Chapter 3

Concept of Designing and Prototyping

3 Concept of Designing and Prototyping

3.1 Aim of the Work

The broad objective of the work is to develop a system of warping by which both types of yarns, i.e. single colored or multi-colored, can be warped on the same machine. The research work progressed in following sequence:

i. Understanding the problem of warping which limit the use for different types of yarns.

ii. Designing manual model for a warping system for unified approach to warping by which any type of yarn can be warped on the same system. Also understanding various issues in the model.

iii. Preparing a Computer Aided Design using a dedicated mechanical engineering design software.

iv. Preparing a 3D model of the design so developed and running in a virtual mode to understand the applicability of the model.

v. Preparing a prototype model, based on the design developed, with the help of a 3D printer system.

Warping is one of the oldest process in use by the mankind. It is an inherent part of the process of making woven fabric. Out of many systems of warping in use today, the focus in this work is on two main systems viz. direct and sectional.

3.1.1 Problems related with Direct Warping

As mentioned in earlier chapter, direct warping is used for mass production of mono colored warp threads. The main problems of the system for universality are as below:

i. The system runs at a very high speed so it is justified for large length of the yarns to be taken per beam and hence for mass production of simple variety.

ii. The creel used has a limit to the upper number. So several beams are required to be prepared containing lesser number of threads than the final requirement.

iii. Due to above reason it is practically not possible to use multi-color warp as an assembly of beams make up the total ends and hence combining the warp thread pattern at a later on stage will not be possible.

3.1.2 Problems related with Sectional Warping

As mentioned in earlier chapter, sectional warping is used for production of multi-color warp threads. The system will also be preferred for single color warp if the length to be warped is less and / or if the sizing is not required to be done. The main problems of the system for using it otherwise are as below:

i. The system is suitable mainly for patterned warp and not economical for single color warp.

ii. It is practically not possible to take length of warp equal to direct warping as there is a limit due to conical shaped drum and its storage capacity.

iii. It is a two stage process i.e. warping and beaming.

So both systems have their own set of applications and there is no single system which can run both types of warp threads. In this research work, an attempt has been made to provide solution to the problem by redesigning the warp beam so as to run all kinds of warp threads.

3.1.3 Flow chart of the work done

Literature Review

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Study of Patents and related prior Art

↓

Understanding Limitations of both systems of warping

↓

Developing a Card Board Model

↓

Taking the concept to NX software
& preparing first rough 2D sketch
of various parts with measurements

↓

Designing the model (First Attempt)

↓

Virtual 3D modelling of the model (First Attempt)

↓

Designing the model (Second Attempt)

↓

Virtual 3D modelling of the model (Second Attempt)

↓

Designing the model (Third Attempt)
Virtual 3D modelling of the model (Third Attempt)

↓

3D Printing of the Third Attempt version

↓

Sample Calculations

3.2 Designing a manual model

It will be useful to list down basic requirements out of a beam if it is meant to run both kinds of warp threads. Following is the list of such requirements.

i. A beam should be able to contain large length of yarn. To ensure, it should be able to take enough diameter of the flanges.

ii. A beam should have provision to accommodate multi-color warp threads to be wound in small width sections.

iii. Beam should have flanges which are adjustable.

iv. It should be possible to adjust width of all the sections independently in a quick manner. The adjustment should be sufficiently accurate.

v. Beam should have the provision for maintaining width of all sections throughout the width and along the length of the warp.

vi. The beam should have an even surface of the barrel so all threads are under same tension.

vii. The beam should be able to be processed in the next level i.e. sizing or loom.

The first step in the designing process was to prepare a manual model with the help of simple raw material to understand the basic requirements for full scale designing. A manual model of the beam is as shown in the figure 3.1 which shows the rough idea about the design.

Manual model was made using simple card board material to get an idea about the practical difficulties to be solved while designing with CAD software. Figure 3.1 shows a beam with barrel with an outer and inner rollers. Both are newly conceptualized. It also shows that the whole width of the beam has been divided in to several segments with the help of separator plates. These separator plates have a strip at a point where it is touching the outer barrel.

There are two flanges as usual (in figure only one is made) but the difference is that both flanges are adjustable. There is one more inner flange which is provided on the barrel surface and can be kept movable or fixed. This inner flange can also be combined with separator plates.

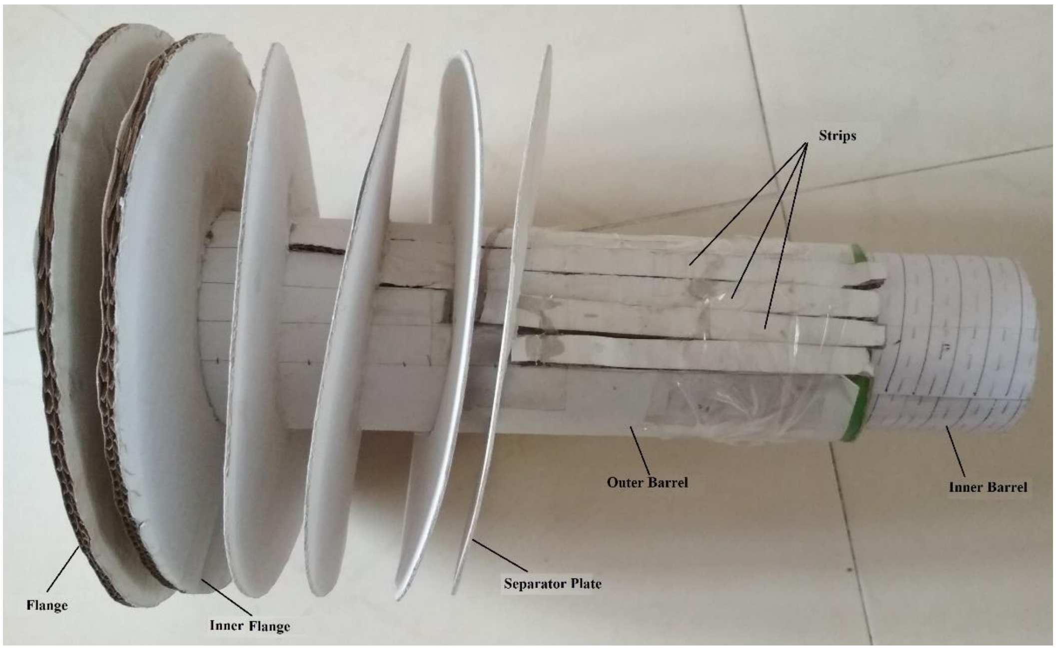


Fig. 3.1 Manual Model

The outer barrel has staggering slots made on to it to accommodate strips which are made on to separator plates. The inner barrel fits inside the outer barrel and has toothed surface. The teeth are supposed to engage with the teeth made at the end of the strip (not shown in the figure).

The whole concept of making such a newly designed beam was found to be feasible from the manual model and a CAD design of the same was prepared using the NX software as provided by Siemens Product Lifecycle Management (PLM).

3.3 Brief about NX Software

The history of the NX software goes back up to 1972 when United Computing Inc. released UNIAPT, one of the world’s first end-user CAM products. In 1973, the company purchased the Automated Drafting and Machining (ADAM) software code from MCS which became a foundation for a product sold commercially as Unigraphics software (51). Later on, for quite some time, the software was owned by GM as their corporate CAD software.

There was another software named I-DEAS (Integrated Design and Engineering Analysis Software) used primarily in the automobile industry. Mainly Ford and GM motors were using the software.

In 2002, first time release of the new "Next Generation" version of Unigraphics and I-DEAS, called NX, happened which started the transition to bring the functionality and capabilities of both Unigraphics and I-DEAS together into a single consolidated product.

In 2007 Siemens Product Lifecycle Management (PLM) took the charge of the software and introduced Synchronous Technology in NX 5 version. Currently NX 12 is in use. The work presented here has been done using version 9. The software is highly useful and has many applications. Some of them are listed below:

- Parametric solid modeling
- Freeform surface modelling
- Reverse engineering
- Styling and computer-aided industrial design
- Engineering drawing (Drafting)
- Product and manufacturing information (PMI)
- Reporting and analytics, verification and validation
- Knowledge reuse, including knowledge-based engineering
- Sheet metal design
- Assembly modelling and digital mockup
- Routing for electrical wiring and mechanical piping

NX is the product development solution from Siemens PLM Software and delivers the advanced performance and leading-edge technologies one needs to master complexity. It supports every aspect of product development, from concept design through engineering and manufacturing, provides an integrated toolset that coordinates disciplines, preserves data integrity and design intent, and streamlines the entire process.

NX also enables collaboration between designers, engineers and the broader organization through integrated data management, process automation, decision support and other tools.

Figure 3.2 below shows one of the screens of the software. The software has an associative integration with all NX product development solutions, including NX industrial design, electromechanical, simulation, tooling and machining solutions. It also has an automated, real-time design validation checking to monitor functional requirements.

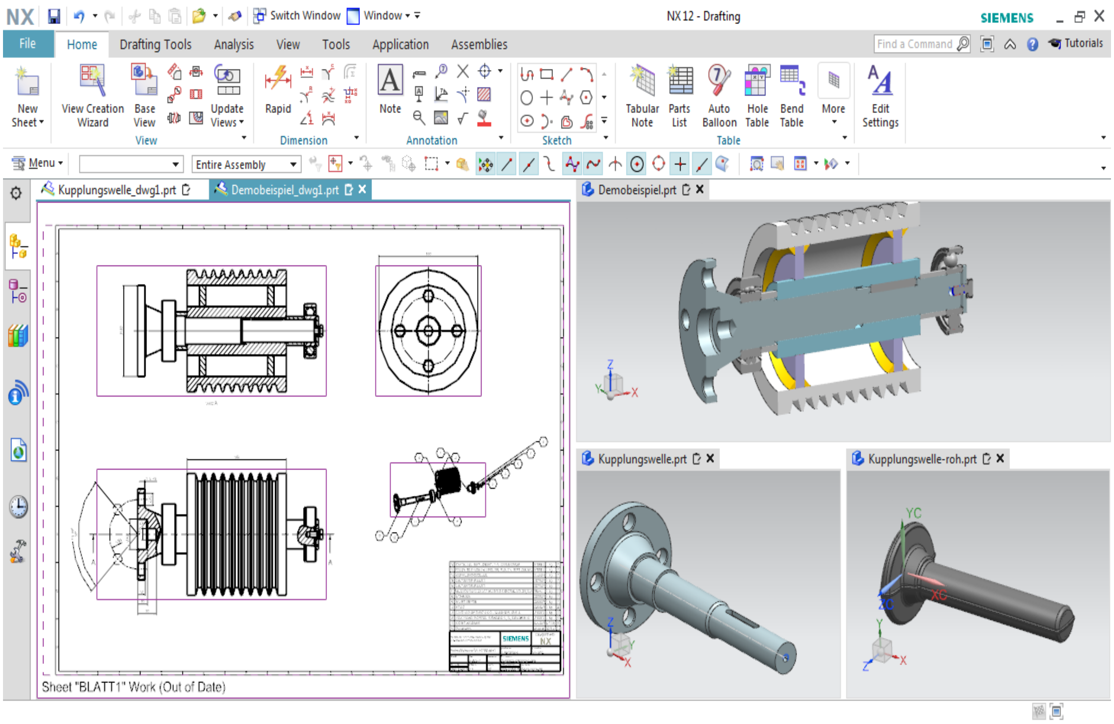


Fig 3.2 Screen of NX Software

3.4 3D Printing

3D printing, also known as additive manufacturing, has been described as a disruptive technology that powers the next industrial revolution, thus transforming the way designers visualize concepts and manufacturers develop and create products. This innovative technology may sound impressively advanced and technical, it is so simple that it cannot be in any way comprehended (52).

