | -284.7 | 515.9 |

Fig. 4.127 shows the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 180 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that interface region of 309 L cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility. But in case of interface region of 309 LNb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{rp} > E_{corr}$ that indicate pitting will occur but damage passive film will repaired that results in decrease in pitting corrosion susceptibility.

#### 4.3.4.2.2.6 Comparison of pitting susceptibility of interface region of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed after PWHT in 6 % $FeCl_3$ Solution

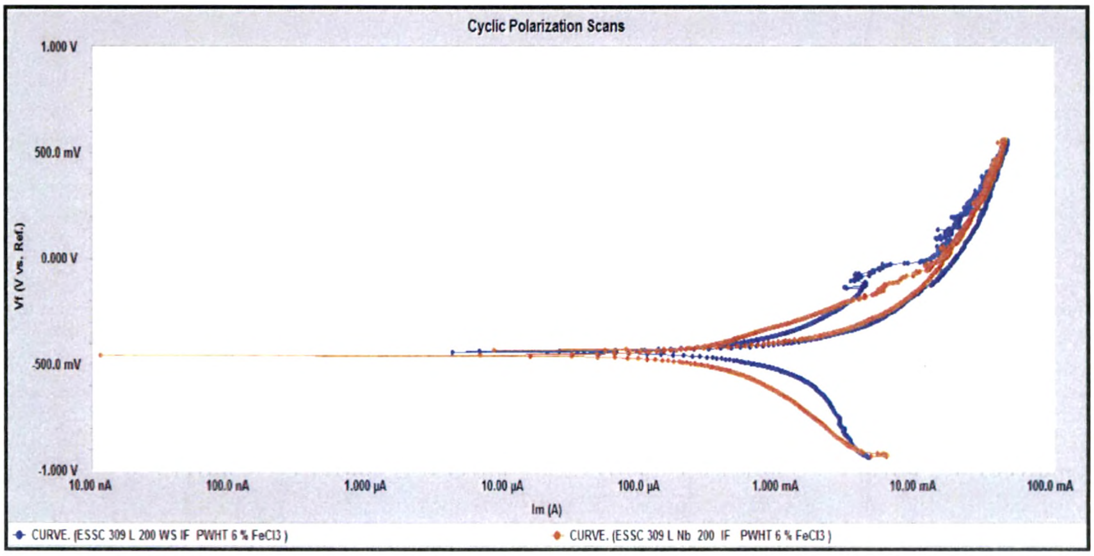



**Fig. 4.128 : Cyclic polarization scans of 309 L & 309 L Nb cladded weld overlay develop with 200 mm / min. welding speed at interface region after PWHT in 6 % $FeCl_3$ Solution**

**Table-4.124 : Electrochemical Parameters of cyclic polarization Scan in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309 L IF 200 WS PWHT | 42.30 | -440.0 | -447.7 | 63.52 |
| 2 | ESSC- 309L Nb IF 200 WS PWHT | 82.70 | 456.0 | -418.6 | 124.1 |

Fig. 4.128 shows the Cyclic polarization scans of interface region of 309L & 309L Nb cladded weld overlays developed at 200 mm /min. welding speed after PWHT in 6% $FeCl_3$ Solution. Results show that interface region of 309 L cladded weld overlays exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ that indicate pitting will occur and damage passive film will not repaired that results in increase in pitting corrosion susceptibility. But in case of interface region of 309 LNb cladded weld overlays exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{rp} > E_{corr}$ that indicate pitting will occur but damage passive film will repaired that results in decrease in pitting corrosion susceptibility

### 4.3.4.3 Effect of Niobium addition on IGC susceptibility of weld overlays

#### 4.3.4.3.1 Effect of Niobium addition on IGC susceptibility of weld overlays as welded condition

##### 4.3.4.3.1.1 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 160 mm/min welding speed as welded condition

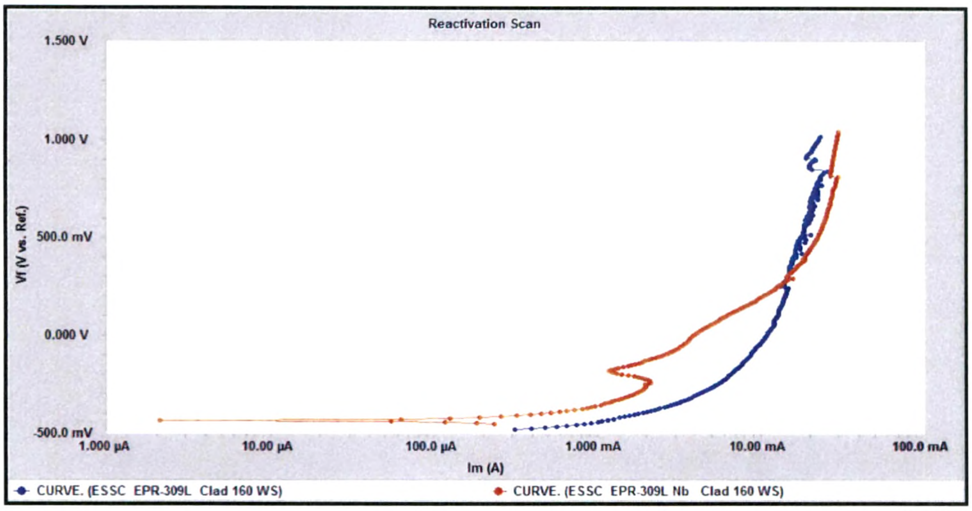



**Fig. 4.129 : EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlays developed with 160 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.125 : Peak Current density of EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 160 mm / min. welding speed**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 160 WS | $2.72 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 160 WS | $1.52 \times 10^{-2}$ |

Fig. 4.129 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlays which were developed at 160 mm/min welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded

weld overlay due to the presence of Nb which form NbC in the matix of austenite & minimizing the $Cr_{23}C_6$ precipitation[92-93]. (Fig.4.45 & Table- 4.40 - SEM & EDAX Analysis)

**4.3.4.3.1.2 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 180 mm/min welding speed as welded condition**

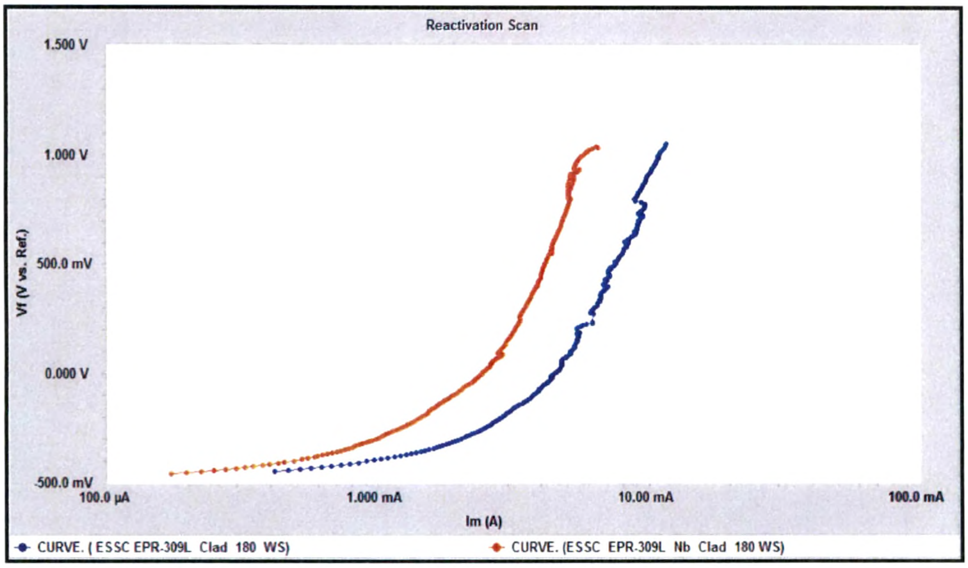



**Fig. 4.130 : EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlays developed with 180 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.126 : Peak Current density of EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 180 mm / min. welding speed**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 180 WS | 1.16 x $10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 180 WS | 1.04 x $10^{-2}$ |

Fig. 4.130 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlays which were developed at 180 mm/min welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that

degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded weld overlay due to the presence of Nb which form NbC in the matix of austenite & minimizing the $Cr_{23}C_6$ precipitation [92-93]. (Fig.4.46 & Table- 4.41 - SEM & EDAX Analysis)

**4.3.4.3.1.3 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 200 mm/min welding speed as welded condition**

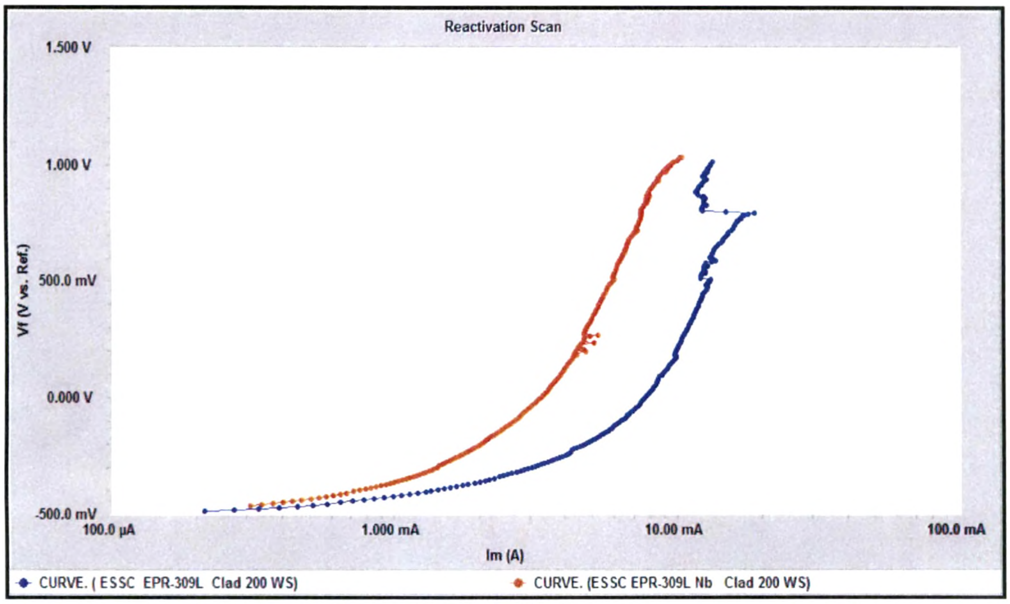



**Fig. 4.131 : EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlays developed with 200 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.127 : Peak Current density of EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 200 mm / min. welding speed**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 200 WS | 1.86 x $10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 200 WS | 1.22 x $10^{-2}$ |

Fig. 4.131 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlays which were developed at 200 mm/min welding speed. EPR test was conducted under de-

aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded weld overlay due to the presence of Nb which form NbC in the matix of austenite & minimizing the $Cr_{23}C_6$ precipitatio [92-93]. (Fig.4.47 & Table- 4.42 - SEM & EDAX Analysis)

