CHAPTER VII

LABORATORY AND FIELD TRIALS

7.1 Laboratory Trials

The instrumentation and software developed was extensively tested in the laboratory complex of ERDA. The different faults such as rotor faults, stator faults, eccentricity faults, bearing faults, misalignment were created. The induction motor of 1hp was taken for the experiment purpose and was loaded with the dynamometer.

The Rotor fault was created by drilling a hole in between the rotor bar and end ring. The stator fault was created by shorting the tapings taken out from stator at 2 turn, 4 turn and 15 turns through rheostat to control the fault current. The bearing fault was created by replacing the driving end bearing with the scrapped bearing having multiple fault on inner race and outer race. The eccentricity fault was created by shifting the end shield bearing housing by 0.1 mm radially. The misalignment was created between motor shaft and dynamometer shaft by mounting the motor with vertical height difference of about 2- 3mm.

The voltage and current signature of the motors were taken at each fault individually with help of instrumentation and software developed by ERDA. The signature for different fault simulated in the laboratory are given below

Rotor Fault

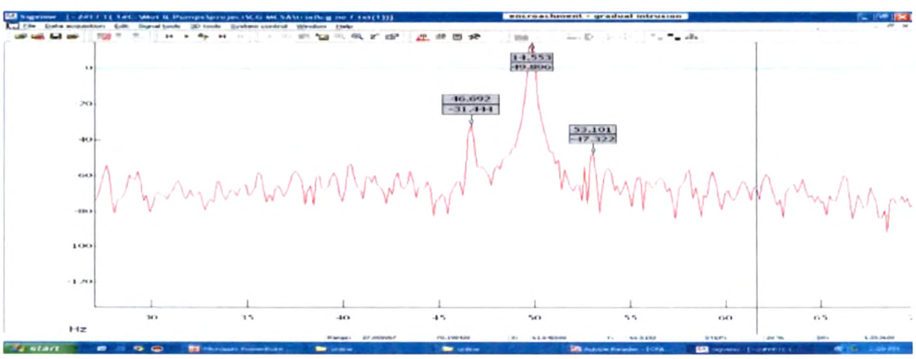


Figure 7.1: Current signature w/o rotor fault

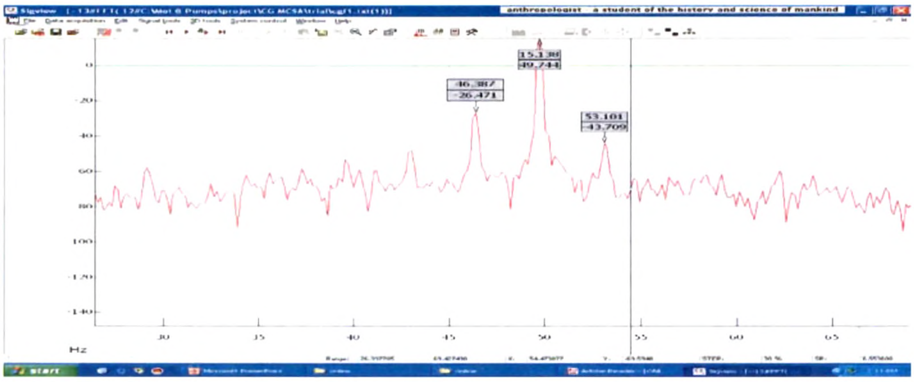


Figure 7.2: Current Signature with rotor Fault.

Figures 7.1 & 7.2 shows the current signature of motor without and with rotor fault of one bar failure. As per the fault detection algorithm developed in section 4.3, the software calculates the side band frequencies fb1 and fb2 along with its magnitude. As per the algorithm figures 7.1 shows the magnitude of side bands and compares it with fundamental. The ratio of fb1 to fundamental is more than 45 db, hence no faults exist. However figure 7.2 show the ratio is less than 45 db, which confirms the fault with one bar failure. Hence this validates the algorithm and software developed for rotor faults.

