Chapter 2

Fabrication of the Continuous Collagen Sheet Forming Machine

2.1 INTRODUCTION

Mechanization of the machinery plays a key role in terms of increasing the productivity and reduction in the manufacturing cost. For a given application, the overall production is improved by the use of the machinery which helps in the speedy and efficient operation. The present work focuses on finding an alternative method to develop wound dressing material in sheet form and produce them in bulk quantities. The disadvantages of the batch process discussed in the previous chapter has paved way for automating the batch process in existence. An attempt is made to design and fabricate a machinery which produces wound dressing material in sheet form continuously. The basic objectives towards fabrication of the machinery are

1. Quick, efficient and precise method of sheet development.
2. Preparation of the sheets within the stipulated time.
3. Automation with minimum operator assistance.
4. Low initial and operational cost.
5. Simple and easy to maintain.

After a brief study, a belt conveyor roller system best suitable for this application was selected.

2.2 SELECTION OF A CONVEYOR SYSTEM

Conveyor system came into existence in 1868. It is a mechanical handling equipment which is commonly used to move materials from one location to another. They are used in applications involving transportation of heavy or bulky materials. A wide variety of materials can be transported quickly and efficiently making them the most popular amongst the material and packaging industries (Ogedengbe 2010). several kind of conveying systems are available (Richardson 2002), and they cater
according to the various needs of different industries. These are widely used across many industries mainly due to the number of benefits they provide (Chun-Hsiung Lan, 2003). Numerous options are available for running conveying systems (Nazzal Nazzal and El-Nashar Ahmed 2007), including the hydraulic, mechanical and fully automated systems, which are equipped to fit individual needs. The advantage of using conveyor based system is safety in transportation of the materials from one level to another, which when done by humans are time consuming, laborious and expensive. The other advantages include installation almost anywhere, and are much safer than using a forklift or other machine to move materials. They can also be used to move loads of all shapes, sizes and weights. Conveyor systems are commonly used in many industries, including the automotive, agricultural, computer, electronic, food processing, aerospace, pharmaceutical, chemical, bottling and canning, print finishing and packaging. Selection of all these factors are very important in the accurate selection of a conveyor system.

Conveyors are classified into different categories (vanamane et al 2011) namely (i) chute conveyor (ii) wheel conveyor (iii) roller conveyor (iv) chain conveyor (v) slat conveyor (vi) flat belt conveyor (vii) magnetic belt conveyor (viii) troughed belt conveyor (ix) bucket conveyor (x) vibrating conveyor (xi) screw conveyor (xii) pneumatic conveyor (xiii) cart on track conveyor (xiv) tow conveyor (xv) trolley conveyor (xvi) power and free conveyor (xvii) monorail (xviii) Sortation conveyor. Although there are different conveyor systems available, the present study focuses on design and implementation of a Flat belt conveyor system.

2.2.1 Belt conveyor system

A belt conveyor is an endless belt, supported on rollers through pin idlers or bed and passes over two or more pulleys so that its direction of travel can be changed, with a continuous loop of material. Pulleys are powered to move the belt and the material on the belt in forward direction. A drive pulley is called the powered pulley while the idler is the unpowered pulley. Belt conveyors are widely preferred owing their cheap and easy maintenance and high loading and unloading capacities (Taiwo 2005). Fig.2.1. illustrates a general belt conveyor system.
Fig. 2.1. Schematic of a Belt Conveyor System

The major advantage of preferring a belt conveyor system is owing to the following advantages:

1. A vast majority of the materials are handled which cause many problems in other transportation means. Belt conveyors can handle wet, dry, sticky, abrasive or dirty material.

2. Compared to other transport system the belt conveyor system covers longer distances economically.

3. The basic conveyor systems can perform additional functions such as weigh, sort, pick, sample, blend, spray, cool and dry.

4. The arrangement can be positioned into horizontal, inclined, declined or combination of all.

5. The operation and maintenance of a belt conveyor system requires minimum labour for its operation.

Though these systems have several advantages they pose several limitations as well. The limitations of the belt conveyor system are:

1. Proper design of loading and transfer points

2. Several protective devices have to be used to protect the belt from damage by operational problems.
3. Initially tension in the belt must be high.

4. The elongation of the belt is higher.

2.2.2 Belt

The belt consists of one or more layers of material usually made of rubber. The various types of belt conveyor systems requires change in the design, manufacturing techniques, operation and maintenance of the belting on a conveyor. In this section the composition of the belt, type of the belt and standard types of belting as well as factors considered for a particular belt are discussed.

2.2.2.1 Conveyor belt composition

The three basic components of a conveyor belt are Carcass, Top Cover and the Bottom Cover shown in Fig.2.2. The carcass is protected by covers on both the ends to protect it from environmental factors.