**4.3.4.3.1.4 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 160 mm/min welding speed as welded condition**

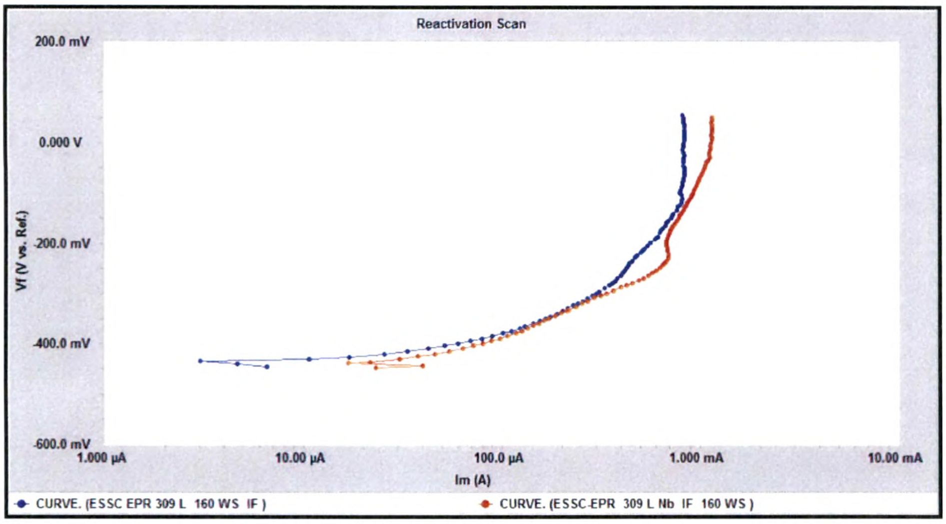



**Fig. 4.132 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlays developed with 160 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.128 : Peak Current density of EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay developed with 160 mm / min. welding speed**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 160 WS | $3.86 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 160 WS | $3.92 \times 10^{-2}$ |

Fig. 4.132 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlays which were developed at 160 mm/min welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the

degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization of interface region 309 L cladded weld overlay was slightly better than 309L Nb cladded weld overlay but the values of peak current density was very nearer to each other and consider being similar behavior as far as sensitization is concerned.

**4.3.4.3.1.5 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 180 mm/min welding speed as welded condition**

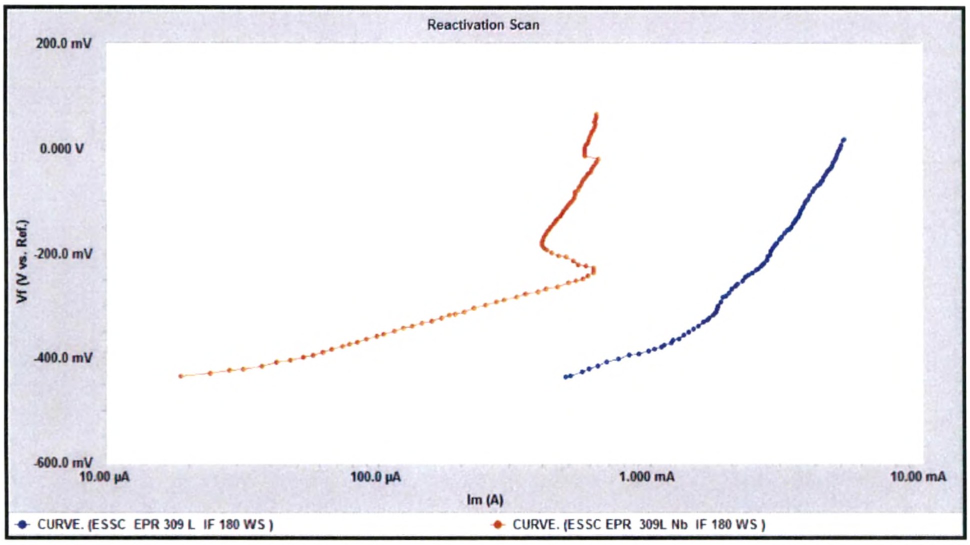



**Fig. 4.133 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlays developed with 180 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.129 : Peak Current density of EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay developed with 180 mm / min. welding speed**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 180 WS | $2.71 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 180 WS | $1.81 \times 10^{-2}$ |

Fig. 4.133 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlays which were developed at 180 mm/min welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the

degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded weld overlay.

**4.3.4.3.1.6 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 200 mm/min welding speed as welded condition**

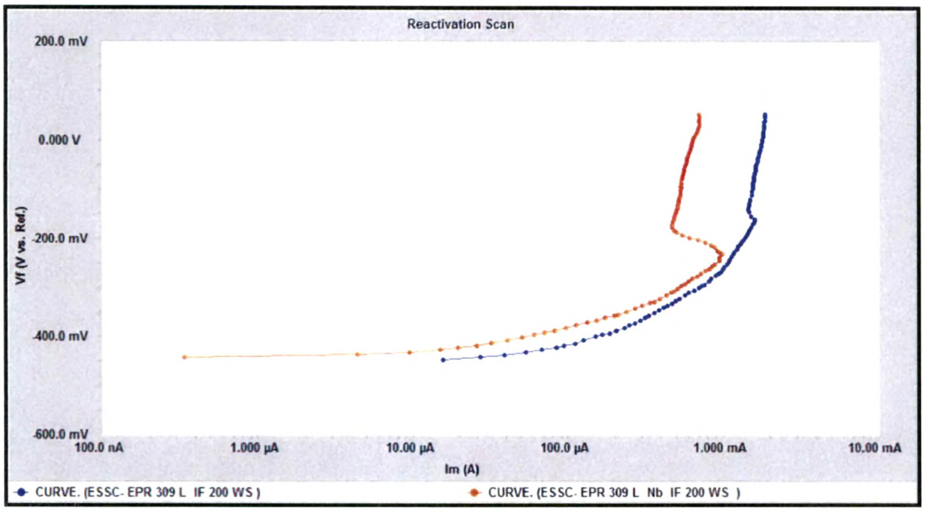



**Fig.4.134 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay s developed with 200 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.130 : Peak Current density of EPR scans of interface region of 309 L & 309 L Nb cladded weld overlays with developed with 200 mm / min. Welding speed**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 200 WS | $9.16 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 200 WS | $6.55 \times 10^{-2}$ |

Fig. 4.134 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlay which were developed at 200 mm/min welding speed. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that

degree of sensitization was lower in 309 L Nb cladded weld overlay than 309L cladded weld overlay which were developed at 200 mm / min welding speed.

#### 4.3.4.3.2 Effect of Niobium addition on IGC susceptibility of weld overlays after PWHT condition

##### 4.3.4.3.2.1 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 160 mm/min welding speed after PWHT condition

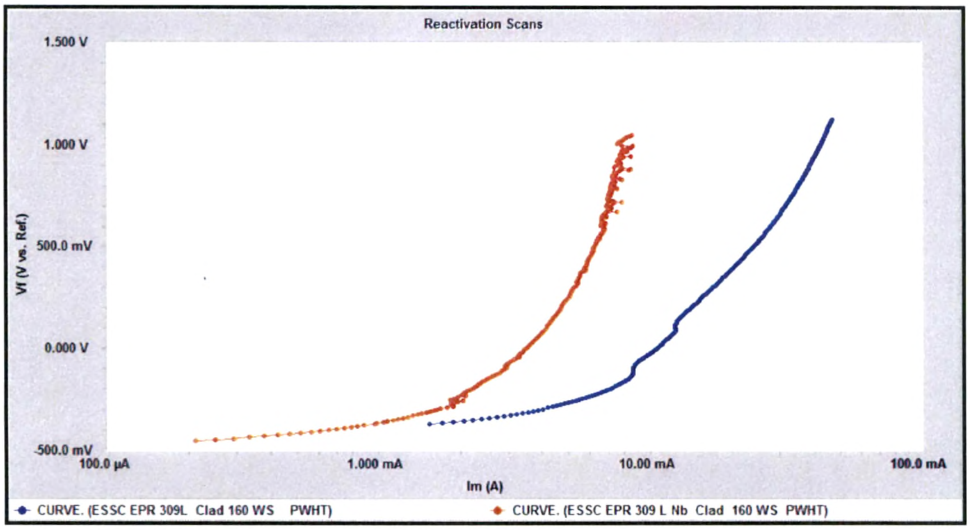



**Fig. 4.135 : EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table - 4.131 : Peak Current density of EPR scans of cladded region og 309 L & 309 L Nb cladded weld overlays developed with 160 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 160 WS PWHT | $4.69 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 160 WS PWHT | $8.64 \times 10^{-3}$ |

Fig. 4.135 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlay which were developed at 160 mm/min welding speed after PWHT. EPR test was

conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded weld overlay this is because of presence on Nb as it form NbC in the matrix of austenite & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT.

**4.3.4.3.2.2 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 180 mm/min welding speed after PWHT condition**

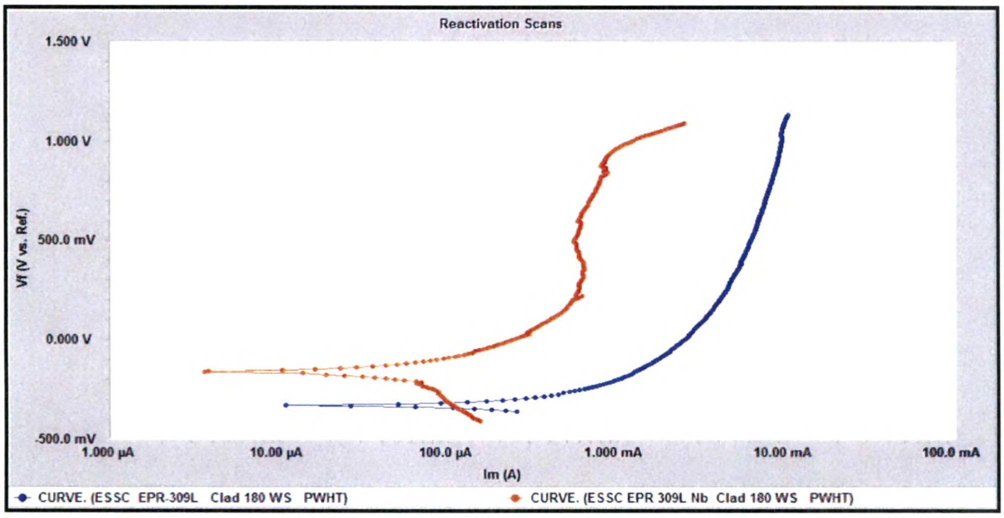



**Fig. 4.136 EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table-4.132 : Peak Current density of EPR scans of cladded region og 309 L & 309 L Nb cladded weld overlays developed with 180 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 180 WS PWHT | $1.03 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 180 WS PWHT | $2.53 \times 10^{-3}$ |

Fig. 4.136 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlay which were developed at 180 mm/min welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was better in 309 L Nb cladded weld overlay than 309L cladded weld overlay this is because of presence on Nb as it form NbC in the matrix & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT.