Additive manufacturing is attracting well- deserved interest and attention under the name 3D printing. It is helping companies worldwide pushing the limit of innovation while reducing cost, streamlining operations and accelerating time to the market. With the availability of engineering grade materials, 3D printed parts can be more geometrically complex, lighter weight, easier to assemble and just durable as traditionally manufactured parts.

3D printing is a process where a physical object is made from a three-dimensional digital model, typically by superimposing several thin layers of a material. The earliest use of additive manufacturing was for rapid prototyping during the late 1980s and 1990s. Instead of simply producing prototypes, 3D printers are now also used to create finished high-quality products. (53, 54)

The process is getting faster and cheaper and is becoming more mainstream, shifting the creative power back to the individual. Because each object is built up uniquely, 3D printing is especially great for making unique and customized items, or small series of objects.

Rapid Prototyping refers to the process that fabricates a physical model from 3D digital data, such as CAD files, by using 3D printing technology. Without the need of assembling separate components, prototypes with movable parts can easily be produced in a single print.

The application has been widely adopted across various industries, such as automotive, consumer goods, electronics, architecture and healthcare sectors, in design validation and form, fit, functional tests such as ergonomics, thermal and mechanical strength testing. Rapid Prototyping is valuable to product designers and engineers who aim to shorten design iteration cycle time and minimize costs and resources, subsequently accelerating time-to-market of new products.

Direct Digital Manufacturing (DDM) is a process that uses 3D printing technology to produce manufacturing tools and production parts directly from CAD files, without machining, molding or casting. In comparison to removing material through traditional (or subtractive) fabrication methods, finished goods are produced by adding material layer by layer. Using production-grade thermoplastics with high mechanical properties that accommodate large-format printing, DDM is ideal for high-mix low-volume production, molds, patterns and tools such as jigs and fixtures that require high complexity and intricate geometries.

3.4.1 Working Principle of 3D printer

Following are the steps of operation for making a prototype using 3D printing concept.

(i) 3D drawing is created through computer-aided design (CAD) software.

(ii) The CAD file is converted to STL (Standard Triangle Language or STereoLithography) file and digitally sliced. The file is sent to 3D printer, printing materials are then selected.

(iii) 3D printer lays down successive layers of materials to build up the model from a series of cross sections.

(iv) Removal of support material and a 3D model is done. Post-processing may be required.

3.4.2 Methods of 3D printing

The term Additive Manufacturing may comprise of technologies like Rapid Prototyping, Direct Digital Manufacturing, Layered Manufacturing and 3D Printing. There are different 3D printing procedures which are developed and available to build 3D structures and objects. A short description of all popular methods is presented below (55). FDM method has been used to produce prototype in the work presented here.

3.4.2.1 Stereolithography (SLA)

Stereolithography method is the oldest one in history of 3D printing and is still being used currently. The process of printing involves a uniquely designed 3D printing machine called a stereolithograph apparatus (SLA), which converts liquid plastic into solid 3D objects.

3.4.2.2 Digital Light Processing (DLP)

Digital Light Processing is yet another 3D Printing process which is very similar to stereolithography. It uses micro mirrors, operating digitally, laid out on a semiconductor chip. The technology is applicable to 3D printing for film/movie projectors, mobile phones etc. DLP as well as SLA works with photopolymers.

3.4.2.3 Fused Deposition Modeling (FDM)

Fused deposition modeling (FDM) technology was developed and implemented for the first time by Scott Crump, working with Stratasys Ltd., in 1980s. Other 3D printing companies have adopted similar technologies but under different names. FDM can print not only functional prototypes, but also concept models and final end-use products. One of the great merit of this technology is that all parts printed with FDM can go in high-performance and engineering-grade thermoplastic. FDM is the only 3D printing technology that builds parts with production-grade thermoplastics, so objects printed are of excellent mechanical, thermal and chemical qualities.

3D printing machines that use FDM Technology build objects layer by layer from the very bottom up by heating and extruding thermoplastic filament. The whole process is a bit similar to stereolithography. Firstly special software “cuts” CAD model into layers and calculates the way printer’s extruder would build each layer. Along with thermoplastic, a support materials is also extruded as well. Then the printer heats thermoplastic till its melting point and extrudes it throughout nozzle onto base that can also be called a build platform or a table, along the calculated path. A computer of the 3D printer translates the dimensions of an object into X, Y and Z coordinates and controls that the nozzle and the base follow calculated path during printing. To support upper layer the printer may place underneath special material that can be dissolved after printing is completed.

When the thin layer of plastic binds to the layer beneath it, it cools down and hardens. Once the layer is finished, the base is lowered to start building of the next layer. Printing time depends on size and complexity of an object to be printed. Comparing to stereolithography this technique is slower in processing. When printing is completed support materials can easily be removed either by placing the whole printed object into a water and detergent solution or snapping the support material off by hand. Then objects can also be milled, painted or plated afterwards. FDM is used for new product development, model concept and prototyping and even in manufacturing development. This technology is considered to be simple-to-use and environment-friendly. With use of this 3D printing method it became possible to build objects with complex geometries and cavities.

Different kind of thermoplastic can be used to print parts. The most common of those are ABS (Acrylonitrile Butadiene Styrene) and PC (polycarbonate) filaments. There are also several types of support materials including water-soluble wax or PPSF (polyphenylsulfone).

Pieces printed using this technology have very good quality of heat and mechanical resistance that allows to use printed pieces for testing of prototypes. FDM is widely useful to produce end-use products, particularly small, detailed parts and specialized manufacturing tools.

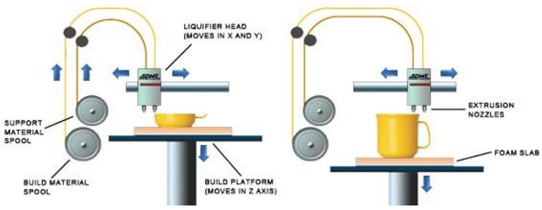


Fig 3.3 Working Principle of FDM 3D Printer (courtesy: 3DMT)

3.4.2.4 Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) is a technique that uses laser as power source to form solid 3D objects. Stereolithography is in some way very similar to Selective Laser Sintering. The main difference between SLS and SLA is that it uses powdered material in the vat instead of liquid resin as stereolithography does. Unlike some other additive manufacturing processes, such as stereolithography (SLA) and fused deposition modeling (FDM), SLS doesn’t need to use any support structures as the object being printed is constantly surrounded by unsintered powder.

3.4.2.5 Selective Laser Melting (SLM)

Selective laser melting (SLM) is a technique that also uses 3D CAD data as a source and forms 3D object by means of a high-power laser beam that fuses and melts metallic powders together. In many sources SLM is considered to be a subcategory of selective laser sintering (SLS). But this is not as true as SLM process fully melts the metal material into solid 3D-dimentional part unlike selective laser sintering

3.4.2.6 Electronic Beam Melting (EBM)

EBM is another type of additive manufacturing for metal parts. The same as SLM, this 3D printing method is a powder bed fusion technique. While SLM uses high-power laser beam as its power source, EBM uses an electron beam instead, which is the main difference between these two methods. The rest of the processes is quite similar.

3.4.2.7 Laminated Object Manufacturing (LOM)

During the LOM process, layers of adhesive-coated paper, plastic or metal laminates are fused together using heat and pressure and then cut to shape with a computer controlled laser or knife. Post-processing of 3D printed parts includes such steps as machining and drilling.

In the current work, FDM technology based 3D printer from Stratasys Ltd with model number *Dimension sst 1200 es* has been used. The machine facilitates in creating functional prototypes with various materials such as ABS+ thermo plastic i.e. production grade plastic. Dimension SST 1200es uses soluble supports - a water-based solution designed to allow to simply wash away the support material. The part is left smooth and clean with the fine details intact. The soluble support material can be removed by hand with relative ease, but is designed to be dissolved off of the parts for hands-free part finishing.

3.4.3 Features of Dimension SST 1200 es 3D Printer

Dimension 1200es printers are designed with ultimate simplicity in mind. The systems enable one to build parts quickly, even if one has never used a 3D printer before. The systems model uses ABS*plus* plastic, so modeled parts are strong and durable (56). ABS*plus* also ensures that it will be possible to drill, tap, sand, and paint creations. With the speed and convenience of Soluble Support Technology, completed parts are quickly available for review and test.