Eccentricity Fault

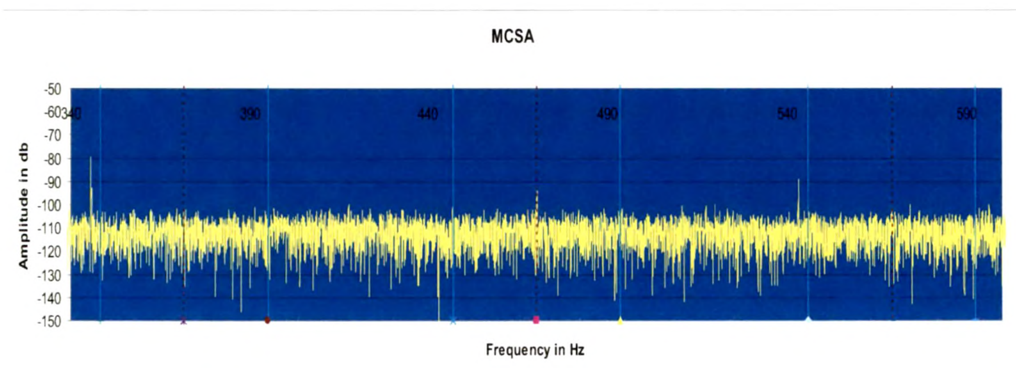


Figure 7.3: Current signature w/o Eccentricity fault

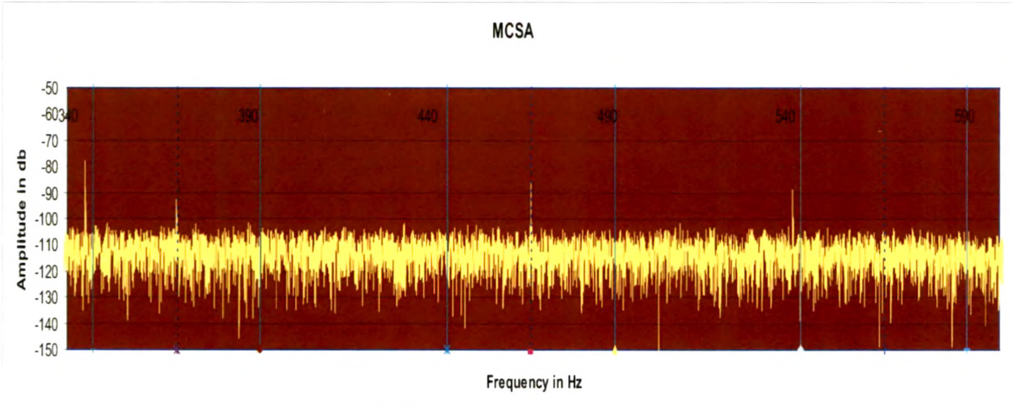


Figure 7.4: Current signature with Eccentricity fault

Figures 7.3 & 7.4 shows the current signature without and with eccentricity fault. As per the algorithm developed in section 4.3, Software calculates the frequency components related to the eccentricity faults as per the equation 3.28 & 3.29. These values are shown in the signature as shown in figure 7.3 by blue lines. These components are not seen in the signature. It also calculates the difference between the fec-d and fec –s components, which is more than 15 db in this case as shown in figure 7.3. Hence no eccentricity faults exits. As per figure 7.4 with static eccentric fault, we can see the components of fec –s by blue dotted lines, at 360 Hz and 460 Hz, and there difference from previous signature is more than 10db. This conforms the static eccentric fault. The fec-d components are not visible, which also conforms the ability of algorithm and software to identify and distinguish between the static and dynamic eccentric faults