![Diagram of conveyor belt composition](image)

**Fig.2.2. Composition of the conveyor system**

Belt carcass provides the required strength for movement of the loaded belt, impact if any of the loading material and provides the required stability for the correct alignment. Genadiev et al 2006 has discussed widely the composition, characterization and reparation of the conveyor belts.
2.2.2.2 Covers

The covers for the conveyor belting and bonding of the belt carcass use the rubber like materials. These covers aid in good resistance to fire, oil or chemicals.

2.2.2.3 Carcass

The carcass provides the required support to the load, the belt tear resistance, the ability for holding the fastener. It also provides the required tensile strength for the movement of the belt.

2.2.3 Conveyor belt fabric

The belt fabric for the conveyor is made up of weft yarns and warp yarns. The weft yarns run crosswise and the warp yarns run lengthwise. Many of the conveyor belt fabrics are produced with polyester warps and nylon wefts. The advantage of using these are they give high strength, good load support and fastener holding ability. The general Carcass materials used in the production of the belt are Cotton, Rayon, Glass, Nylon Polyamide, Polyester, Steel.

2.2.4 Conveyor belt selection criteria

The process involved in the selection of the conveyor involves several factors related to its installation. The designer has a wide variety of choice to choose the standard belt from the suppliers and criteria in selection such as hot material, large or small lump size etc. The fundamental requirement for the belt selection considered by designers is discussed below.

2.2.4.1 Tension rating

The rating of the conveyor belts are based on the ability to withstand the operating tension. The tension rating is expressed in kN/m of the belt width. The tension ratings are standardised within the industry and they provide a generous factor of safety i.e. 6.7: 1 for steel cord and 10: 1 for fabric belting respectively.
2.2.4.2 Number of plies (Fabric belt only)

The process of selection of the conveyor belt ensures that the full load of the material for which the conveyor is designed can be supported on the belt, as the belt spans between two idler sets.

2.3 THEORETICAL DESIGN GUIDELINES IN THE DESIGN OF A BELT CONVEYOR SYSTEM FOR THE AUTOMATED COLLAGEN SHEET FORMING MACHINE

All belt conveyors are designed as per the guidelines of Conveyor Equipment Manufacturers Association (CEMA) and Fenner Dunlop (2009)

2.3.1 Belt speed

To decide the right conveyor belt speed a number of factors are considered like particle size of the material, the inclination of the belt at the loading point, degradation of the material during loading and unloading, belt tensions and power consumption (Anath 2013).

2.3.2 Belt width

The belt width determined is a function of the quantity of the material conveyed (Fenner Dunlop 2009). The recommended belt widths are 800mm. For special applications belt width of 650mm are used and for reversible conveyors belt width should not be less than 800mm.

2.3.3 Carrier and return idler diameter

The specifications for carrier and return idler diameter are

> 100 mm for 650 to 1000 mm belts

> 127 mm for belts 1200 mm and wider
For all the belt widths, the Carrier idler spacing should not exceed 1250 mm. The specifications of the return idler and impact idler are 300mm and 3000mm for all belt widths. Rubber disc rolls or anti adhesive rubber tubes are preferred for handling sticky materials.

2.3.4 Weather protection covers

- Conveyors are provided with belt covers.
- Belt covers are semi-circular metal sheets with clamps.

The above design guidelines are followed in deciding a suitable belt conveyor system.

The present study implements the following steps to design a suitable belt conveyor system.

- Design considerations
- Selection of CAD software
- Designing and fabrication of prototype of continuous sheet forming machine.

2.4 DESIGN CONSIDERATION

The important aspect in the design of the machinery is to fix the dimensions and components of the machinery. The identified components of the machinery are the designing of the hopper and its size, the length of the conveyor, the dimensions of the roller, the frame design etc.

2.4.1 The design of a belt conveyor system

A belt conveyor system is used to carry material from one location to another. These have high load carrying capacity, large length of conveying path, easy maintenance, simple design and high reliability of operation. The parameters for the design of a belt conveyor system are
2.4.2 Conveyor belt dimension, capacity and speed

The type and dimension of conveyor belting is used to determine the diameter of the driver and driven pulley. The design in the diameter of the pulley is such that it does not place undue stress on the belt. The length of a belt conveyor expressed in metres is the length from the centre of pulley parallel to belt line. Belt length is dependent on both the pulley diameters and centre distances (Taiwo 2005).

To design a belt conveyor system the necessary design related basic information about the belt conveyor are the Input data listed below:

1. Material density $= 2000$Kg/m$^3$.
2. Length of the Conveyor $L = 976$mm.
3. Height of the material $H = 1$ mm.
4. Motor speed $N$ in RPM $= 1500$ RPM.
5. Maximum Load Capacity $M_m = 0.5$kg.
6. Diameter of the Two Pulley $D_1 = D_2 = 118$mm
7. Type of the belt = Fabric Type
8. Number of ply’s $= 3$.
9. Type of drive = Belt Drive

The design procedure for a belt conveyor system is as follows:
2.4.2.1 Belt width, $W$:

$$Mm = W \times L \times H \times \rho$$

Substituting the input design values in equation 1

Width of the belt is $256.15 \text{ mm}$.  