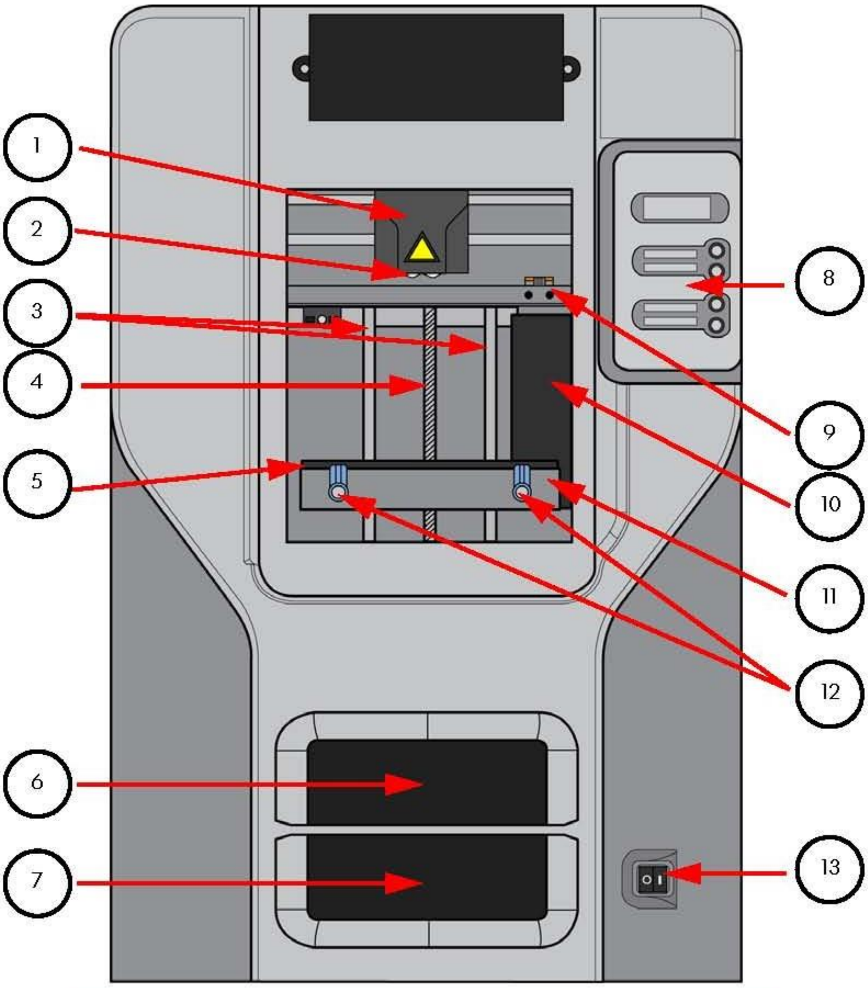
Dimension 1200es printers are an innovative combination of proprietary hardware, software, and material technology. Dimension 1200es printers can build models, including internal features, from CAD STL files. Three dimensional parts are built by extruding a bead of ABS plastic through a computer-controlled extrusion head, producing high quality parts that are ready to use immediately after completion.

With two layer resolution settings, one can choose to build a part quickly for design verification, or a finer setting for higher quality surface detail. The Dimension 1200es systems consist of two primary components — the Dimension 1200es 3D printer and CatalystEX. CatalystEX is the preprocessing software that runs on a Windows Vista or Windows 7 platform.

The build envelope measures 254 x 254 x 305 mm (10 x 10 x 12 in). Figure 3.16 shows various components of the printer.

The main features of the machine are as listed below:

- Wide range of material options available – ABS*plus* Thermo Plastics i.e. production grade plastics, or rubberlike material, transparent material, flexible material, nylon etc.
- Can build colored parts and models
- Very easy to operate – designers can themselves build prototypes – no need of trained personnel
- Three simple steps to build prototypes: Create CAD Design – save in .STL format – build a prototype
- Creating prototypes only takes a few hours
- Helps build life like models
- Ideal for fit, form, functional and ergonomic product design validation
- Can build highly accurate models
- Can build intricate designs with extreme precision (16 microns to 127 microns layer thickness)
- High temperature materials (from 50 degrees Celsius to 180 degrees Celsius)
- Easy to remove support material – either water soluble or can be removed with water jet.



1	Extrusion Head	8	Display Panel
2	Extrusion Tips	9	Tip Cleaning Assembly
3	Guide Rods	10	Purge Container
4	Lead Screw	11	Z stage platen
5	Modeling Base	12	Modeling Base Retainers (2)
6	Model Material Cartridge	13	Power Switch
7	Support Material Cartridge		

Fig 3.4 Various components of *Dimension* 3D Printer

3.5 Design of the Model using NX software

Design of individual parts was generated using NX version 9.0 software. Following parts were designed in a totally new way independently except flanges (Patent Applied).

As seen in earlier part, there have been many attempts to provide solution to the problem of requirement of two systems of warping. There were few attempts which addressed the problem directly but not solving problem in total. The question of adjustment of section width is still not addressed anywhere. An attempt has been made to offer the solution to the problem by a novel design of a beam which is to be used on a direct warper and at the same time, one will be able to wind the sections of the threads in a limited width like sectional warping.

If one wants to prepare the beam containing mono-colored warp, then normal beam, as used regularly on a direct warper, is to be used. The newly designed beam is to be used when it is required to warp multicolor warp with complicated design on a direct warping machine.

The measurements, wherever necessary, were taken of an actual beam used currently on an air jet loom of RIFA make.

It will be apt to mention here that total 3 attempts were made. The first design as per first attempt was not found to be working as per the requirement. This led to further explorations and two more versions were developed which are working as per the requirement. All three versions will be discussed in coming sections one after the other.

3.5.1 First Attempt

The first version is based on the initial thought process according to the manual model prepared. Following parts were designed using the NX software:

i. Outer Barrel
ii. Inner Barrel
iii. Flanges
iv. Inner Flange
v. Separator plates
vi. Retainer Block

3.5.1.1 Design of Outer Barrel

The existing weaver's and warper's beams are as shown in figure 3.3 (a) and (b) respectively. There are two main parts in both types of beams viz. barrel (or sometimes referred as tube) and flanges. Warper's beams are produced at direct warping stage. Whereas sectional warping can use both types of beams. In the work presented here, mainly the barrel has been modified to a great extent with minor changes being incorporated in the flanges.

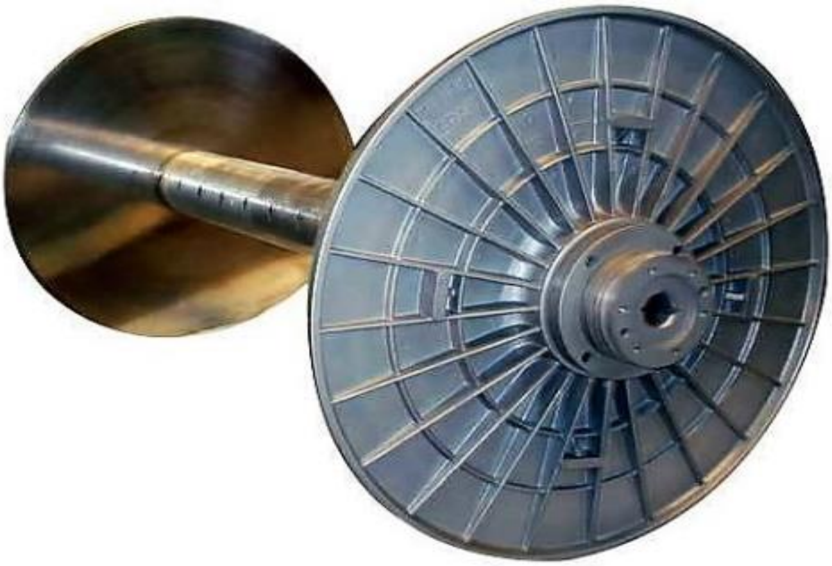


Fig 3.5 (a) Weaver's Beams

Fig 3.5 (b) Warper's Beams

The new design of barrel of the beam is composed of two parts named outer barrel and inner barrel. The outer barrel is modification of an existing beam barrel in various ways. While designing the outer barrel for the work presented here, the base has been taken of the barrel of weaver's beam. The circumference of the barrel has been modified and rectangular slots are made through out. The width of the slot has to be decided and the same will depend upon the number of sections usually are taken. The slots are so designed that there is equal width of the barrel surface also between two consecutive slots.

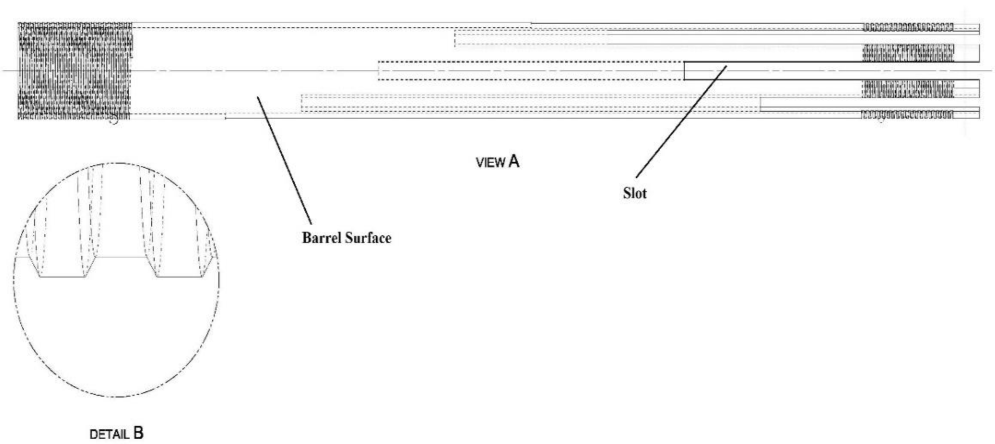


Fig 3.6 (a) Outer Barrel

Fig 3.6 (b) Outer Barrel – 3D View

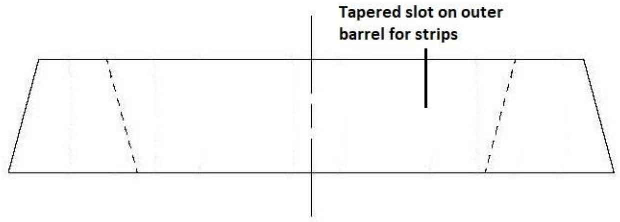


Fig 3.6 (c) Tapered Slot on outer barrel

Figure 3.6 (a), (b) and (c) show the outer barrel views. As can be seen in the figures, the slots are staggering in terms of the length of the slot. The first slot will be longest and gradually all slots in turn will be in reducing length. The length and width of the slots are required to be precisely worked out as they are required to engage with the teeth made on the strips. As shown in Figure 3.6 (c) the slots are wedge shaped so as to provide proper grip to the strips provided on to the separator plate.

One side of the outer barrel will have usual surface with teeth made on to it. The inset diagram in figure 3.6 (a) shows the detailed view of the toothed surface. The flange fixed on this side of the barrel can be rotated on these teeth to adjust the width of the section. The other side will have slots with teeth made on to the uncut part of the barrel. The flange will be fixed on this side of the barrel and will be mounted on toothed uncut part of the barrel surface. This arrangement will allow the rotation of the flange for adjustment of the width of the section. The whole barrel otherwise is hollow.

Also a provision has been made to fit a retainer block which locks the whole system i.e. outer and inner barrels, during running of the beam at warping process. The retainer block will be accommodated between the slotted portions of the outer barrel surface. The detailed account of the retainer block will be discussed in coming sections.

Figure 3.5 shows the assembly of the outer barrel with the flanges mounted. As mentioned earlier, both flanges are adjustable for width. So, the flanges will have provision, for rotations, at the part where it fixes with the barrel.

In case of normal warping operation practiced currently, one side of the beam flange is kept fixed and all adjustment of the width are usually done via the other side of the flange. So in most of the cases the flange is adjusted from one side only. This practice is also not usual and is done only during rare occasions. In the current design, flanges on both sides are required to be adjusted.