**4.3.4.3.2.3 Effect of Nb addition on IGC susceptibility of cladded region of weld overlays developed at 200 mm/min welding speed after PWHT condition**

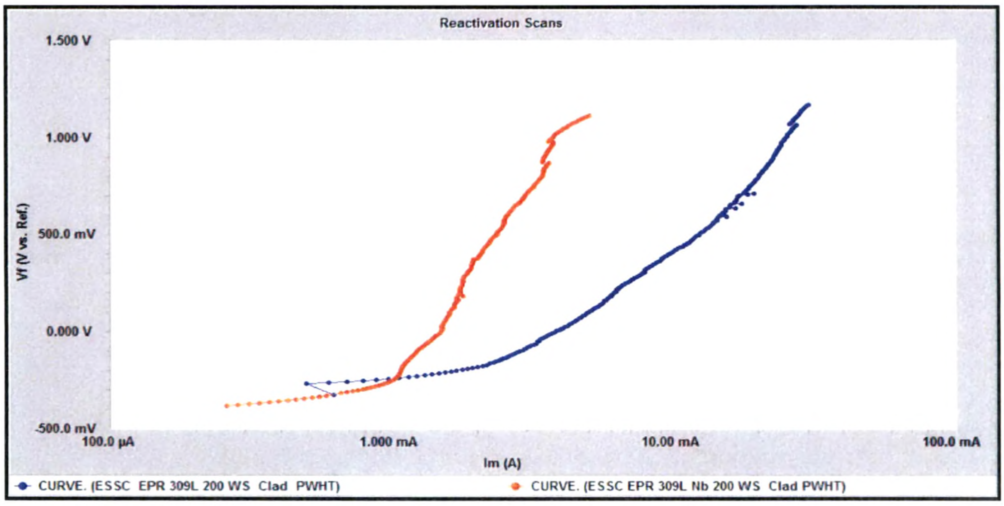



**Fig. 4.137 : EPR scans of cladded region of 309 L & 309 L Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table - 4.133 : Peak Current density of EPR scans of cladded region og 309 L & 309 L Nb cladded weld overlays developed with 200 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 200 WS PWHT | $3.01 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb Clad 200 WS PWHT | $5.03 \times 10^{-3}$ |

Fig. 4.137 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309 L & 309 L Nb cladded weld overlay which were developed at 160 mm/min welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was lower in 309 L Nb cladded weld overlay than 309L cladded weld overlay which were developed at 200 mm / min welding speed this is because of presence on Nb as it form NbC in the matrix & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT.

**4.3.4.3.2.4 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 160 mm/min welding speed after PWHT condition**

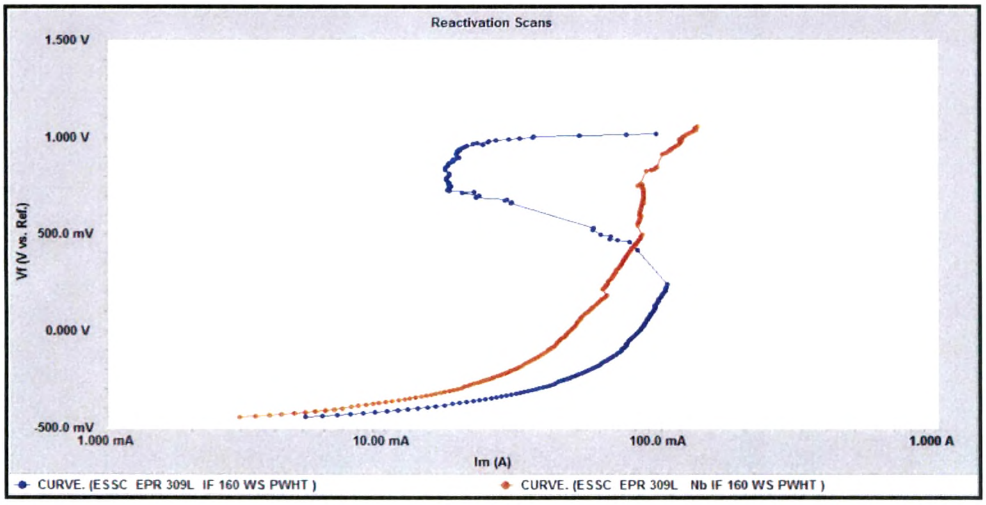



**Fig. 4.138 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay developed with 160 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table - 4.134 : Peak Current density of EPR scans of interface region og 309 L & 309 L Nb cladded weld overlays developed with 160 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 160 WS PWHT | $5.68 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 160 WS PWHT | $1.37 \times 10^{-2}$ |

Fig. 4.138 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlay which were developed at 160 mm/min welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was lower in 309 L Nb cladded weld overlay than 309L cladded weld overlay which were developed at 160 mm / min welding speed this is because of presence on Nb as it form NbC in the matrix & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT.

**4.3.4.3.2.5 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 180 mm/min welding speed after PWHT condition**

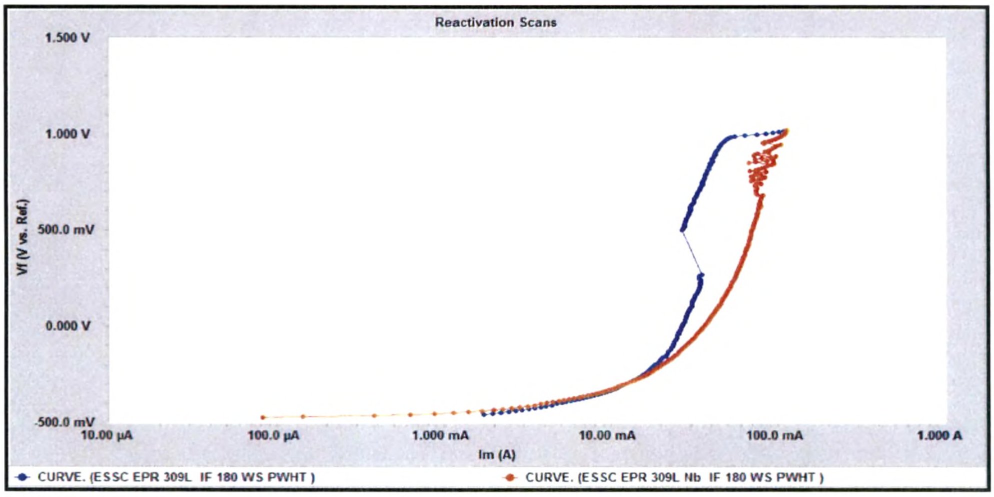



**Fig. 4.139 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay developed with 180 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table - 4.135 : Peak Current density of EPR scans of interface region og 309 L & 309 L Nb cladded weld overlays developed with 180 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 180 WS PWHT | $3.81 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 180 WS PWHT | $1.05 \times 10^{-2}$ |

Fig. 4.139 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlay which were developed at 160 mm/min welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was lower in 309 L Nb cladded weld overlay than 309L cladded weld overlay which were developed at 180 mm / min welding speed this is because of presence on Nb as it form NbC in the matrix & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT)

**4.3.4.3.2.6 Effect of Nb addition on IGC susceptibility of interface region of weld overlays developed at 200 mm/min welding speed after PWHT condition**

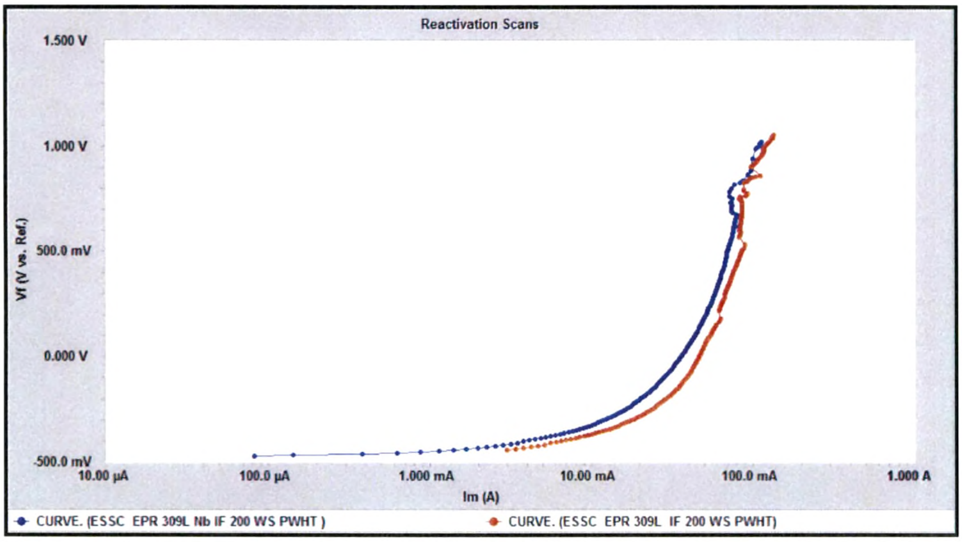



**Fig. 4.140 : EPR scans of interface region of 309 L & 309 L Nb cladded weld overlay developed with 200 mm / min. welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution after PWHT**

**Table -4.136 : Peak Current density of EPR scans of interface region og 309 L & 309 L Nb cladded weld overlays developed with 200 mm / min. welding speed after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 200 WS PWHT | $3.90 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Nb IF 200 WS PWHT | $1.06 \times 10^{-2}$ |

Fig. 4.140 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309 L & 309 L Nb cladded weld overlay which were developed at 200 mm/min welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that degree of sensitization was lower in 309 L Nb cladded weld overlay than 309L cladded weld overlay this is because of presence on Nb as it form NbC in the matrix of austenite & minimizing the $Cr_{23}C_6$ precipitation & relieving of stresses after PWHT.

# 4.4 Result of Effect of Post Weld Heat Treatments (PWHT) on Micro-structural changes, ferrite content, Micro-hardness and Corrosion behaviour of Weld Overlays

