

# Table of Contents

---

| Chapter No. | Title                                                        | Page No. |
|-------------|--------------------------------------------------------------|----------|
|             | List of Figures                                              | xi       |
|             | List of Tables                                               | xiv      |
|             | Abstract                                                     | xv       |
| 1           | Introduction                                                 | 1        |
|             | 1.1 Introduction                                             | 2        |
|             | 1.2 Direct Warping                                           | 2        |
|             | 1.3 Sectional Warping                                        | 3        |
|             | 1.4 Objectives of the Work                                   | 5        |
| 2           | Literature Review                                            | 7        |
|             | 2.1 General                                                  | 8        |
|             | 2.2 Effect of Process Control Parameters                     | 9        |
|             | 2.2.1 Quality of Beam                                        | 9        |
|             | 2.2.2 Objectives for Designing Beam for Direct Warper        | 13       |
|             | 2.2.3 Objectives for Designing Beam for Sectional Warper     | 15       |
|             | 2.2.4 Yarn Stresses on a Beam                                | 16       |
|             | 2.2.5 Problems of Running Smaller Lots                       | 17       |
|             | 2.2.6 Problems of Calculating Movement for Sectional Warping | 18       |
|             | 2.3 Patents                                                  | 19       |
|             | 2.3.1 Modifications in the Creel                             | 19       |
|             | 2.3.1.1 Circular Creel                                       | 20       |
|             | 2.3.1.2 Automatic switching of threads in creel              | 22       |

|  |                                                                    |    |
|--|--------------------------------------------------------------------|----|
|  | 2.3.2 Modifications of the beam flanges                            | 23 |
|  | 2.3.2.1 Use of metal sleeve                                        | 23 |
|  | 2.3.2.2 Modifications based on smaller beams                       | 27 |
|  | 2.3.2.3 Flange with metal and coating                              | 28 |
|  | 2.3.2.4 Conical shaped flange                                      | 30 |
|  | 2.3.2.5 Patent about width adjustment of weaver's beam             | 32 |
|  | 2.3.3 Sections in the beam                                         | 33 |
|  | 2.3.3.1 Early Version of Sectional Warping                         | 33 |
|  | 2.3.3.2 Patents about Setting Warp on Beam                         | 34 |
|  | 2.3.3.3 Problems with beams to be used for multi width working     | 36 |
|  | 2.3.3.4 Using narrow width beams for normal yarns                  | 37 |
|  | 2.3.3.5 Using narrow width beams for specialty yarns               | 39 |
|  | 2.3.3.6 Producing two beams from one sectional warping drum        | 41 |
|  | 2.3.3.7 Section Beams with Separator Plates                        | 42 |
|  | 2.3.4 Beams with Adjustable Sections                               | 42 |
|  | 2.3.4.1 Multiple beamer for Raschel Knitting with width adjustment | 43 |
|  | 2.3.4.2 Double Warp beam Warper                                    | 45 |
|  | 2.3.4.3 Double beam for warping or sizing                          | 46 |
|  | 2.3.4.4 Dividing the warp by semicircular disc                     | 48 |

|   |                                                              |          |
|---|--------------------------------------------------------------|----------|
|   | 2.3.4.5 Variable Separator Plates                            | 49       |
|   | 2.3.4.6 Dividable / Divisional Beams for<br>creel efficiency | 53       |
| 3 | Concept of Designing and Prototyping                         | 59       |
|   | 3.1 Aim of the Work                                          | 60       |
|   | 3.1.1 Problems related with Direct Warping                   | 60       |
|   | 3.1.2 Problems related with Sectional Warping                | 61       |
|   | 3.1.3 Flow chart of the work done                            | 61       |
|   | 3.2 Designing a Manual Model                                 | 63       |
|   | 3.3 Brief about NX Software                                  | 65       |
|   | 3.4 3D Printing                                              | 67       |
|   | 3.4.1 Working Principle of 3D printer                        | 67       |
|   | 3.4.2 Methods of 3D Printing                                 | 68       |
|   | 3.4.2.1 Stereolithography (SLA)                              | 68       |
|   | 3.4.2.2 Digital Light Processing (DLP)                       | 68       |
|   | 3.4.2.3 Fused Deposition Modeling (FDM)                      | 70       |
|   | 3.4.2.4 Selective Laser Sintering (SLS)                      | 70       |
|   | 3.4.2.5 Selective Laser Melting (SLM)                        | 70       |
|   | 3.4.2.6 Electronic Beam Melting (EBM)                        | 71       |
|   | 3.4.2.7 Laminated Object Manufacturing<br>(LOM)              | 71       |
|   | 3.4.3 Features of Dimension SST 1200 es 3D<br>Printer        | 73<br>74 |
|   | 3.5 Design of the Model using NX software                    | 75       |
|   | 3.5.1 First Attempt                                          | 79       |
|   | 3.5.1.1 Design of Outer Barrel                               | 80       |
|   | 3.5.1.2 Design of Inner Barrel                               | 81       |
|   | 3.5.1.3 Design of Flanges                                    | 83       |
|   | 3.5.1.4 Design of Inner Fixed Flange                         | 86       |
|   | 3.5.1.5 Design of Separator Plates                           | 87       |
|   | 3.5.1.6 Design of Retainer Block                             | 89       |

|   |                                                      |     |
|---|------------------------------------------------------|-----|
|   | 3.5.1.7 Main Assembly                                | 90  |
|   | 3.5.1.8 3D Modelling                                 | 91  |
|   | 3.5.1.8.1 3D Graphic Modelling                       | 93  |
|   | 3.5.1.8.2 Motion Simulation                          | 93  |
|   | 3.5.2 Second Attempt                                 | 94  |
|   | 3.5.2.1 Design of Inner barrel                       | 95  |
|   | 3.5.2.2 Design of Separator Plate                    | 96  |
|   | 3.5.2.3 Full Assembly                                | 96  |
|   | 3.5.3 Third Attempt                                  | 97  |
|   | 3.5.3.1 Design of Inner barrel                       | 98  |
|   | 3.5.3.2 Design of Separator Plate                    |     |
|   | 3.5.3.3 Full Assembly                                |     |
| 4 | Result and Discussion                                | 100 |
|   | 4.1 Introduction                                     | 101 |
|   | 4.2 3D Prototype                                     | 101 |
|   | 4.2.1 Parts – First Attempt                          | 102 |
|   | 4.2.2 Motion Simulation of Prototype – First Attempt | 104 |
|   | 4.2.3 Parts – Third Attempt                          | 106 |
|   | 4.2.4 Motion Simulation of Prototype – Third Attempt | 107 |
|   | 4.3 Measurements                                     | 109 |
|   | 4.3.1 Measurements for Second Attempt                | 110 |
|   | 4.3.2 Calculations for Second Attempt                | 115 |
|   | 4.3.3 Measurements for Third Attempt                 | 117 |
|   | 4.3.4 Calculations for Third Attempt                 | 118 |
| 5 | Conclusions                                          | 119 |
|   | 5.1 Major Outcomes                                   | 120 |
|   | 5.2 Scope for Future Work                            | 122 |
| 6 | References                                           | 123 |
| 7 | List of Publications                                 | 129 |