Adjustable flanges are very vital for the whole design of the beam because they take part in width adjustments of the sections. In all other aspects the beam flanges are similar to the ones used with current warping systems. The flanges can be locked in to the place, after adjustment of width, in the usual manner. The diameter of the flanges again can be the one used currently, for example, 800, 1000 mm or even higher.

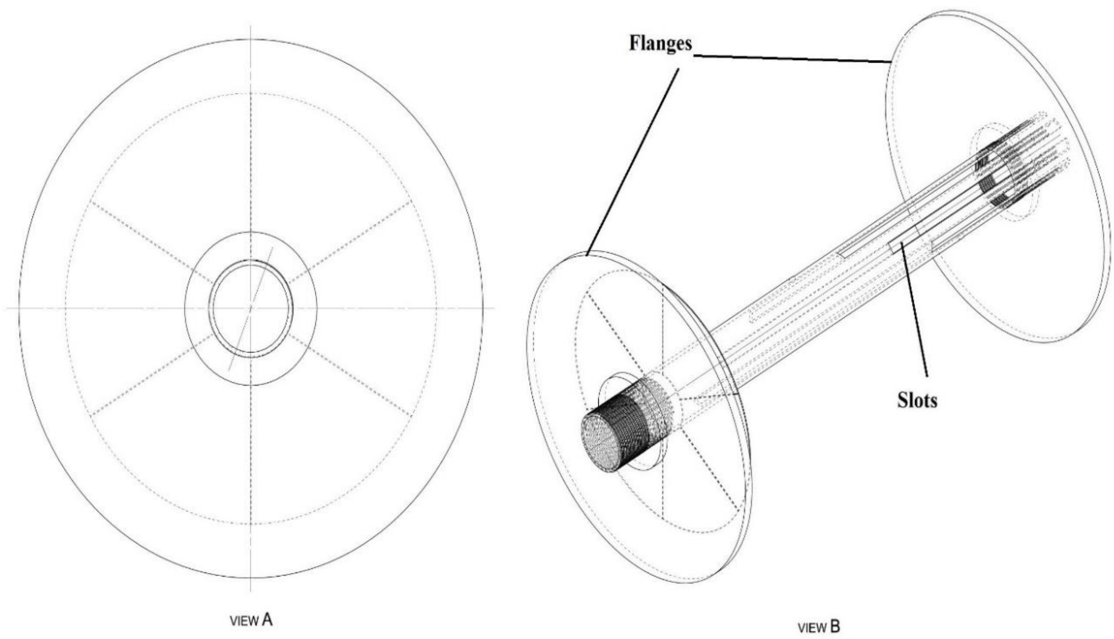


Fig 3.7 Outer Barrel Assembly

The thickness of the plates of flanges should preferably be same as that of weaver's beam as this beam can be used directly on loom if sizing is not required to be done. Else lesser thickness can be taken since weaver's beam will be formed after sizing. Alternatively the beam can be taken for rebeaming operation to get the final weaver's beam. Of course the beam discussed here is fully capable of containing all threads.

3.5.1.2 Design of Inner Barrel

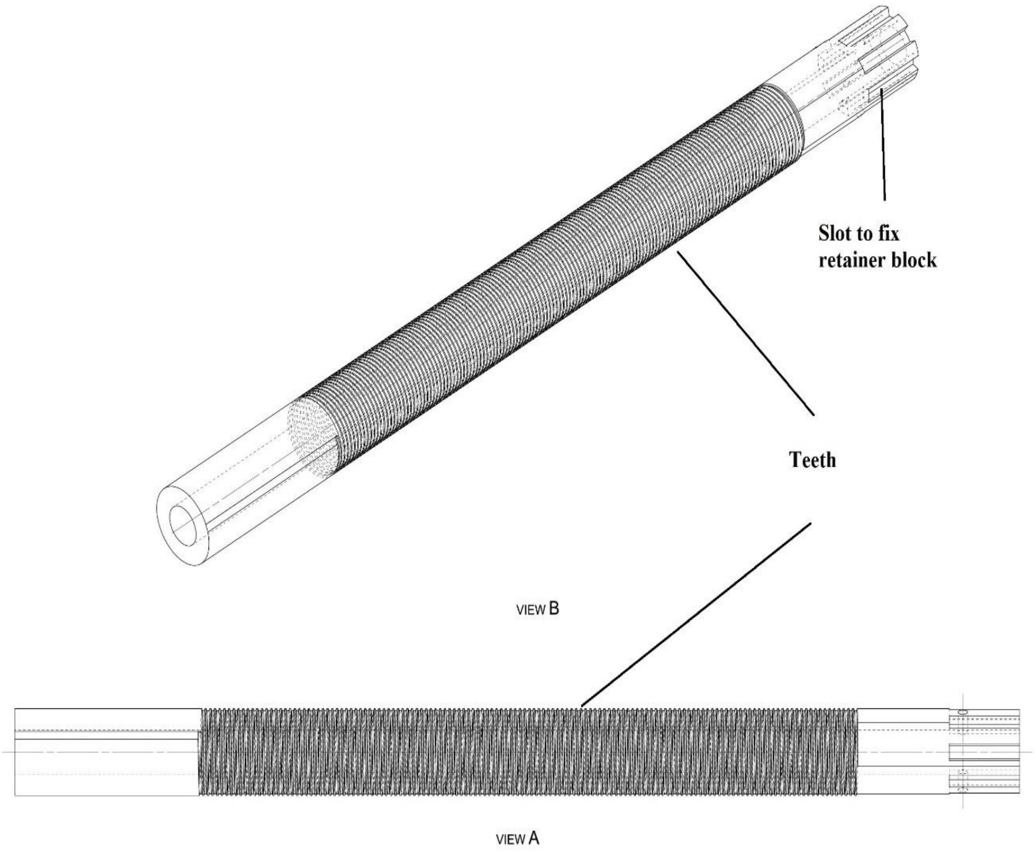


Fig 3.8 Inner Barrel

There is one more barrel too. It is named as inner barrel since it fits inside the outer barrel. The diameter of the inner barrel is slightly less than the inside diameter of the outer barrel such that inner barrel can be easily fitted in to outer barrel. Figure 3.8 shows the design.

As can be seen in the figure 3.8, it is a roller with teeth made on to the central part of the barrel. On one end of the barrel the surface is normal plain without any special structure made on to it. While on the other end slots are made for shorter distance. These slots are made to house the retainer block.

The teeth made on to the main part of inner barrel are supposed to engage with the teeth made on the bottom part of the strips attached with the separator plates. These strips will move laterally when the inner barrel is rotated. This will cause the sliding of the strips and thereby the separator plates.

The amount of movement will depend on the section width required which in turn depends on various factors like total number of ends, creel capacity, thread density, pattern repeat size etc. Very less number of rotations will be sufficient to cause the required shifting of the separator plates. Also it is possible to customize the movement for the required conditions by keeping different ratio for number of teeth on to strip to inner barrel.

The inner barrel provides movement to all strips mounted on various separator plates simultaneously (Except the inner fixed flange). The movement given to all strips will be same. Also the movement can happen in both directions i.e. inner barrel can be moved clockwise or anticlockwise. So the distance between separator plates can be increased or decreased by the same amount simultaneously.

In the current design it has been considered that the inner barrel is to be moved manually. Designing a small device with a motor can make the inner barrel moving mechanically. Also there is possibility of using the servomotor with small customized software for calculating the amount of rotations needed in a particular situation.

3.5.1.3 Design of Flanges

As mentioned earlier section, flanges were not designed in the present work. The beam flanges used currently can be used directly in the design. The thickness of the flanges can be as per the ones used currently. The thickness of the flanges are to be selected carefully as the fully warped beams are handled, on the floor, through flanges only.

It is already known that there is provision for width adjustment through flange. In the present set up the flange on one side of the beam is not adjusted. Whatever adjustment required in the width is done by adjusting the flange on the other side. Though this adjustment will be only for minor adjustment of the widths. Also after adjustment of the width the flanges are required to be fixed with the barrel surface.

In the current design minor modifications in flange working are suggested. The flanges of both the sides of the beam are to be adjusted. The flanges in the current design are to be fixed onto the outer barrel surface. The outer barrel has teeth made on both ends. The surface of the outer barrel is plain normal on one side so making teeth will be easily done. The other side of the outer barrel has slots made on to it. The outer barrel has an equal portion of the solid surface also between two consecutive slots. The solid portion of the barrel surface (i.e. without slots made on to it) will have teeth made on to it. The flange will be fixed on to this toothed portion. With this provision it will also be possible for the flange to be rotated.

With this modification it has been made possible to rotate the flange after fitting it on to the newly designed outer barrel. The flanges are otherwise similar to the ones used currently.

3.5.1.4 Design of the Inner Fixed Flange

There is one more flange in the newly designed beam. This flange is named as Inner Fixed Flange. This flange can be provided inside either right or left hand side of the main flange. This flange has to be firmly attached on to the outer barrel surface because this is not required to be adjusted in all circumstances. Figure 3.9 shows the views of the arrangement as designed for the current version of the beam. In the current design, the inner fixed flange has been provided inside the left hand side of the main flange.

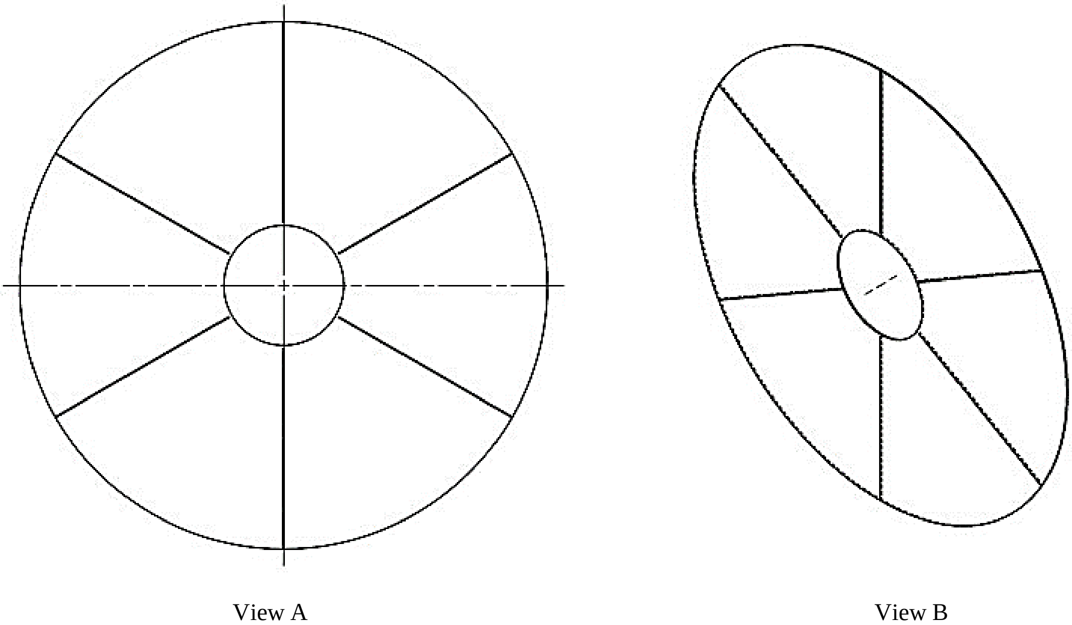


Fig 3.9 Inner Fixed Flange

The main aim of providing this arrangement is the fact that while working with patterned warp, selvedges are normally of different color. So, when the creel is set for patterned warp, the first section of the thread will be inclusive of selvedge threads too. Many a times it is required to adjust the width of the first section differently. On a present set up of sectional warping machines, the width of the section can be handled by adjusting the width in the expandable comb or similar type of reed. Width adjustment of any section also requires the adjustment of reed. This arrangement will be required for the current design and can be retrofitted.