## 4.4.1 Effect of Post Weld Heat Treatment on Microstructure change of weld overlays:

### 4.4.1.1 Effect of Post Weld Heat Treatment on Microstructure changes clad region of both weld overlay

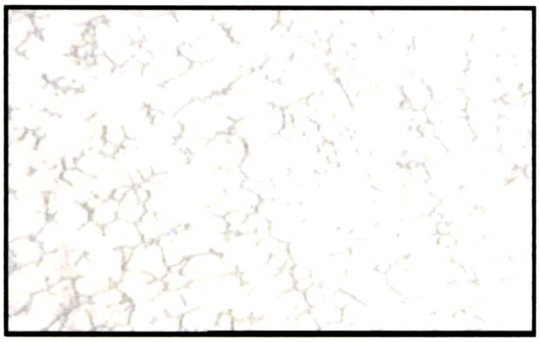


**Fig.4.141 (a) Cladded region of 309 L Clad at 160 WS as welded condition**

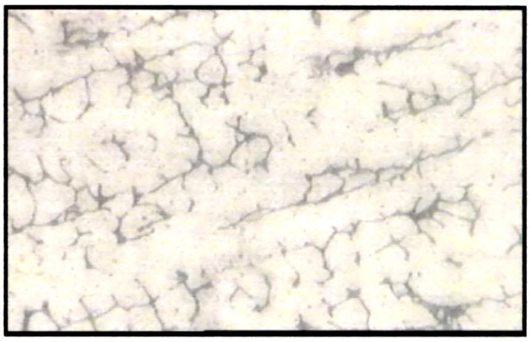


**Fig.4.141 (b) Cladded region of 309 L Clad at 160 WS after PWHT**

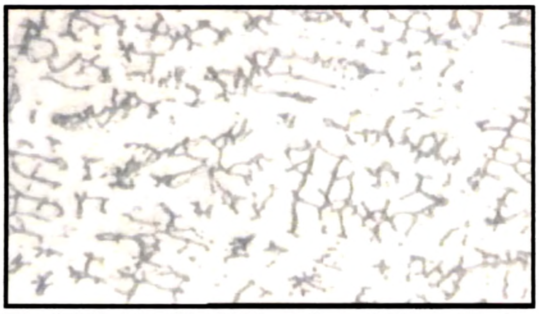


**Fig.4.142 (a) Cladded region of 309 L Clad at 180 WS as welded condition**

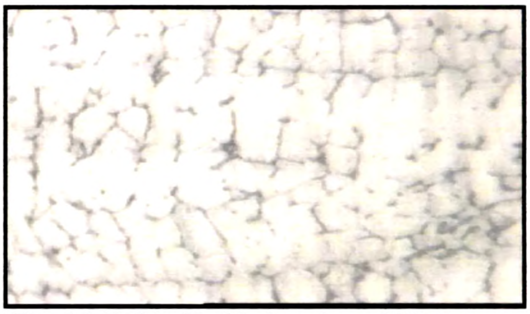


**Fig. 4.142 (b) Cladded region of 309 L Clad at 180 WS after PWHT**

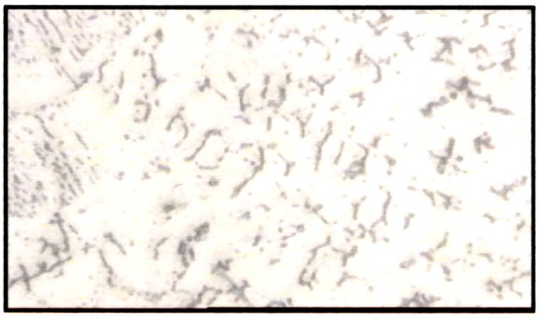


**Fig.4.143 (a) Cladded region of 309 L Clad at 200 WS as welded condition**

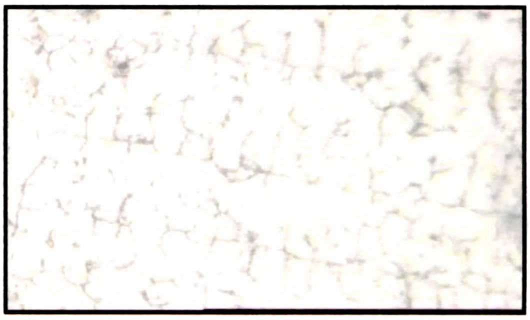


**Fig.4.143 (b) Cladded region of 309 L Clad 200 at WS after PWHT**

Fig.4.141 (a) to fig. 4.143 (a) shows the microstructure of clad region of 309 L Cladded weld overlay at different welding speeds in welded condition while Fig4.141 (b) to fig.

4.143 (b) shows the microstructure of 309 L Cladded weld overlay at different welding speeds after PWHT conditions.

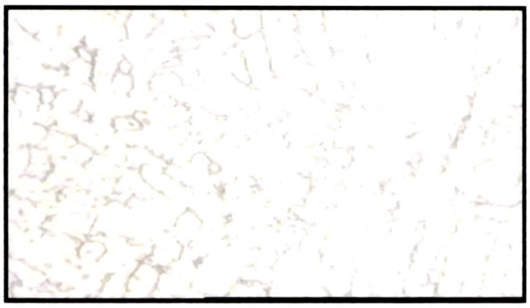


**Fig.4.144 (a) Cladded region of 309 L Nb Clad 160 WS**

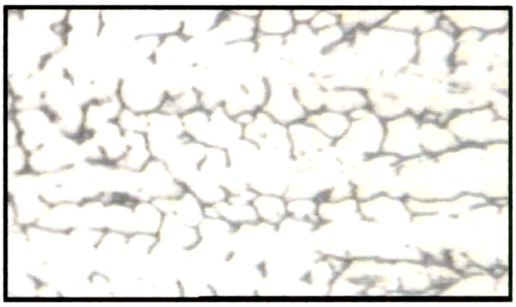


**Fig.4.144 (b) Cladded region of 309 L Nb Clad at 160 WS after PWHT**

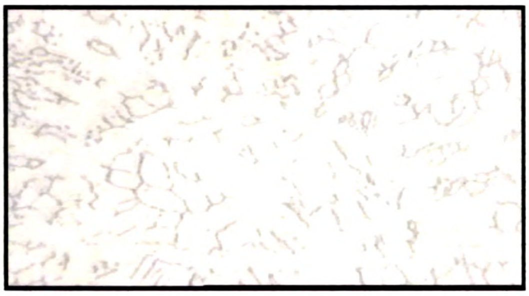


**Fig .4.145 (a) Cladded region of 309 L Nb Clad 180 WS**

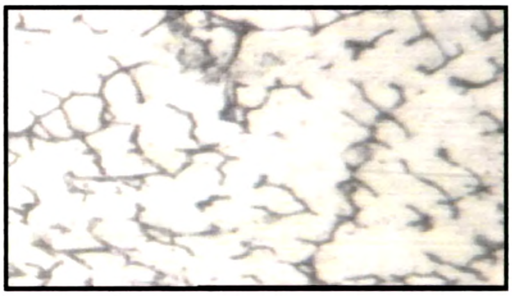


**Fig.4.145 (b) Cladded region of 309 L Nb Clad at 180 WS after PWHT**

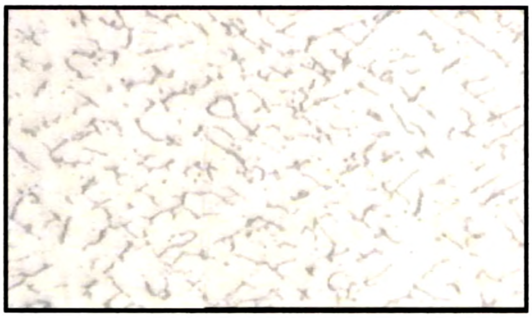


**Fig.4.146 (a) Cladded region of 309 L Nb Clad 200 WS**

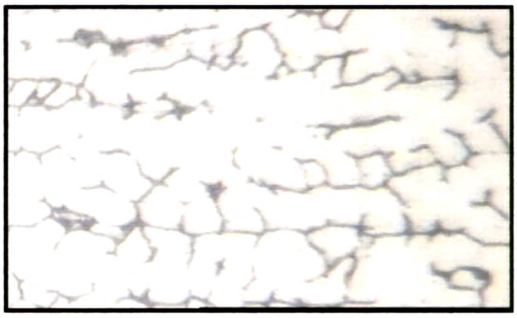


**Fig.4.146 (b) Cladded region of 309 L Nb Clad at 200 WS after PWHT**

Fig.4.144 (a) to 4.146 (a) shows the microstructure of clad region of 309 L Nb Cladded weld overlay at different welding speeds as welded condition while Fig. 4.144 (b) to fig.4.146 (b) shows the microstructure of 309 L Nb Cladded weld overlay at different welding speeds after PWHT conditions.

**Discussion on the micro-structural change at clad region of both weld overlays as welded condition:**

The Aquaregia etchant used reveals predominantly the ferrite distribution in the austenite matrix. In bulk cladding, the modes of solidification were primary ferrite & at the end a peritectic-eutectic reaction results in the formation of austenite along the ferrite cell & dendrite boundaries at all welding speeds at as welded condition for the both weld overlay.

**Discussion on the micro-structural change at clad region of both weld overlay after PWHT:**

After PWHT at $690^0$C for 24 hr holding time the skeletal or vermicular network of ferrite became coarser & amount of austenite phase were increases whereas the ferrite network gets decreases with increase in the welding speed for the both weld overlays. This was further confirmed by ferrite content measurement. It was found that island of ferrite in 309L Nb cladded weld overlay is more thicker as compared to 309L cladded weld overlay which were developed at different speeds[94-96].

### 4.4.1.2 Effect of Post Weld Heat Treatment on Microstructure changes interface region of both weld overlays

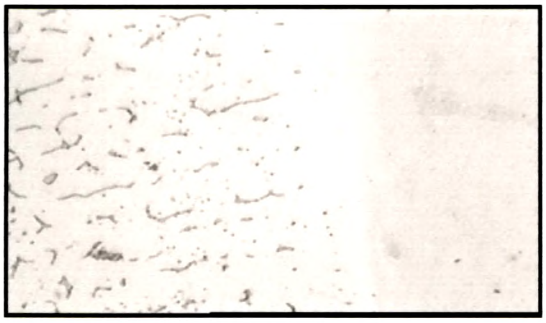


**Fig.4.147 (a) Interface region of 309 L Clad at 160 WS as welded condition**

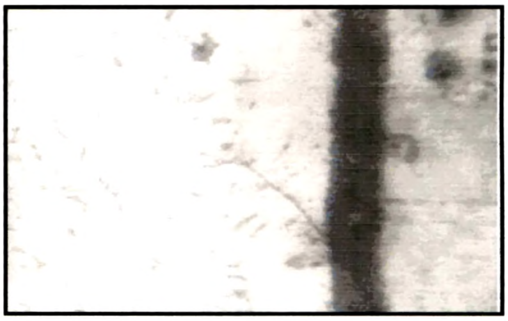


**Fig.4.1467 (b) Interface region of 309 L Clad at 160 WS after PWHT**

**Fig.4.148 (a) Interface region of 309 L Clad at 180 WS as welded condition**

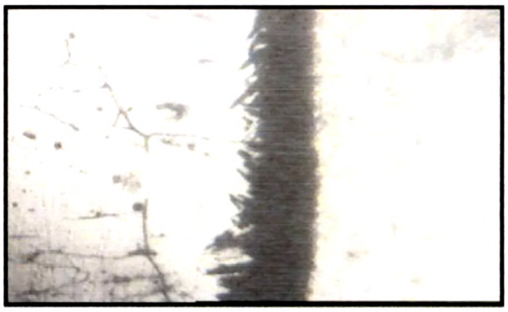


**Fig.4.148 (b) Interface region of 309 L Clad at 180 WS after PWHT**

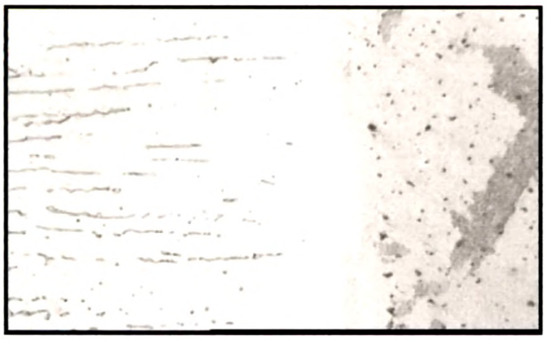


**Fig.4.149 (a) Cladded region of 309 L Clad at 200 WS as welded condition**

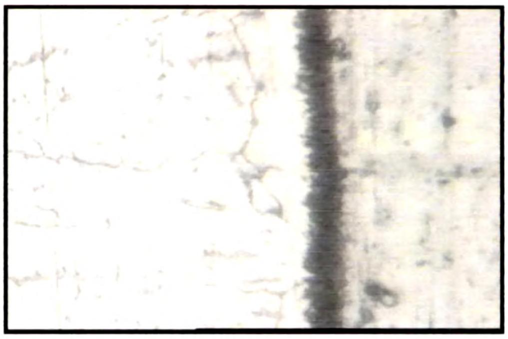


**Fig.4.149 (b) Interface region of 309 L Clad 200 at WS after PWHT**

Fig.4.147 (a) to fig.4.149 (a) shows the microstructure of interface region of 309 L cladded weld overlay at different welding speeds as welded condition while Fig.4.147 (b) to 4.149 (b) shows the microstructure of interface region 309 L cladded weld overlay at different welding speeds after PWHT conditions. The Aquaregia etchant used reveals predominantly the ferrite distribution in the austenite matrix.