Stator Faults

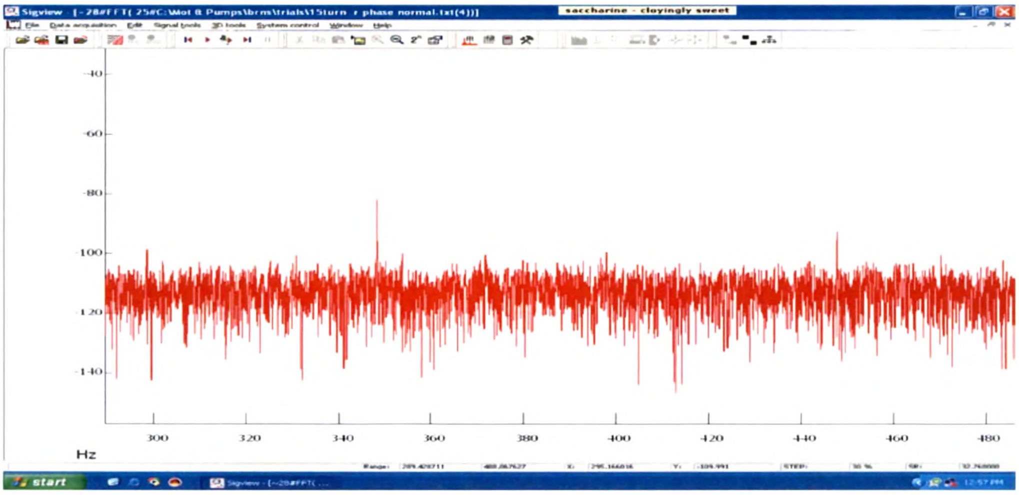


Figure 7.5: Current signature w/o Stator fault

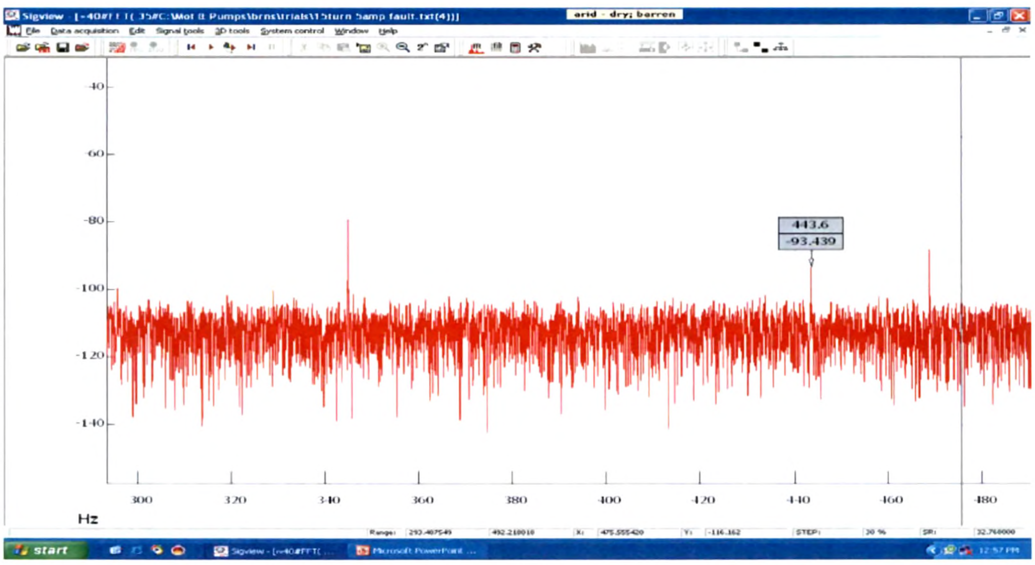
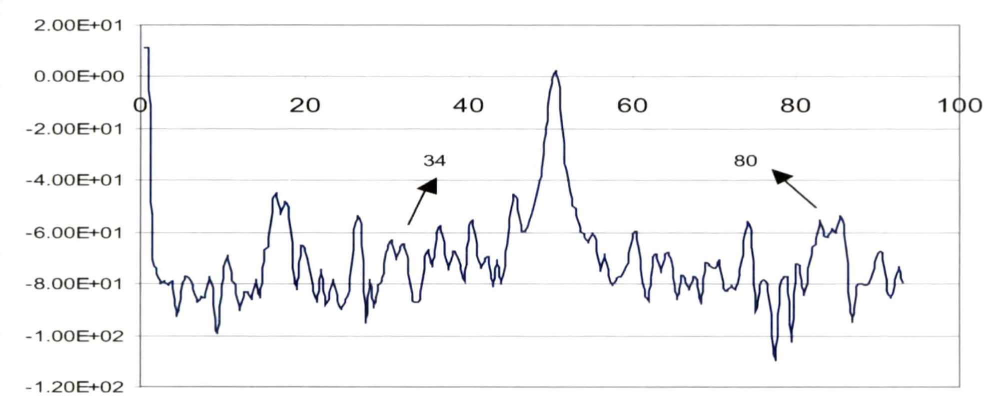