In the newly designed beam, the width of the first section will be adjusted by rotating the left hand side main flange. After adjustment, the left side main flange is to be firmly fixed on to the barrel surface. As mentioned earlier, the flanges normally come with adjustment possibility on both the sides.

To enable this task the outer barrel surface will have teeth made on to it on left side also. So with this provision there is no restriction about the amount of width which can be accommodated in the first section.

The whole aspect depends upon the thread density to be kept on the beam. But with all these points considered, the newly designed arrangement provides facility to adjust the width from a certain minimum to maximum value without any restrictions. The inner fixed flange (and separator plates also) may have slits made on to it throughout the circumference to accommodate the lease bands. This provision is optional and can be arranged if required.

3.5.1.5 Design of the Separator Plates

The current design of the beam has a totally new feature and it is again one of main important parts for concept of unifying both systems of warping. The part has been named as separator plates.

As mentioned in earlier chapter, there have many attempts so far of preparing the beam by narrowing the width. Also there are few attempts towards use of separator plates also. But so far no work is reported about the manner in which the plates can be adjusted and fixed on to the barrel surface. The whole work refers to the concept of using the plates only and not about various adjustments required for using patterned warp.

The concept of using narrow width beam is also not very new. There are examples of use of tape warping systems in old days. Also the sizing of the narrow width has been tried out. The narrow width beams are currently used in following cases:

(i) Sample weaving
(ii) Warp Knitting
(iii) Narrow width tape weaving etc.

It will be very difficult to use narrow width beams for preparing sections of the warp separately. Combining all these beams at a later on stage for a given warp pattern will be very difficult from space requirement point and also will be time consuming process. The work presented here offers a totally new concept of organizing all these aspects of beam in to one assembly.

The separator plate is simply a plate provided on to the outer barrel surface. Figure 3.10 shows design in two different views. There are many such plates throughout the width of the beam. The diameter of inner fixed flange and the separator plates will be same. The diameter is kept slightly less than the diameter of main flanges. This will ensure that when the beams are handled on the floor only the main flanges will be touching the floor.

The thickness of inner fixed flange and separator plates is again selected to be very less say about 3–5 mm only. So, even with about 10 separator plates across the width the increase in the width will not be more than permissible limit.

The separator plates are to be mounted on the outer barrel. The space between two separator plates will be as per the section width requirement. This simply means that the space between plates should be adjustable. As mentioned earlier, the first section, which includes selvedge threads, has been taken care of and the separator plates will accommodate second section onwards till second last. The last section again will be containing selvedge threads. The width of the last section is adjusted by rotating right hand side main flange.

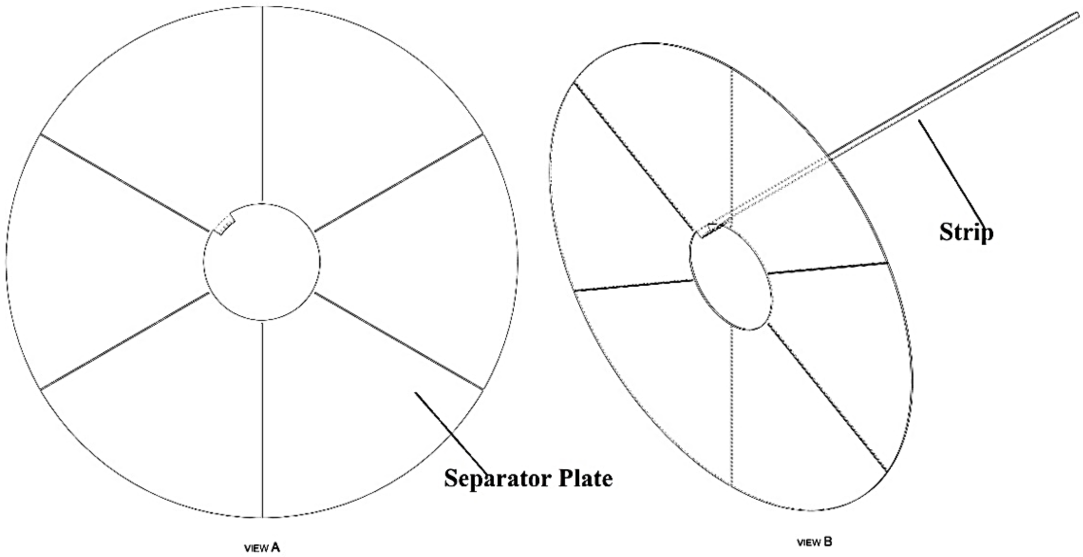


Fig 3.10 Separator Plate

The separator plates have a strip also attached to it at the periphery of central hole. This strip is having teeth made on to it at the underside. These teeth engage with the teeth made on to the inner barrel. So whenever the inner barrel is rotated in either direction the strip will move either forward or backward and so will the separator plates. Henceforth the distance between two separator plates can be adjusted. It is also seen that the distance between all separator plates will be adjusted at the same time and the value will also be same as they all are mounted on the outer barrel and they engage with the same inner barrel. This will ensure that the section width of all main sections (i.e. excluding the first and the last section section) is maintained at the same value.

The ratio of number of teeth on the strips and on the inner barrel can be selected as per requirement. In the current design the same has been selected as 1:1. This means that one revolution of the inner barrel will cause one tooth equivalent movement of the strip. The same will be converted in to horizontal shifting of the separator plates depending on the pitch of the teeth.

The strips fix in to the slots made on the outer barrel. The length of the slot on the outer barrel surface will be as per the position of the separator plate. The first separator plate will have the longest strip whereas the last one will have the shortest one. The strips and the slot design has been made in such a way that they will remain in position without any problem. Figure 3.11 shows a detailed view of the whole arrangement. As can be seen in the figure, the design of the strip and slots is in to 'V' shape.

The number of separator plate to be provided is required to be calculated and will remain fixed for a given size of the beam. The maximum possible number of strips and separator plates are to be provided in the design so there will not be requirement of adding any more number of strips. However it will be possible to remove one or maximum two separator plates if not required.

The number of separator plates will require equal number of strips and the same number of slots being made on to the outer barrel. Depending upon the diameter of the outer barrel it will be possible to make about 15 to 20 slots on to the outer barrel surface. This number will take care of creel sizes used currently. Also the number is sufficient to take care of most of the situations for an apparel fabric warping. A detailed calculation will be presented in the next chapter.

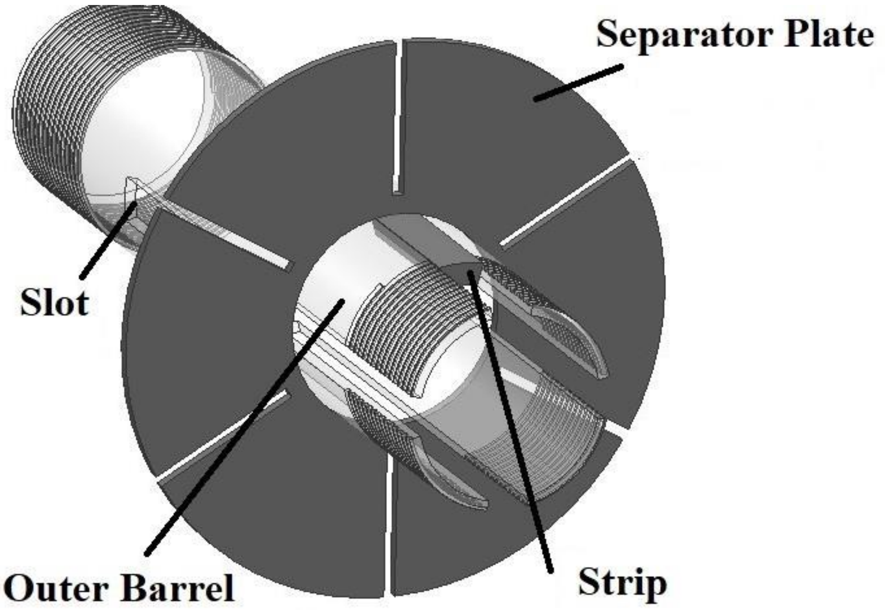


Fig 3.11 Detailed view of the separator plate, strip and slot

Another point about the design of the separator plate and fixed flange is a small slit made at about six or seven positions over the circumferential portion. The provision of the slit may be made if one wants to make provision to insert the leasing band.

3.5.1.6 Design of Retainer Block

As mentioned in earlier sections, the adjustments of the width for a given situation will be carried out by adjusting the main flanges and the separator plates. Now the beam will be ready for warping. It is important to lock the entire system so that during running of the beam on warping machine the widths are maintained. So a new mechanism named retainer block has been devised. The purpose of the block is to provide a firm locking of the entire system.

Many different designs were thought of for the purpose and one of the simpler one for explaining the concept is presented here. It is also possible to apply a locking mechanism available in the market.

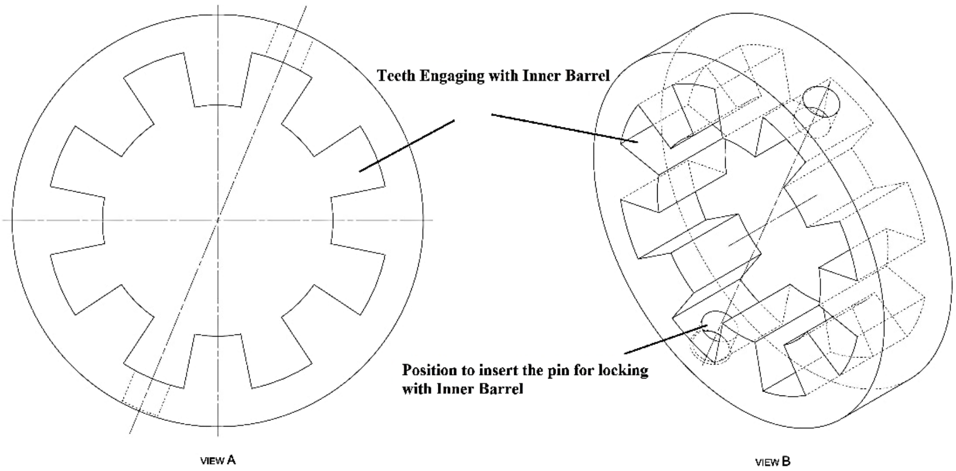


Fig 3.12 Retainer Block

The figure 3.12 shows two different views of one of the mechanism designed for the current work. The retainer block has large size teeth made on the underside which match with the grooves made on the end part of the inner barrel. The internal diameter of the block will fit firmly on the inner barrel.