**Fig.4.150 (a) Interface region of 309 L Nb Clad at 160 WS as welded condition**

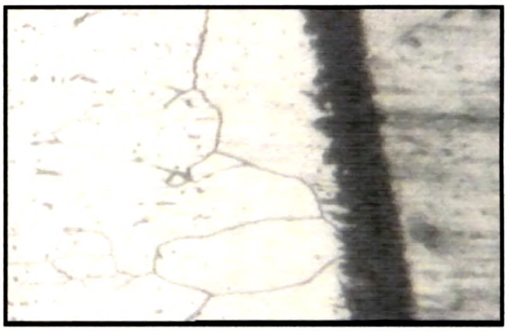


**Fig.4.150 (b) Interface region of 309 L Nb Clad at 160 WS after PWHT**

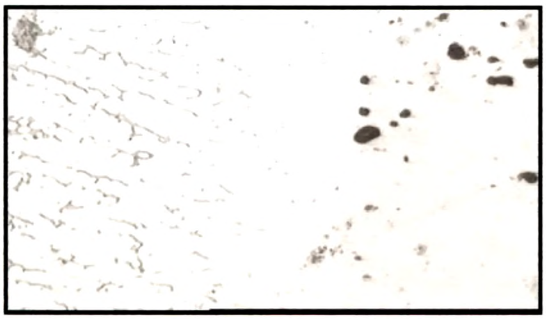


**Fig.4.151 (a) Interface region of 309 L Nb Clad at 180 WS as welded condition**

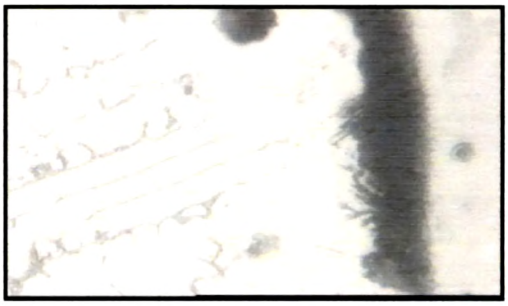


**Fig.4.151 (b) Interface region of 309 L Nb Clad at 180 WS after PWHT**

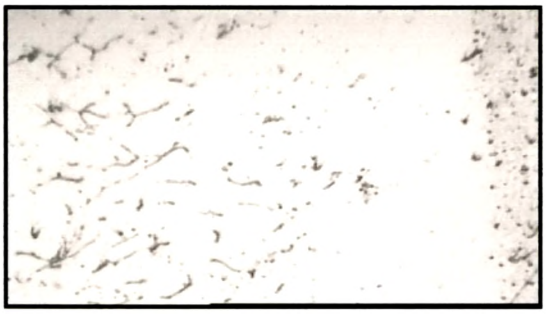


**Fig.4.152 (a) Cladded region of 309 L Nb Clad at 200 WS as welded condition**

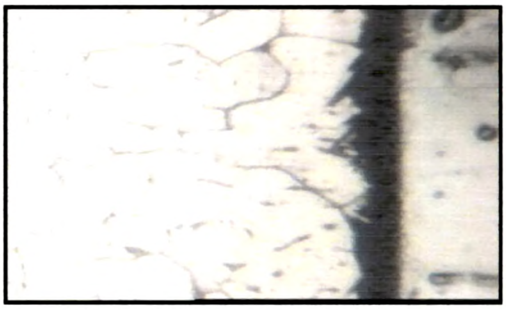


**Fig.4.152 (b) Interface region of 309 L Nb Clad 200 at WS after PWHT**

Fig.4.150 (a) to fig. 4.152 (a) shows the microstructure of interface region of 309 L Nb cladded weld overlay at different welding speeds as welded condition while Fig4.150 (b) to fig. 4.152 (b) shows the microstructure of interface region 309 L Nb cladded weld overlay at different welding speeds after PWHT conditions. The Aquaregia etchant used reveals predominantly the ferrite distribution in the austenite matrix. Micro-structural changes were similar to 309 L cladded weld overlay after PWHT at 690$^0$C for 24 Hr at all welding speeds.

**Discussion on the micro-structural change at interface region of both weld overlays as welded condition:**

Fig. 4.151 (a) shows the interface region of 309L Nb cladded weld overlay developed at 180 mm/min. welding speed. At interface region there were significant composition gradients produced due to a combination of dilution and other factors which have a profound effect on the micro-structural development. The dilution level in the bulk weld metal under ESSC conditions is known to be not more than about 8 to 10% ,but at interface the degree of dilution will be much higher which result in the formation of a stagnant fluid layer in the weld pool adjacent to the base metal. The transition from the low alloy content (Cr, Mo) in the base metal to the high alloy content (Cr, Ni, Nb) in the bulk weld metal occurs in this transition zone. The layer originally had the same composition as the base metal, but develops higher chromium and nickel contents as a result of diffusion from the cladding due to the concentration gradients [97]. The stagnation layer has also been called the unmixed zone. It may be seen from Table -4.39

that Cr contents over 9.06 % and Ni contents around 9.35 % could develop in the transition zone during cladding The composition in the layer is such that during cooling following overlaying this region transforms to martensite. Similar types of micro-structural changes were observed in Fig.4.147 (a) to Fig. 4.152(a).

**Discussion on the micro-structural change at interface region of both weld overlays after PWHT condition**

The microstructures at the weld interface region of both weld overlay developed at different welding speeds after post weld heat treatment exhibit several features of interest. Fig.4.150 (b) reveals a zone in the base metal adjoining the fusion boundary in which there was heavy de-carburization and a structure that is nearly fully ferritic. It shows a thin dark-etching layer on the weld metal side of the fusion boundary. It should be noted that this was the region of the transition zone which in the as-welded condition exhibited a martensitic condition. During the long post weld heat treatment for 24 h at $690^{O}C$, carbon tends to diffuse from the base metal into the cladding on account of the difference in carbon contents: the base metal had 2 .13% C which was reduced to 1.9 % C at base metal near to interface & at interface it was 4.02 % C. The carbon migration is also aided by the fact that chromium content in the clad is far higher than that in the base metal. The migrated carbon from base metal mainly form iron carbide ( FeC ) and litter chromium carbide but not $Cr_{23}C_6$ as volume fraction was not matching with Cr23C6 (11.81% Cr & 4.02 % C) at the weld interface. (Ref. Table 4.51 : Percentage elements present at different location of weld overlay by EDAX analysis) As the carbon thus leaves the base metal, a carbon-depleted zone is formed adjacent to the fusion boundary Such decarburized zones are known to form in heat-treated ferritic- austenitic welds. .Next to this layer on the clad metal side the normal epitaxial nucleation of austenite cannot occur and hence the it is forced to nucleate heterogeneously from the fusion boundary & form Type II boundary of austenite phase which is approximately parallel to the dark-etching layer . Further into the weld metal on the left of the Type II boundary austenitic weld metal structure containing ferrite in the substructure boundaries which is refer as type I boundaries [98]. These results in the formation of Type I & Type II boundaries as shown in Fig.4.149 (b). Results of micro-structural studies of 309 L & 309 L Nb cladded weld overlay developed at different welding speeds after PWHT shows that at clad region of both weld overlays, the island of ferrite become courser and the amount of austenite was increases while the ferrite content was decreases at all welding speeds which were confirmed by ferrite measurements. After PWHT, at interface region of both weld overlays, there is diffusion of carbon atom from base metal region near to interface in the form of iron carbide & next to this layer on the clad metal side it formed Type II boundary of austenite phase which is approximately parallel to the dark-etching layer & further into the weld metal on the left of the Type II boundary austenitic weld metal structure containing ferrite in the substructure boundaries which is refer as type I boundaries. Similar types of micro-structural changes were observed in Fig.4.147 (b) to Fig. 4.152(b).

### 4.4.2 Effect of Post Weld Heat Treatment on Ferrite Content of the weld overlays

**Table- 4.137 : Effect of PWHT on of ferrite content in 309 L & 309 L Nb cladded region**

| Welding speed (mm/min.) | Amount of ferrite Content in 309 L cladded region | | Amount of ferrite Content in 309 L Nb cladded region | |
|---|---|---|---|---|
| | Before PWHT | After PWHT | Before PWHT | After PWHT |
| **160** | 5.4 | 3.7 | 5.1 | 3.6 |
| **180** | 3.7 | 3.1 | 4.6 | 2.8 |
| **200** | 3.3 | 2.0 | 4.3 | 2.6 |

Table-4.137 shows the effect PWHT on the amount of ferrite content in clad region of 309 L & 309 L Nb cladded weld overlays. It reveals that after PWHT amount of ferrite was decreased at all welding speed for the both weld overlays.

### 4.4.3 Effect of Post Weld Heat Treatment on hardness value of weld overlays

#### 4.4.3.1 Effect of post weld heat treatment on hardness value at cladded region of 309L & 309 L Nb cladded weld overlay

**Table- 4.138 : Effect of PWHT on hardness value at clad region**

| Welding speed (mm/min.) | Micro hardness at 309 L cladded region ( VPN) | | Micro hardness at 309 L Nb cladded Region (VPN) | |
|---|---|---|---|---|
| | Before PWHT | After PWHT | Before PWHT | After PWHT |
| **160** | 242 | 227 | 222 | 217 |
| **180** | 260 | 248 | 235 | 223 |
| **200** | 271 | 264 | 254 | 249 |

Table-4.138 shows the effect PWHT on hardness value at clad region of 309 L & 309 L Nb cladded weld overlays. It reveals that after PWHT hardness value was decreased at all welding speed for the both weld overlays due to relieving of stresses.

**4.4.3.2 Effect of Post Weld Heat Treatment on hardness value at interface region of 309L & 309 L Nb cladded weld overlay**

**Table- 4.139 : Effect of PWHT on hardness value interface region**

| Welding speed (mm/min.) | Micro hardness at 309 L cladded region ( VPN) | | Micro hardness at 309 L Nb cladded Region (VPN) | |
|---|---|---|---|---|
| | Before PWHT | After PWHT | Before PWHT | After PWHT |
| 160 | 278 | 307 | 249 | 294 |
| 180 | 289 | 322 | 266 | 305 |
| 200 | 312 | 346 | 281 | 317 |

Table-4.139 shows the effect PWHT on hardness value at interface region of 309 L & 309 L Nb cladded weld overlays. It reveals that after PWHT hardness value was increased at all welding speed for the both weld overlays due to increases in the amount of austenite & decrease the amount of ferrite at this region during cooling[99].