Figure 7.6: Current signature with stator fault- 15turn short

Figures 7.5 & 7.6 shows the current signature without & with stator inter turn fault. As per the algorithm in section 4.3, software calculates the frequency components as per equation 3.28 & 3.38 for different values of n & k. As shown in figure these components are not visible in the current spectrum for healthy motor. As shown in figure 7.6, one of these components at 443.6 Hz, the frequency peak is visible having a absolute magnitude of 93.4 db, which more than 10db increase from its previous value. As per algorithm in section 4.3, this confirms the stator inter fault in the motor.

Bearing Faults



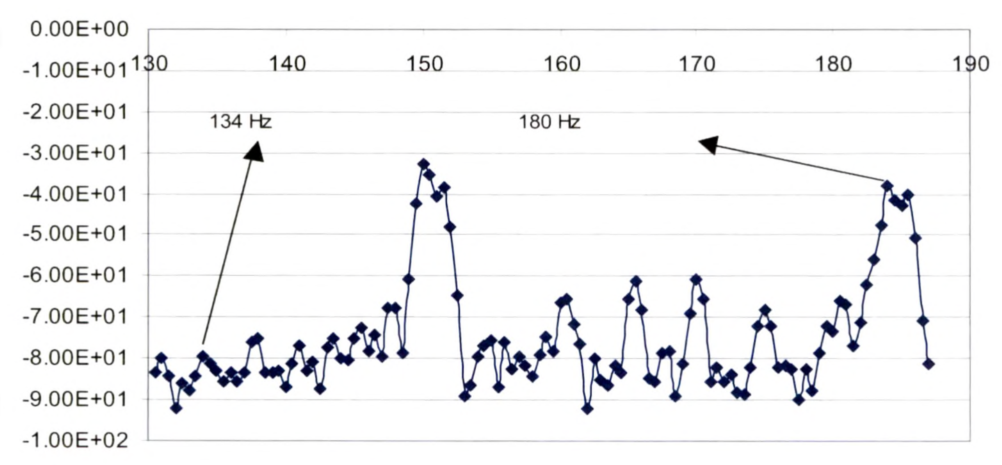


Figure 7.7: Current Signature in respective frequency bands with bearing fault-multiple fault on inner and outer race.

Figure 7.7. shows the current signature with bearing faults on inner and outer race of bearing. The software calculates fault frequency for bearing as per equation (3.25), (3.26). The calculates bearing frequency were 34 Hz, 84Hz, 134Hz & 180Hz. These all frequencies are visible in the current spectrum, with lower magnitude. However difference in magnitude from previous measurement was around 10db with extreme fault on outer and inner race. This confirms the capability of software to detect the late bearing faults.