After necessary adjustments have been carried out for the warping situation, the retainer block will be attached and a pin will be inserted at two points as shown in the diagram. This pin will pass through the block and inner barrel locking both system. This way the whole system will become locked and will be ready for warping. The retainer block has to be removed at the time of making adjustments for the width of sections.

3.5.1.7 Main Assembly

All parts discussed above are required to be assembled in to one beam. The assembly, as shown in figure 3.13 is a normal warper beam with many modifications made.

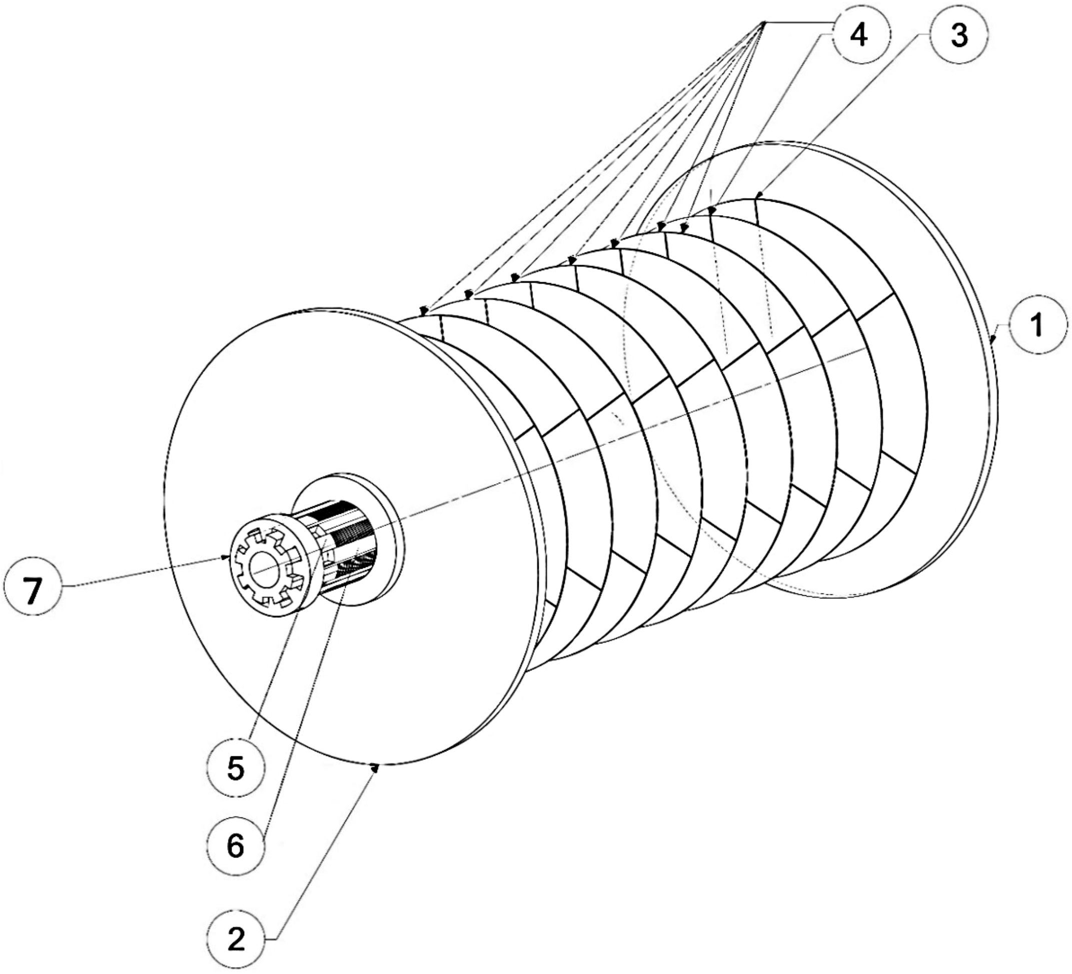


Fig 3.13 Main Assembly

Following are the parts shown in figure 3.13 and 3.14

1. Main Flange Left hand side
2. Main Flange Right hand side
3. Inner Fixed Flange
4. Separator Plates
5. Outer Barrel
6. Inner Barrel
7. Retainer Block

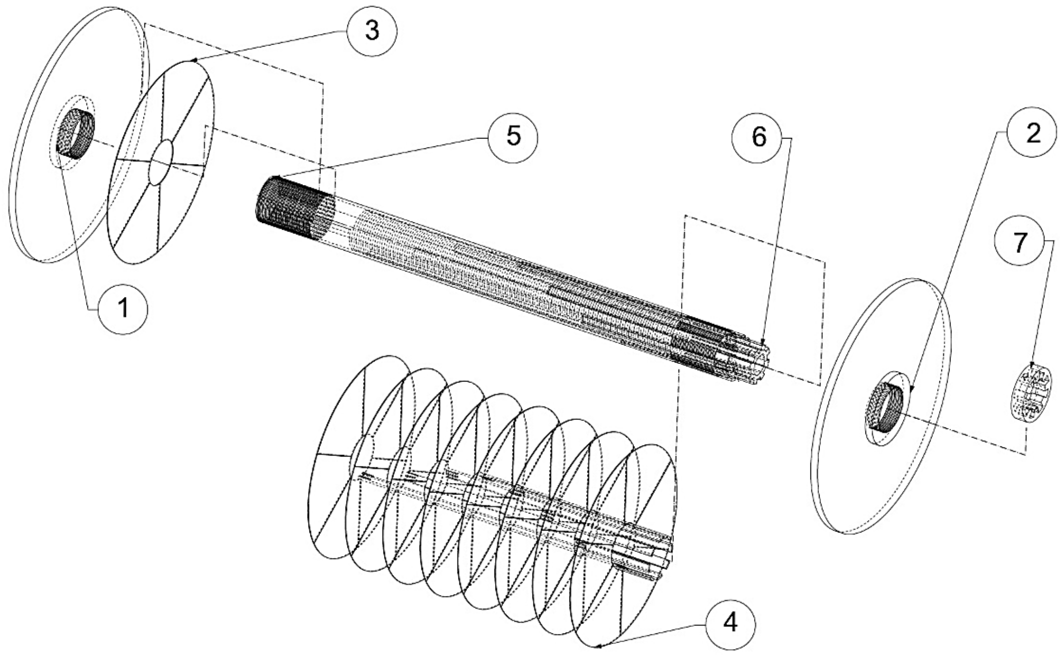


Fig 3.14 An Exploded view of the main assembly

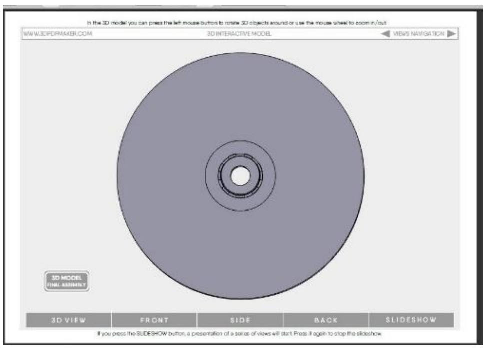
In figure 3.14 all parts are shown in exploded view. As can be seen in the figure, the slots which are made on outer barrel are in staggering manner as far as the length is concerned. This is because it will provide a gap for the particular strip of the particular numbered separator plate which is to be fixed in to it. This way the design of all main components was carried out using Siemens NX software. Each component was designed individually first and then it was merged with other parts. This way the whole assembly was generated. The components were designed using actual measurements. As mentioned earlier, the measurements wherever necessary, of an actual beam used on RIFA air jet loom were used.

3.5.1.8 3D Modelling

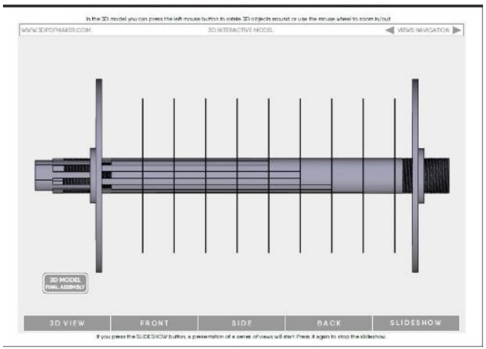
After designing all necessary parts and assembling them, a 3D modelling work was taken up. Some of the minor flaws in the design and fine tuning of the mechanism is possible through modelling. The same software was used to generate a 3D model.

3.5.1.8.1 3D Graphic modelling

Initially 3D graphic model, using all parts, was generated. It is possible to view the parts or the whole assembly by rotating freely in to any way on 3D space. Various diagrams generated are presented in figure 3.15. It is possible to make the whole assemble step by step to inspect the entire procedure. Also it is possible to see two or more parts in the diagram. This helps in understanding all issues related with motion simulation.