**4.4.3.3 Effect of Post Weld Heat Treatment on hardness value at base metal**

**Table- 4.140 : Effect of PWHT on Hardness value at base Metal**

| Welding speed (mm/min.) | Micro hardness at base metal (VPN) | |
|---|---|---|
| | Before PWHT | After PWHT |
| **160** | 206 | 190 |
| **180** | 208 | 184 |
| **200** | 210 | 179 |

Table-4.140 shows the effect PWHT on hardness value at base metal. It reveals that after PWHT hardness value was decreased at all welding speed due to relieving of stresses which was generated during solidification of cladding.

### 4.4.4 Effect of Post Weld Heat Treatment on Corrosion Behaviour of weld overlays

**4.4.4.1 Effect of Post Weld Heat Treatment on pitting Corrosion susceptibility:**

**4.4.4.1.1 Effect of welding speed on pitting corrosion behaviour of base metal of cladded weld overlay after PWHT in 6% $FeCl_3$ Solution**

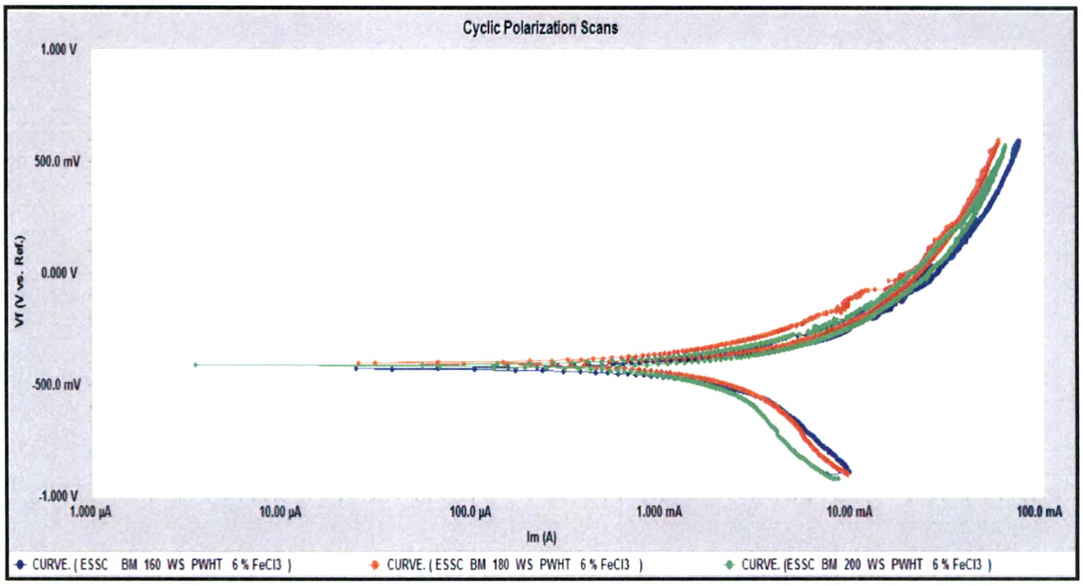



**Fig. 4.153 Cyclic polarization scans of base metal at different welding speed after PWHT in 6% $FeCl_3$ Solution**

**Table-4.141 : Electrochemical Parameters of cyclic polarization Scan base metal after PWHT in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-BM 309L 160 WS PWHT | 585.0 | -429.0 | -400.5 | 878.4 |
| 2 | ESSC-BM 309L 180 WS PWHT | 305.0 | -400.0 | -401.6 | 457.0 |
| 3 | ESSC-BM 309L 200 WS PWHT | 330.0 | -412.0 | -419.5 | 494.8 |

Fig. 4.153 show the Cyclic polarization scans of base of cladded weld overlay at different welding speed after PWHT in 6% $FeCl_3$ Solution. By comparing corrosion behavior of base metal of cladded weld overlay at different welding speeds in 6% $FeCL_3$ solution it shows that $E_{rp} < E_{corr}$ for 160,180 & 200 mm / minute welding speed so here

pitting will occur and corrosion rate will increase because damaged passive film will not get repaired.

#### 4.4.4.1.2 Effect of Welding Speed on Pitting corrosion behaviours of 309 L cladded weld overlays after PWHT in 6% $FeCl_3$ Solution

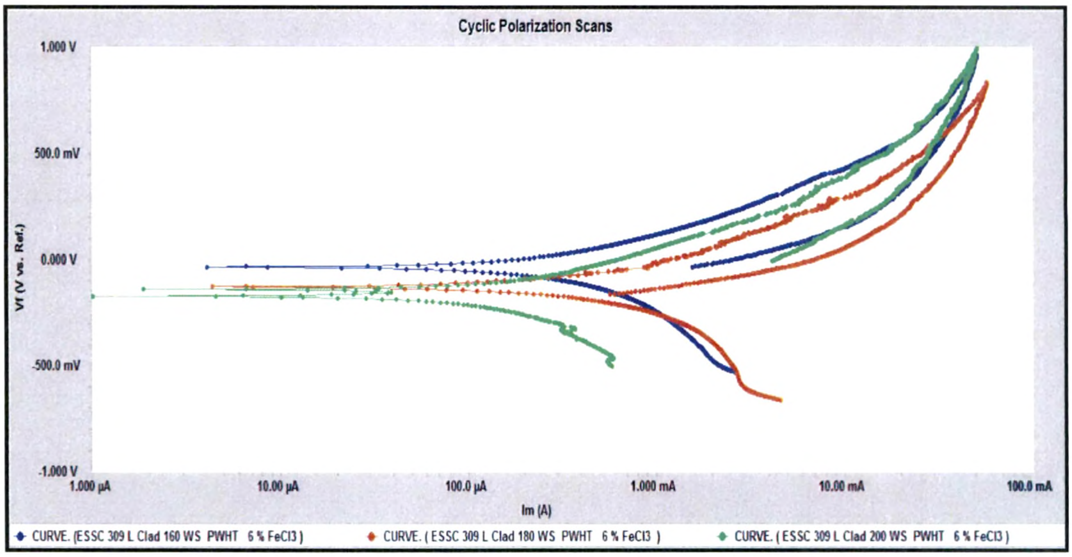



**Fig. 4.154 : Cyclic polarization scans of cladded region of 309L cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution**

**Table-4.142 : Electrochemical Parameters of cyclic polarization Scan of cladded region 309L cladded weld overlays after PWHT in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309L Clad 160 WS PWHT | 88.50 | -33.10 | -87.37 | 132.9 |
| 2 | ESSC-309L Clad 180 WS PWHT | 40.80 | -127.0 | -178.5 | 61.20 |
| 3 | ESSC-309L Clad 200 WS PWHT | 124.0 | -173.0 | -298.8 | 185.8 |

Fig. 4.154 show the cyclic polarization scans of 309L cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution. By comparing corrosion behavior of cladded region, it shows that all scans exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for all welding speeds which implies that pitting will occur and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility.

### 4.4.4.1.3 Effect of welding speed on pitting corrosion behaviours of clad region of 309 L Nb cladded weld overlays after PWHT in 6% $FeCl_3$ Solution

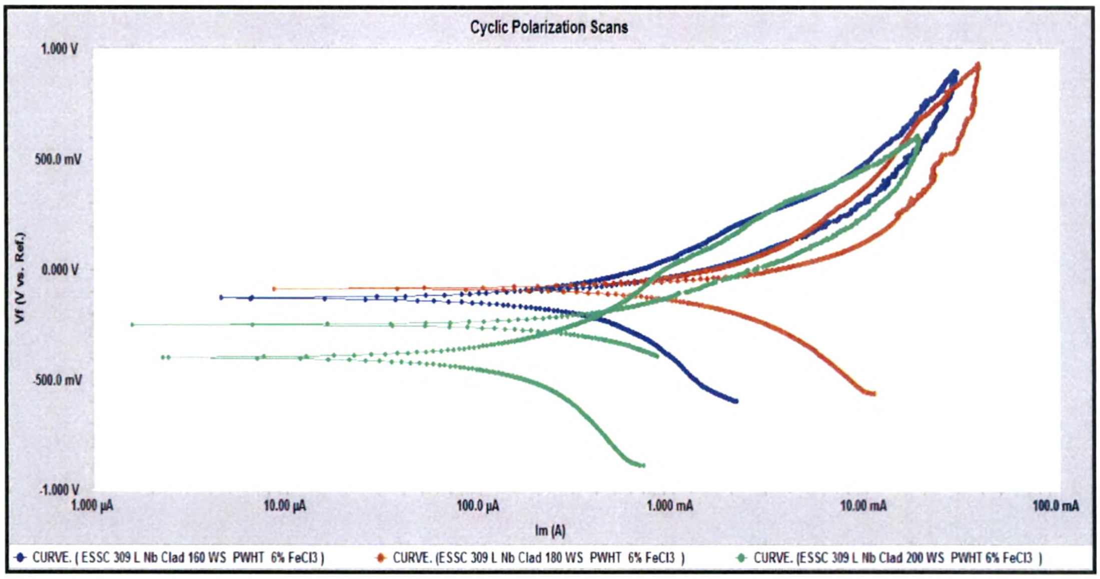



**Fig. 4.155 : Cyclic polarization scans of clad region of 309LNb Cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution**

**Table-4.143 : Electrochemical Parameters of cyclic polarization scan clad region of 309LNb Cladded weld overlays after PWHT in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC-309L Nb Clad 160 WS PWHT | 49.10 | -126.0 | -110.5 | 73.63 |
| 2 | ESSC-309L Nb Clad 180 WS PWHT | 215.0 | -82.70 | -67.37 | 322.3 |
| 3 | ESSC-309L Nb Clad 200 WS PWHT | 268.0 | -395.0 | -181.9 | 402.8 |

Fig. 4.155 show the Cyclic polarization scans of 309L Nb cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution. By comparing corrosion behavior of cladded region, it shows that cladded region of at all welding speeds exhibit negative hysteresis which indicates that the reverse scan current density is less than that for the forward scan. Here $E_{rp} > E_{corr}$ for all welding speeds which indicate that the pitting will occur but damaged passive film will get repaired & protecting further pitting corrosion susceptibility.