Misalignment

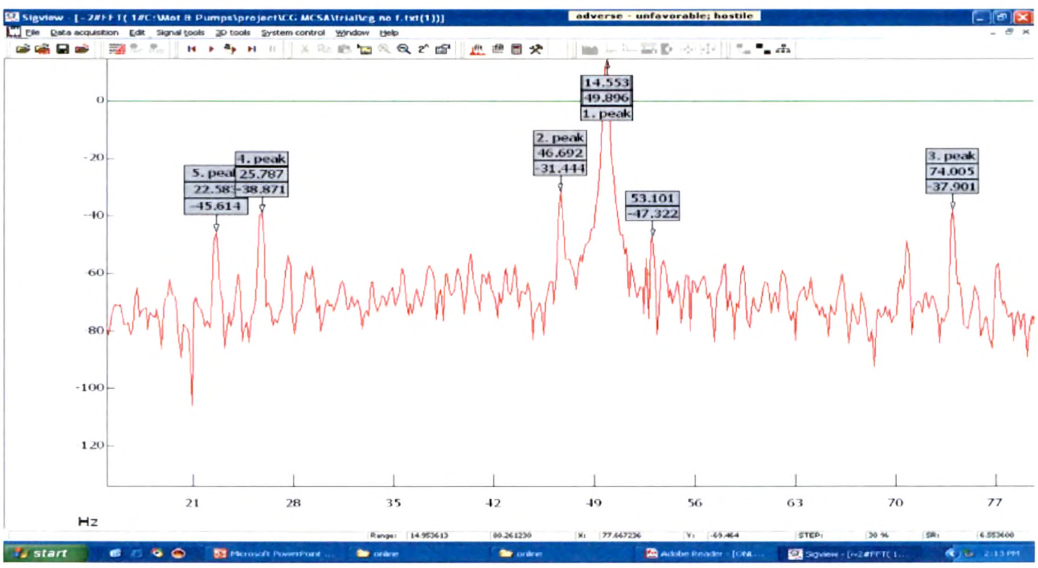


Figure 7.8: Current Signature with Misalignment between motor shaft and dynamometer

Figure 7.8 shows the current signature with misalignment between motor shaft and dynamometer shaft axis. The algorithm calculates the frequencies as per the equation 3.29. These frequencies are shown in figure 7.8 at 25.78 Hz and 74.00Hz with absolute magnitude of 38.87db and 37.9 db respectively. As per the algorithm, this confirms that misalignment exists between the motor shaft and dynamometer shaft.

7.2 Field Trials

After successful completion of laboratory trials, the field trials were undertaken to analyze the use of instrumentation and its capabilities to analyze the fault at site. More than 150 motors were analyzed in different units such as Kakrapar Atomic power Station, Rajasthan Atomic power station, SKF bearing, Maharashtra Thermal power station etc. The different motors analyzed were

Boiler Feed Pump Motors
Primary Water Pump Motors
Cooling Water Circulation Motors
Bearing Grinding Motors

The instrumentation was able to capture online the 3 line voltages and 3 line current from the motor control panel. The software was able to analyze the signal captured. Out of above motors, majority of problem detected at site were of Torque pulsations and misalignment. In couple of motors, instrument has detected the rotor bar failure. The current signature for these problems has been given below.