(i)



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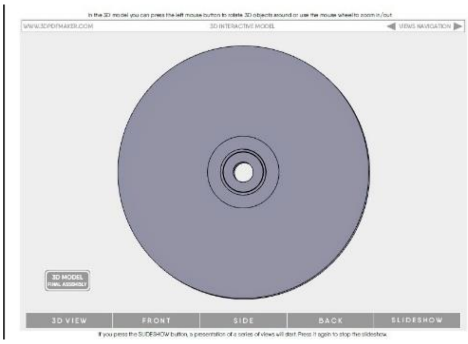

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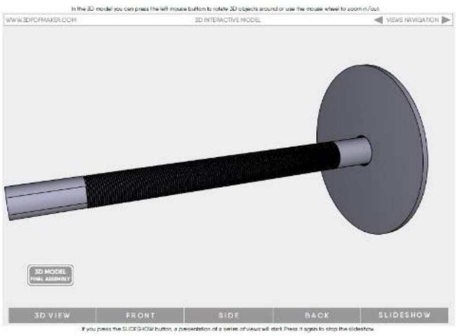

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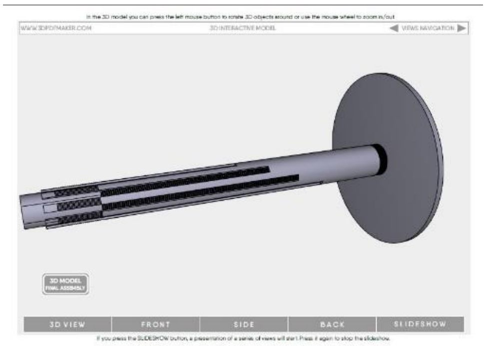

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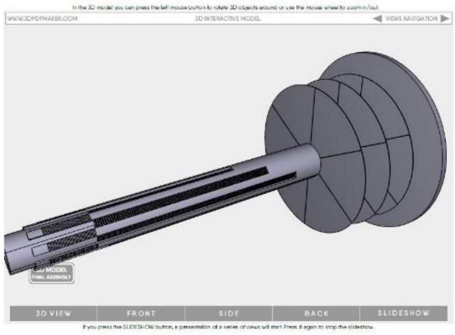
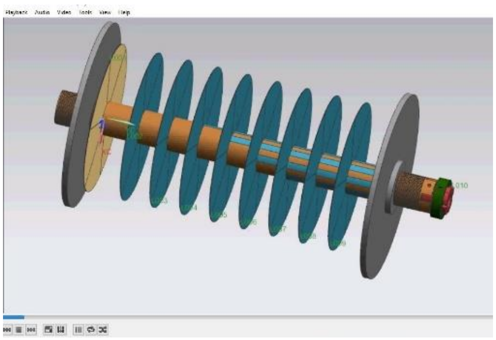


(vi)

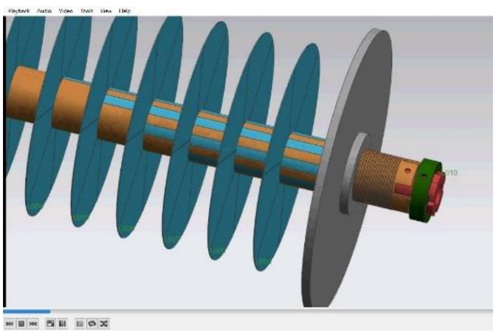
Fig 3.15 Diagrams of 3D model (i) side view - right side (ii) front view (iii) side view - left side (iv) inner barrel attached (v) outer barrel attached (vi) separator plates attached

3.5.1.8.1 Motion Simulation

Also a motion simulation was prepared to view the entire mechanism in the virtual working model. All parts can be moved virtually as they are supposed to be moved actually. The entire exercise can be recorded as a video which can be viewed on any video player to understand the mechanism in virtual action. Some of the screen shots from the video are presented in the figure 3.16.



(i)



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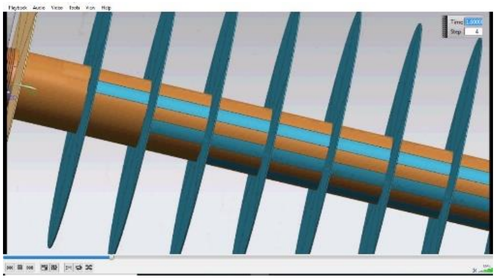

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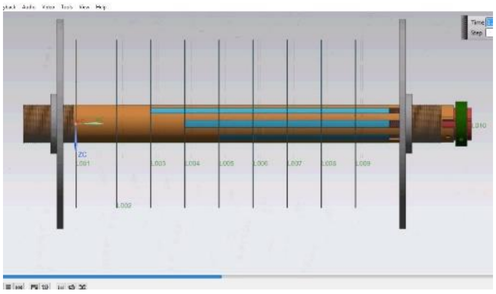

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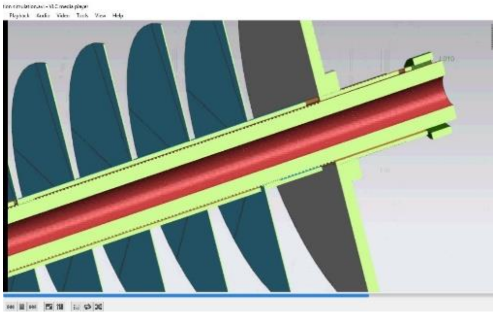

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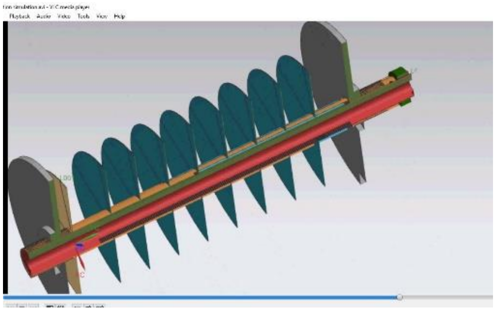


(vi)

Fig 3.16 Screen shots of various views from motion simulation

At this point it was realized that the movement is not as per requirement. The section width of all sections is supposed to increase or decrease by the same amount. Also the section width of first and the last section is to be adjusted separately. Out of these requirements only the section width of first and the last section was as per requirement but the section width of remaining sections was not adjusted by the same mount. In fact it remained same as per the initial conditions. In between 3D printing of the design was also finished. After 3D printing (discussed in next chapter) it became clear that the design requires modification. Also it also was revealed that the changes are required to be made only in the inner barrel with very minor changes in the separator plates.

This required altogether a new thought process about the lead screw mechanism. Also a new exploration was required to be done in to the software about the movement that is needed. The entire process inspired for a new insight to be applied to the problem. In the end it was possible to offer two more design solutions for the problem.

3.5.2 Second Attempt

As mentioned in earlier section, modifications were made in mainly two parts viz. inner barrel and separator plates.

3.5.2.1 Design of Inner barrel

The problem with the first design was that the pitch of the threads made on to the inner barrel was kept same. This led to an equal movement of all separator plates. Whereas the horizontal movement required out of separator plate will be in increasing order. Which means that each separator plate will have an incremental value compared to the movement of the previous plate. For an example, if first separator plate is moved horizontally by one mm then the second plate is to be moved by 2 mm and third by 3 mm etc. This requires differential movement, out of lead screw type of mechanism, being provided on the inner barrel.

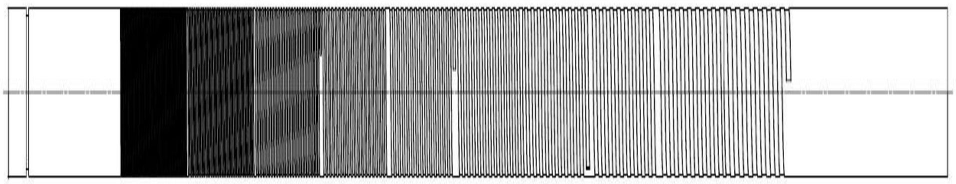


Fig 3.17 Second Design of Inner Barrel

The trial was made by making different pitch over the entire width of the inner barrel. In the current design, the pitch was started with a value of 1 mm. This means that the first defined segment of the inner barrel will have 1 mm pitch for 150 mm length. The pitch will be in increasing order for each segment, of 150 mm, of the inner barrel. The arrangement is shown in figure 3.17. The number of segments will be matching with number of separator plates. Current diagram shows total ten segments made on to it with pitch ranging from 1 mm to 10 mm, in a step of 1 mm each, for a distance of 150 mm for each segment. This means that the last segment of 150 mm will have a pitch of 10 mm. Rest of the details of the inner barrel will remain as that of the first version with reference to front and the rear part. The designed inner barrel will now be inserted inside the outer barrel. The design of outer barrel will be as per the first attempt.

It is possible to design the inner barrel with different value of pitch but more importantly with different values of section width. As the thread densities vary and the total number of threads engaged in the creel also vary, it is required to have various values of different section widths being made on the inner barrel.

3.5.2.2 Design of Separator Plate

As the changes in inner barrel have been made, separator plates will also require matching changes to be made. Overall design of the plate has been retained and changes in the teeth are newly incorporated. In the first version the pitch of the thread for strips made on to the separator plate was kept same. Also in the first attempt the teeth on the strip were made for the entire length whereas in the second attempt, the teeth are made only for 20 mm since the pitch of the teeth of each strip is in increasing order and they engage the matching tooth pitch made on to the inner barrel. Rest of the portion of the strip will be flat and will not engage with the teeth anywhere of any segment.

In the second attempt the pitch of the teeth made on the strips mounted on each separator plate is in increasing order so that it will match the pitch made onto the various segments made on the inner barrel. As the pitch made on the inner barrel for first segment is 1 mm, the pitch of the threads made on the underside of the strip mounted on the first separator plate is also 1 mm. Similarly the pitch of the threads made on the underside of the strip mounted on the last separator plate will be 10 mm. This way the separator plates will have matching and an increasing movement. Also this will make sure that the plates move by an equal distance for all segments.

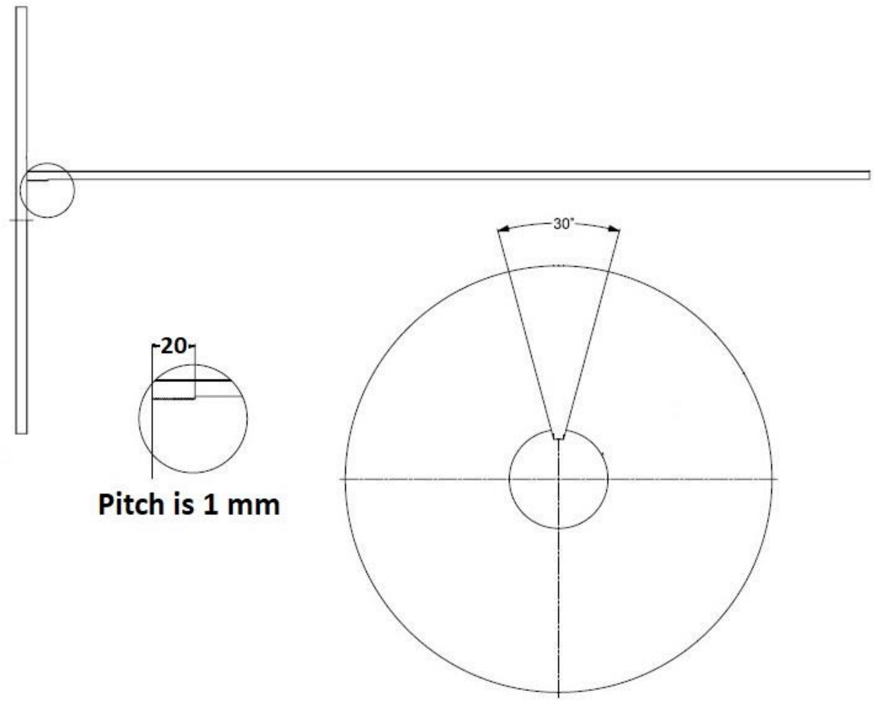


Fig 3.18 Second Design of Separator Plate

Rest of the design of the plate is same as that of the first version. The whole arrangement is shown in figure 3.18 which shows the view of the first plate with a pitch of 1 mm.