**4.4.4.1.4 Effect of Welding Speed on Pitting corrosion behaviours of Interface 309 L cladded weld overlays after PWHT in 6% $FeCl_3$ Solution**

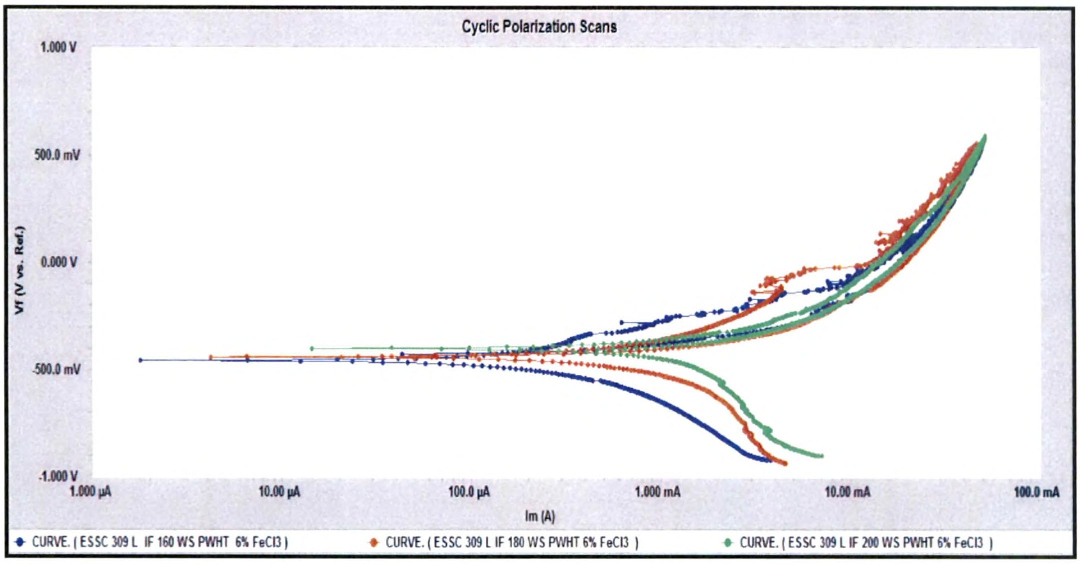



**Fig. 4.156 : Cyclic polarization scans of interface region 309L cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution**

**Table-4.144 : Electrochemical Parameters of cyclic polarization Scan of interface region309L cladded weld overlays after PWHT in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | $E_{rp}$ (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC- 309L IF 160 WS PWHT | 112.0 | -456.0 | -467.1 | 167.9 |
| 2 | ESSC- 309L IF 180 WS PWHT | 617.0 | -400.0 | -412.7 | 925.5 |
| 3 | ESSC- 309L IF 200 WS PWHT | 42.30 | -440.0 | -447.7 | 63.52 |

Fig. 4.156 show the cyclic polarization scans of interface region of 309L cladded weld overlays at different welding speed after PWHT in 6% $FeCl_3$ Solution. By comparing corrosion behavior of cladded region, it shows that all scans exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} < E_{corr}$ for all welding speeds which implies that pitting will occur and damaged passive film will not get repaired that results in increase in pitting corrosion susceptibility.

### 4.4.4.1.5 Effect of Welding Speed on Pitting corrosion behaviours of interface region of 309 L Nb cladded weld overlays in 6% $FeCl_3$ Solution

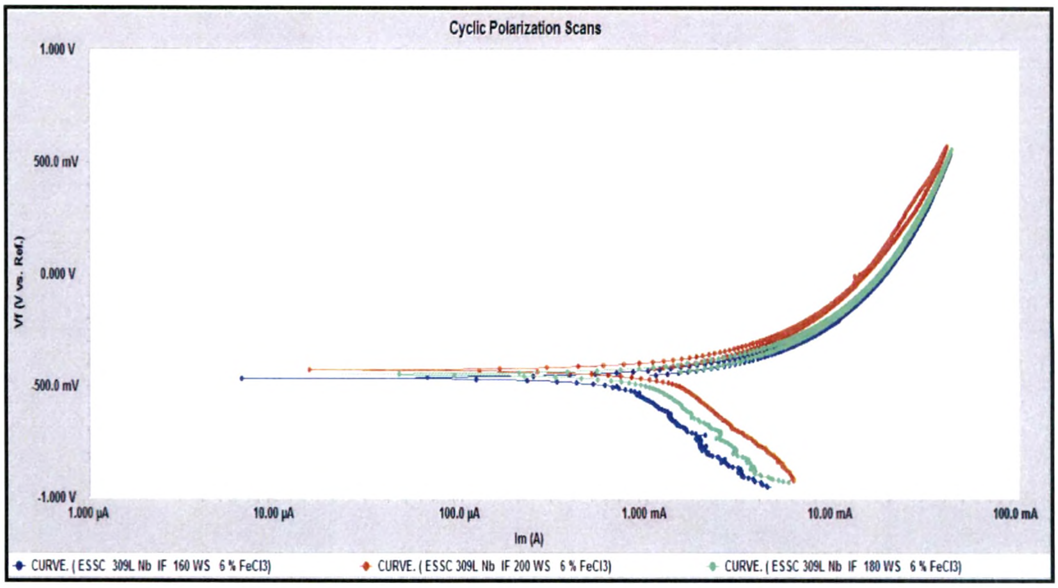



**Fig. 4.157 : Cyclic polarization scans of interface region of 309LNb Cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution**

**Table-4.145 : Electrochemical Parameters of cyclic polarization Scan interface region of 309LNb Cladded weld overlays in 6% $FeCl_3$ Solution**

| Sr. No | Samples | $I_{Corr}$ (µA) | $E_{Corr}$ (mV) | Erp (mV) | Corrosion Rate (mpy) |
|---|---|---|---|---|---|
| 1 | ESSC- 309L Nb IF 160 WS PWHT | 98.80 | -289.0 | -281.2 | 148.2 |
| 2 | ESSC- 309L Nb IF 180 WS PWHT | 344.0 | -519.0 | -284.7 | 515.9 |
| 3 | ESSC- 309L Nb IF 200 WS PWHT | 82.70 | -456.0 | -418.6 | 124.1 |

Fig. 4.157 shows the cyclic polarization scans interface region of 309L Nb cladded weld overlays at different welding speed in 6% $FeCl_3$ Solution. By comparing corrosion behavior of interface region, it shows that cladded region of at all welding speeds exhibit positive hysteresis which indicates that the reverse scan current density is greater than that for the forward scan. Here $E_{rp} > E_{corr}$ for all welding speeds which implies that pitting will occur and damaged passive film will get repaired that results in decreases susceptibility toward pitting corrosion.

**Table-4.146 : Comparisons of pitting behaviour of both weld overlay before & after PWHT**

| Sr. No | Samples | Relation between $E_{pp}$ & $E_{corr}$ | |
|---|---|---|---|
| | | Before PWHT condition | After PWHT condition |
| 1 | ESSC – 309L Clad 160 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 2 | ESSC- 309L Clad 180 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 3 | ESSC- 309L Clad 200 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 4 | ESSC – 309L IF 160 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 5 | ESSC- 309L IF 180 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 6 | ESSC- 309L IF 200 WS | $E_{rp} < E_{corr}$ | $E_{rp} < E_{corr}$ |
| 7 | ESSC – 309L Nb Clad 160 WS | $E_{rp} < E_{corr}$ | $E_{rp} > E_{corr}$ |
| 8 | ESSC- 309L Nb Clad 180 WS | $E_{rp} > E_{corr}$ | $E_{rp} > E_{corr}$ |
| 9 | ESSC- 309L Nb Clad 200 WS | $E_{rp} < E_{corr}$ | $E_{rp} > E_{corr}$ |
| 10 | ESSC – 309L Nb IF 160 WS | $E_{rp} < E_{corr}$ | $E_{rp} > E_{corr}$ |
| 11 | ESSC- 309L Nb IF 180 WS | $E_{rp} < E_{corr}$ | $E_{rp} > E_{corr}$ |
| 12 | ESSC- 309L Nb IF 200 WS | $E_{rp} < E_{corr}$ | $E_{rp} > E_{corr}$ |

The results of cyclic polarization studies of 309 L & 309 L Nb cladded weld overlay developed at different welding speeds before & after PWHT is shown in tablw-4.142. From these results it can be concluded that there is no improvements in pitting resistance at clad as well as at interface region of 309 L cladded weld overlay at different welding speeds but in case of 309 L Nb cladded weld overlays exhibit better pitting resistance at clad as well as at interface region developed at different welding speeds .

**4.4.4.2 Effect of Post Weld Heat Treatment on IGC susceptibility of weld overlays**

**4.4.4.2.1 Effect of Welding Speed on corrosion behaviour of clad region of 309 L cladded weld overlay after PWHT in 0.1 H2SO4 + 0.01 M NaCl Solution**

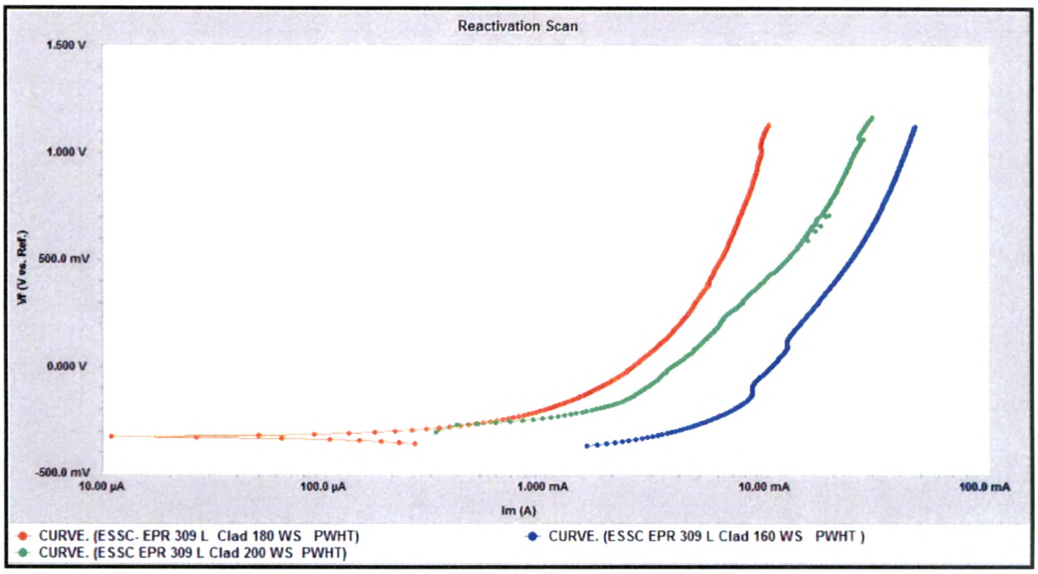



**Fig. 4.158 : EPR scans of clad region of 309L cladded weld overlays after PWHT at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table - 4.147 : Peak Current density of EPR scans ofcladded region of 309L cladded weld overlays after PWHT**

| Sr. No | Samples | Peak Current density ($A/cm^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Clad 160 WS PWHT | $4.69 \times 10^{-2}$ |
| 2 | ESSC-EPR 309L Clad 180 WS PWHT | $1.03 \times 10^{-2}$ |
| 3 | ESSC-EPR 309L Clad 200 WS PWHT | $3.01 \times 10^{-2}$ |

Fig. 4.158 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309L cladded weld overlay which were developed at different welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decreased with increasing the welding speed from 160 to 180 mm /min

welding speed then after it was increased at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed[100-101].