The Details analysis report of each motor are given the Annexure A

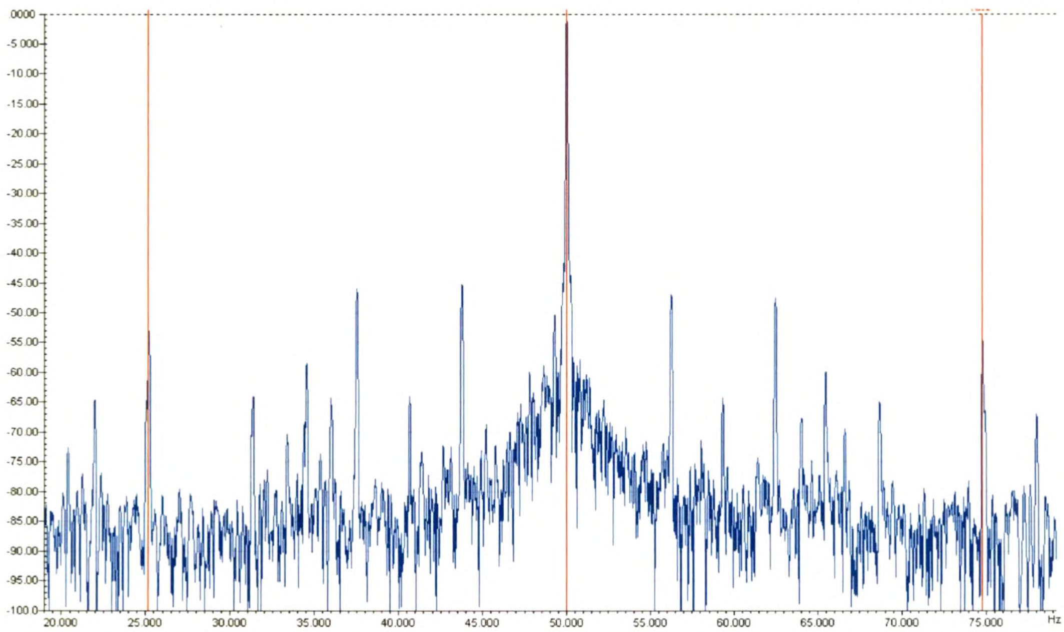


Figure 7.9: Current Signature with Torque Pulsation

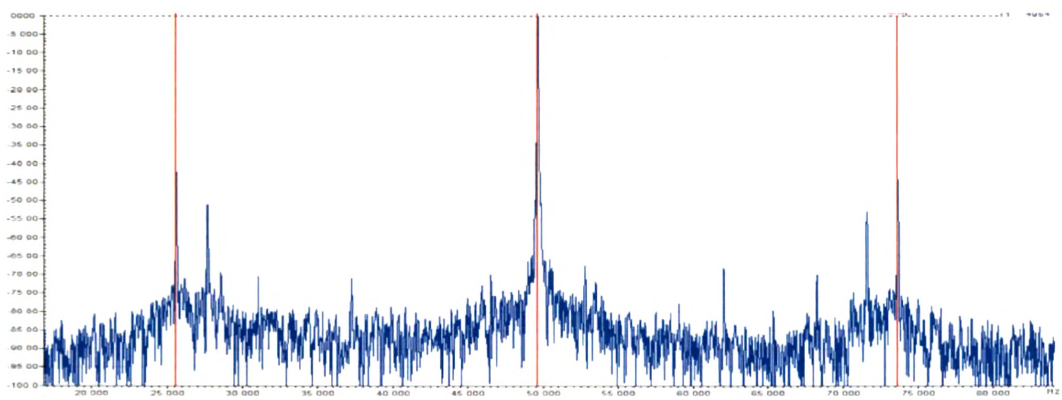


Figure 7.10: Current Signature with Misalignment /Unbalance

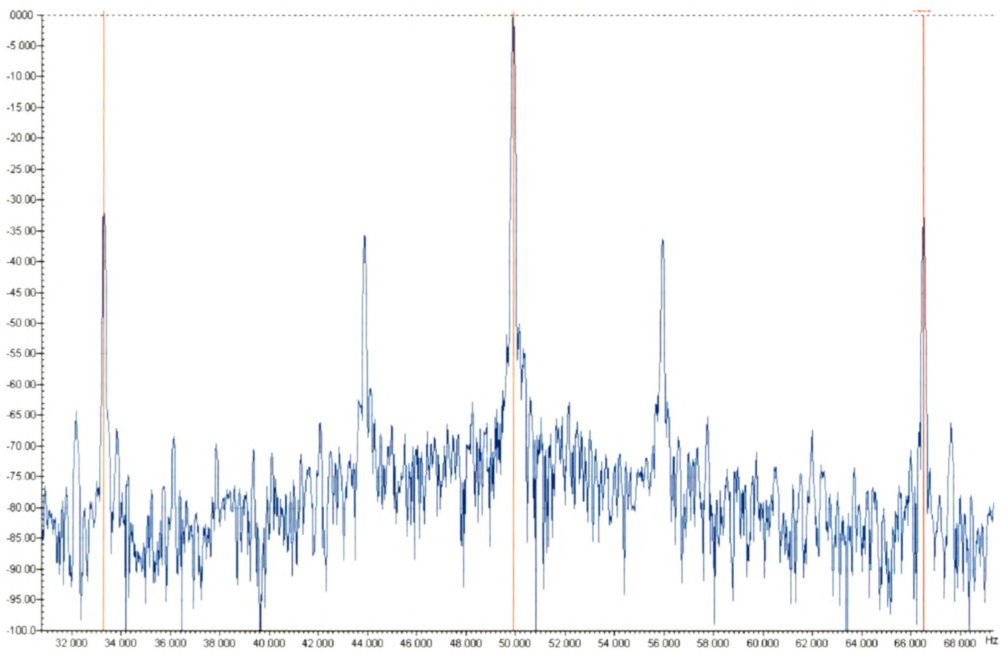


Figure 7.11: Current Signature with Rotor fault

7.3 Conclusion

The instrumentation developed is extensively tested in laboratory conditions and also at field conditions. The working of instrumentation was satisfactory in both the cases. The instrumentation diagnosed various faults in laboratory conditions and it also diagnosed the critical faults such Rotor faults, misalignment, Torque pulsations in the field conditions. The instrumentation is capable of recording the online three phase voltage and currents successfully at site and it is also capable of performing the analysis based on fault detection algorithm.