3.5.2.3 Full Assembly

Figure 3.19 shows the full assembly of the second attempt of the design. As mentioned earlier, only the teeth on both inner barrel and strip of the separator plates have been changed, so there is not much of the apparent change seen in the main assembly of the final beam.

Another change made in this version is removal of inner fixed flange. As it was realized that the function of flange can be replaced by a separator plate. So now with this assembly adjustment of width for section two to second last will be carried out by rotating inner barrel in either direction whereas adjustment of the width for first and the last section will be carried out by rotating main flange in either direction. A detailed calculation about the possibilities with this design and few limitations of the same are being discussed in the next chapter.

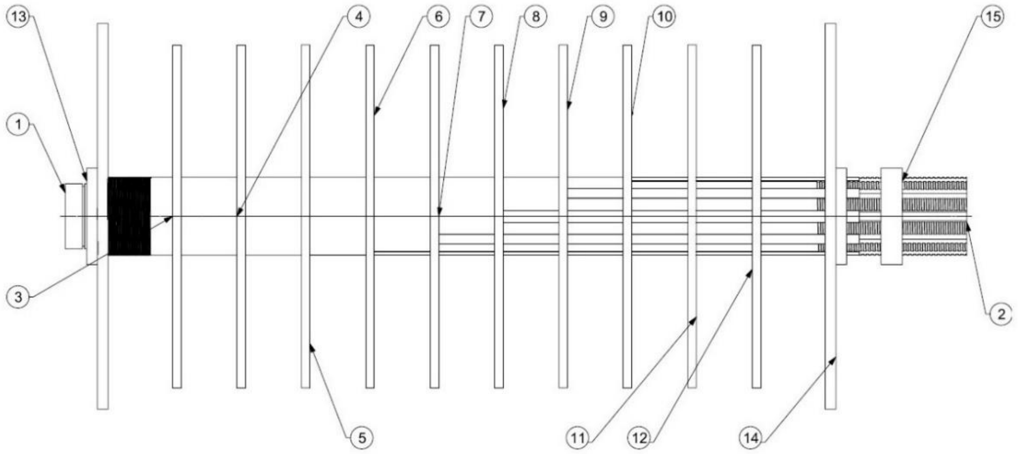


Fig 3.19 Full Assembly – Second Attempt

3.5.3 Third Attempt

One more attempt was also made to provide yet another solution to the problem mentioned in the first attempt. Again the modifications were made in to two main parts i.e. inner barrel and separator plates. The design of inner barrel involved more changes whereas only minor changes were required to be made in the separator plates.

3.5.3.1 Design of Inner barrel

As mentioned in the second trial, the problem with the first design was that the pitch of the threads made on to the inner barrel was kept same. This led to an equal movement of all separator plates. Whereas the horizontal movement required out of separator plate will be in increasing order. Which means that each separator plate will have an incremental value compared to the movement of the previous plate. For an example, if first separator plate is moved horizontally by one mm then the second plate is to be moved by 2 mm and third by 3 mm etc. This requires differential movement, out of lead screw type of mechanism, being provided on the inner barrel.

The design trial was made by making pitch having continuously increasing pitch over the required width of the inner barrel. In the current design, the pitch was started with a value of 10 mm and was continuously increased so as to give 20 mm pitch at the end. This means that each consecutive thread made on to the inner barrel will have slight increase in the pitch value compared to the previous tooth. The teeth will be made over the required width of the inner barrel. In the current design the width was taken to be 160 cm over which the threads were made. The separator plates will be placed at a specified point on the width of the inner barrel. The design is shown in figure 3.20.

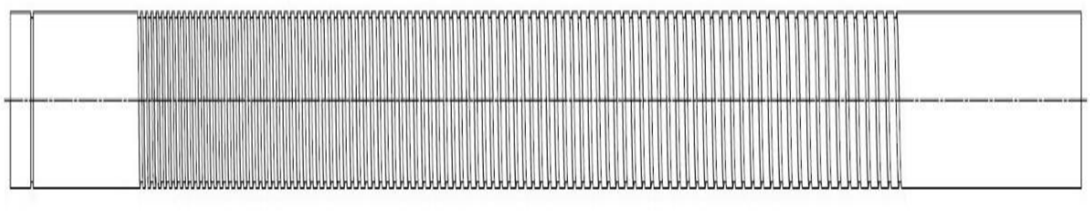


Fig 3.20 Third Design of Inner Barrel

Rest of the details of the inner barrel will remain as that of the first version with reference to front and the back part. The designed inner barrel will now be inserted inside the outer barrel. The design of outer barrel will be as per the first attempt.

3.5.3.2 Design of Separator Plate

The overall design of the separator plate was retained in the third version too. Main change was that the teeth on the strips were not made in this attempt. Instead a pin was provided at a point on to the strip. The pin will glide in to the teeth made on to the inner barrel as it is rotated. Hence there will be horizontal shifting of the strips and the separator plate. The initial portion of strip should have a spring acting mechanism (not included in the diagram) for snapping at the position.

The number of separator plates to be provided should be estimated first and only after that the plates are to be positioned. The first plate will be provided at tooth number one on to the inner barrel in such a manner that the pin will fit inside the depth of the tooth. The whole arrangement is shown in figure 3.21.

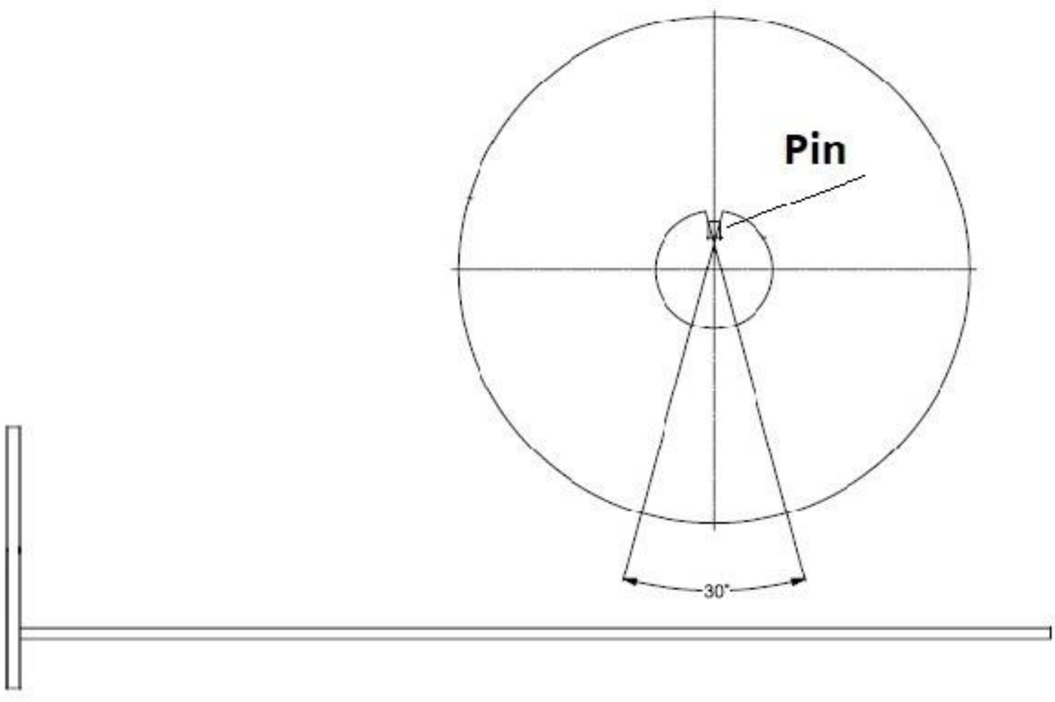
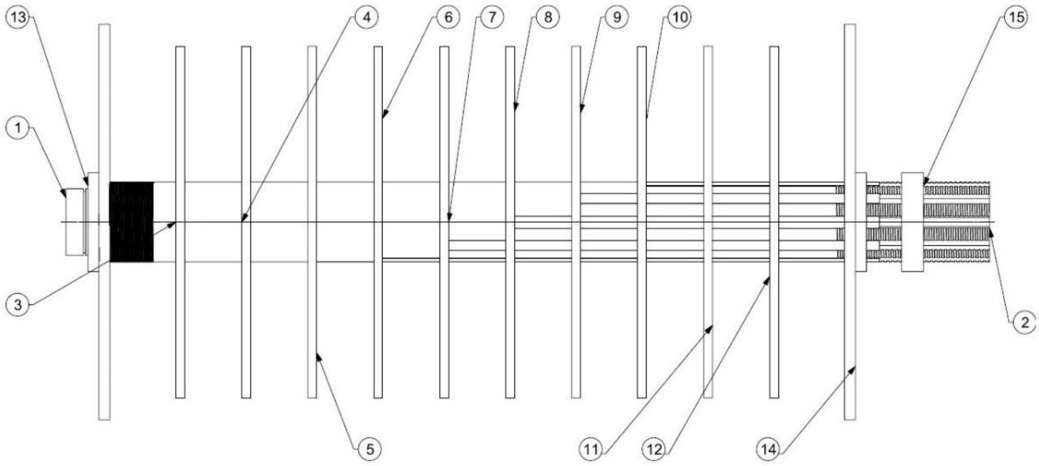


Fig 3.21 Third Design of Separator Plate

3.5.3.3 Full Assembly

As the changes were made in the inner barrel with minor changes in the separator plates, there is not much of the change in the full assembly of the design. One change brought in was again having the inner fixed flange which was there in the first attempt. This means that distance between inner fixed flange and the main flange of the left side will depend on the section width of the first section which in turn will depend on a given situation. The inner fixed flange will not be moved at all. So the distance of second section onwards will be decided by moving separator plates. The inner barrel fits inside the outer barrel and the pins are fixed on to the teeth of the inner barrel, the full assembled view of the design will be as shown in figure 3.22. The design of rest of parts was maintained as that of the first attempt.



1. Inner Barrel 2. Outer Barrel 3. Inner Fixed Flange 4 to 12. Separator Plates 13 & 14. Main Flanges 15. Retainer

Fig 3.22 Full Assembly – Third Attempt

For any kind of design modification currently under consideration, there are few requirements. The system can work for patterned warp if the reed stand, as used on a sectional warping machine, is to be installed with a retrofitting mode. Also this stand should have a simple shifting and locking mechanism so that the reed can be aligned with the particular section.

The 3D printing of the design of the third attempt was carried out by scaling down measurement as per the maximum size permissible with 3D printer. Only the inner barrel and the separator plates were made again. Rest of the parts were used from the first attempt. The same is presented in the next chapter.