### 4.4.4.2.2 Effect of Welding Speed on corrosion behaviour of cladded region of 309 L Nb Cladded weld overlay after PWHT in 0.1 H2SO4 + 0.01 M NaCl Solution

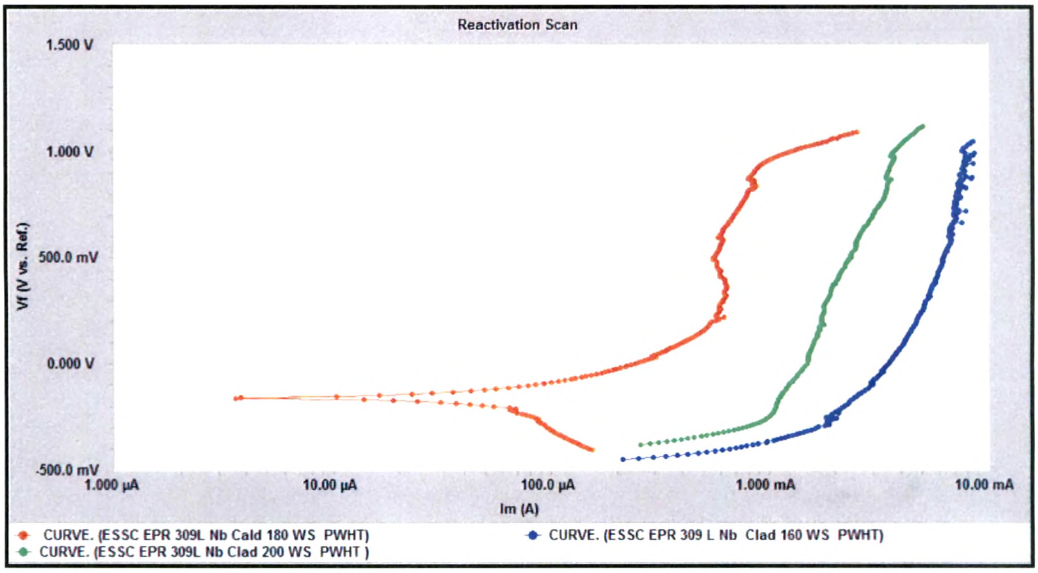



**Fig. 4.159 : EPR scans of clad region of 309LNb cladded weld overlays at after PWHT at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table- 4.148 : Peak Current density of EPR scans ofcladded region of 309LNb cladded weld overlays after PWHT**

| Sr. No | Samples | Peak Current density (A/cm) |
|---|---|---|
| 1 | ESSC –EPR 309L Nb Clad 160 WS-PWHT | **8.64 x $10^{-3}$** |
| 2 | ESSC-EPR 309L Nb Clad 180 WS-PWHT | **2.53 x $10^{-3}$** |
| 3 | ESSC-EPR 309L Nb Clad 200 WS-PWHT | **5.03 x $10^{-3}$** |

Fig. 4.159 show the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of cladded region of 309LNb cladded weld overlay which were developed at different welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the

degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decrease with increasing the welding speed from 160 to 180 mm /min welding speed then after it was increase at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed [100-101].

**4.4.4.2.3 Effect of Welding Speed on corrosion behaviour of interface region of 309 L Cladded weld overlay after PWHT in 0.1 H2SO4 + 0.01 M NaCl Solution**

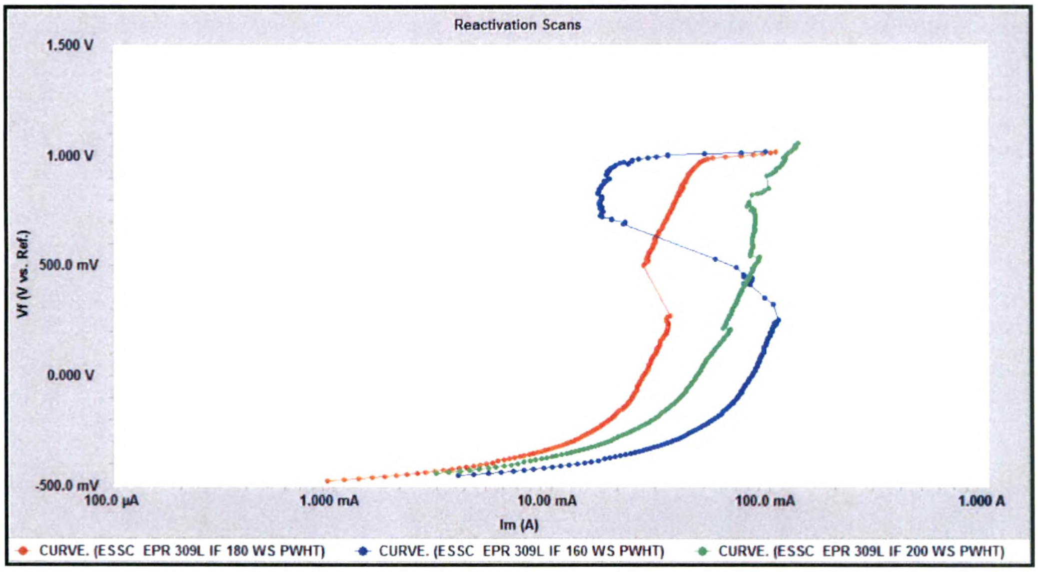



**Fig. 4.160 : EPR scans of interface of 309L cladded weld overlays after PWHT at different welding speed in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table- 4.149 : Peak Current density of EPR scans of intefcae region of 309L cladded weld overlays after PWHT**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L IF 160 WS-PWHT | **5.68 x $10^{-2}$** |
| 2 | ESSC-EPR 309L IF 180 WS-PWHT | **3.81 x $10^{-2}$** |
| 3 | ESSC-EPR 309L IF 200 WS-PWHT | **3.90 x $10^{-2}$** |

Fig. 4.160 shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309L cladded weld overlay which were developed at different welding speed after PWHT. EPR test was conducted under de-

aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decrease with increasing the welding speed from 160 to 180 mm /min welding speed then after it was slightly increase at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

**4.4.4.2.4 Effect of Welding Speed on corrosion behaviour of interface region of 309 L Nb Cladded weld overlay after PWHT in 0.1 H2SO4 + 0.01 M NaCl Solution**

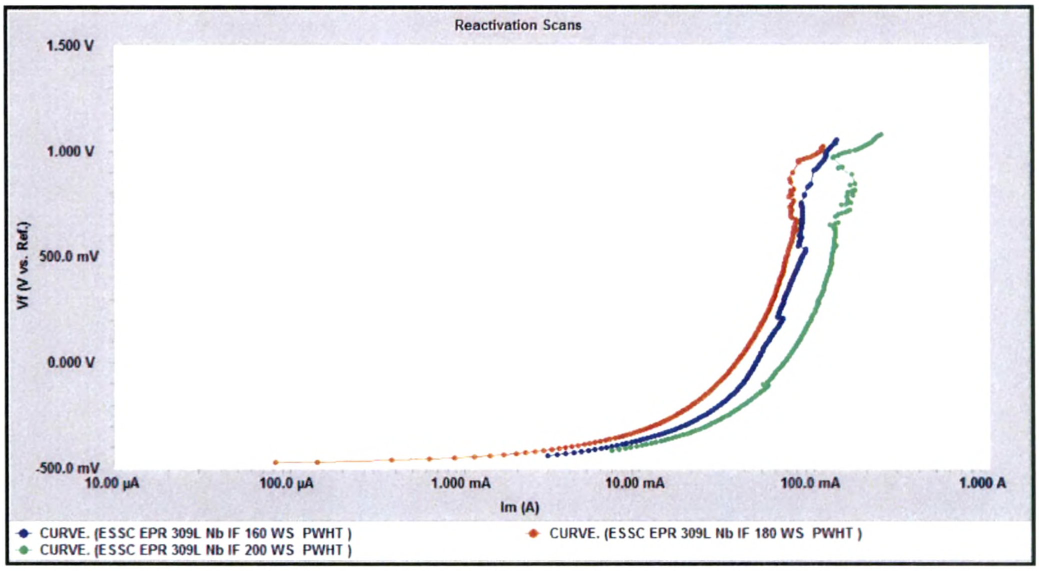



**Fig. 4.161 : EPR scans of interface of 309LNb cladded weld overlays after PWHT at different welding speeds in 0.1 $H_2SO_4$ + 0.01 M NaCl Solution**

**Table-4.150 : Peak Current density of EPR scans o f intefcae region of 309 LNb cladded weld overlays after PWHT**

| Sr. No | Samples | Peak Current density (A/cm$^3$) |
|---|---|---|
| 1 | ESSC –EPR 309L Nb IF 160 WS-PWHT | **1.37 x $10^{-2}$** |
| 2 | ESSC-EPR 309L Nb IF 180 WS-PWHT | **1.05 x $10^{-2}$** |
| 3 | ESSC-EPR 309L Nb IF 200 WS-PWHT | **1.06 x $10^{-2}$** |

Fig. 4.161shows the combination of single loop electrochemical potentio-kinetic reactivation (EPR) test of interface region of 309LNb cladded weld overlay which were developed at different welding speed after PWHT. EPR test was conducted under de-aerated condition at room temperature in 0.1 $H_2SO_4$ + 0.01 M NaCl solution to assess the degree of sensitization (DOS) in terms of peak current density. Results indicate that sensitization was decrease with increasing the welding speed from 160 to 180 mm /min welding speed then after it was slightly increase at 200 mm / min welding speed but it was less than that of 160 mm/min welding speed.

**Table- 4.151 : Comparisons of sensitization behaviour of weld overlays before and PWHT**

| Sr. No | Samples | Peak Current density (A/cm$^3$) | |
|---|---|---|---|
| | | As Received condition | PWHT condition |
| 1 | ESSC –EPR 309L Clad 160 WS | 2.72 x $10^{-2}$ | 4.69 x $10^{-2}$ |
| 2 | ESSC-EPR 309L Clad 180 WS | 1.16 x $10^{-2}$ | 1.03 x $10^{-2}$ |
| 3 | ESSC-EPR 309L Clad 200 WS | 1.86 x $10^{-2}$ | 3.01 x $10^{-2}$ |
| 4 | ESSC –EPR 309L IF 160 WS | 3.86 x $10^{-2}$ | 5.68 x $10^{-2}$ |
| 5 | ESSC-EPR 309L IF 180 WS | 2.71 x $10^{-2}$ | 3.81 x $10^{-2}$ |
| 6 | ESSC-EPR 309L IF 200 WS | 9.16 x $10^{-2}$ | 3.90 x $10^{-2}$ |
| 7 | ESSC –EPR 309L Nb Clad 160 WS | 1.52 x $10^{-2}$ | 8.64 x $10^{-3}$ |
| 8 | ESSC-EPR 309L Nb Clad 180 WS | 1.04 x $10^{-2}$ | 2.53 x $10^{-3}$ |
| 9 | ESSC-EPR 309L Nb Clad 200 WS | 1.22 x $10^{-2}$ | 5.03 x $10^{-3}$ |
| 10 | ESSC –EPR 309L Nb IF 160 WS | 3.91 x $10^{-2}$ | 1.37 x $10^{-2}$ |
| 11 | ESSC-EPR 309L Nb IF 180 WS | 1.81 x $10^{-2}$ | 1.05 x $10^{-2}$ |
| 12 | ESSC-EPR 309L Nb IF 200 WS | 6.55 x $10^{-2}$ | 1.06 x $10^{-2}$ |

The results of EPR studies of 309 L & 309 L Nb cladded weld overlay developed at different welding speeds after PWHT shows that the degree of sensitization was decreases at clad region as well as at interface region of 309L Nb cladded weld overlay developed at different welding speeds while in case of 309 L cladded weld overlays, the degree of sensitization was decreases at clad region of weld overlay developed at 180 mm/min welding speed & at interface region of weld overlay developed at 200 mm/min welding speed [100-101].