2.4.2.2 Belt speed, $V$

$$V = \pi \times D \times N / 60$$

Substituting the input design values in equation 2

$$(\pi \times 1500 \times 0.118) / 60 = V$$

The Belt Speed is $9.263 \text{ m/s}$.  

2.4.2.3 Belt capacity, $C$

$$C = 3.6 \times A \times \rho \times V$$

Substituting the input design values in equation 3

The Belt capacity is $16673.56 \text{ Tonnes/hour}$.  

2.4.2.4 Belt rating

Taking formulae and assumptions from PSG data book

Belt rating = 0.0289 KW/mm/ply at 180 degree arc of contact.

Substituting the values

$$belt \ rating = 0.0289 \times 9.263 \times 3 \times 1/10 = 0.08031021 \text{ KW/mm}$$

The Belt Rating is $0.08031021 \text{ KW/mm}$
2.4.2.5 Design power

Design Power = Belt width * belt rating

The Design power is 20.57 Kw

2.4.2.6 Rated power

Design power = rated power * service factor * arc of contact factor.

Service factor = 1.2 for light duty

Arc of contact for 180 degree = 1

Substituting the values

The Rated power is **17.143 Kw**

2.4.2.7 Total length of belt

\[ L = 2L + \frac{\pi}{2} (D1 + D2) + \left( \frac{(d1-d2)^2}{4L} \right) \]

The total length of the belt is **2322.52 mm**

2.4.2.8 Tension in belt

Tension in belt = 1.5% of the length of the belt

The tension of the belt is **34.83 mm**.

2.4.2.9 Length of the tightened belt

Length of the tightened belt = Total length of the belt - Tension of the belt

The length of the tightened belt is **2287.69 mm**.
2.4.2.10 Pulley width

Pulley Width = belt width +38mm {for belt width greater than 250mm}

Substituting the values

The Pulley width is 303.15 mm.

2.4.2.11 Gear box

A gear box aids in changing the revolutions per minute. It is fitted with the drive and driven pulleys.

The summary of values obtained after substitution in the formulae for the proposed belt conveyor system are summarized in Table 1.

Table 2.1. Design values for belt conveyor system

<table>
<thead>
<tr>
<th></th>
<th>Belt Width(mm)</th>
<th>256.15</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Length of Conveyor(mm)</td>
<td>976</td>
</tr>
<tr>
<td>3.</td>
<td>Basic belt length without tension (mm)</td>
<td>2322.52</td>
</tr>
<tr>
<td>4.</td>
<td>Basic belt length with tension (mm)</td>
<td>2287.65</td>
</tr>
<tr>
<td>5.</td>
<td>Height of conveyor(mm)</td>
<td>1000</td>
</tr>
<tr>
<td>6.</td>
<td>Angle of inclination</td>
<td>10</td>
</tr>
<tr>
<td>7.</td>
<td>Conveyor capacity(tonnes/hr)</td>
<td>16673.56</td>
</tr>
<tr>
<td>8.</td>
<td>Motor design power(KW)</td>
<td>20.57</td>
</tr>
<tr>
<td>9.</td>
<td>Motor rated power(KW)</td>
<td>17.143</td>
</tr>
<tr>
<td>10.</td>
<td>Diameter of the pulley (mm)</td>
<td>118</td>
</tr>
<tr>
<td>11.</td>
<td>Motor RPM</td>
<td>1500</td>
</tr>
<tr>
<td>12.</td>
<td>Thickness of belt (mm)</td>
<td>1</td>
</tr>
<tr>
<td>13.</td>
<td>Maximum Load Capacity(Kg)</td>
<td>0.5</td>
</tr>
<tr>
<td>14.</td>
<td>Material density(kg/m3)</td>
<td>2000</td>
</tr>
<tr>
<td>15.</td>
<td>Belt speed(m/s)</td>
<td>9.26</td>
</tr>
</tbody>
</table>
In earlier times more number of designer or designer's had to be employed with good exposure and expertise towards drafting tools to make a design. To do a design the cost incurred was high. The factors that contribute to the high cost of designing are creating, optimization, analysis and modifications time and again. Presently many systems are available which have been replaced by the computer. CAD provides a good solution as the design is easily made and checked by using computers. The advantage of this method is much time is saved during the design phase. The cost incurred in developing a design is fairly reduced and does not require a skilled engineer. Fig.2.3 illustrates the manual drawing of the hopper.

Fig.2.3. The orthographic view of the hopper with dimensions.
It can be seen from the above figure that designing each and every component of the machinery manually is a time consuming and tedious process. Therefore with computer aided designing much of the time dedicated for design is saved. The present day designing work is done using CAD (Computer Aided Design) tools. The steps involved in the computer aided design is summarized in the flow chart Fig.2.4.

2.5 THE COMPUTER AIDED DESIGN OF THE MACHINERY

![Flowchart of the CAD design](image)

The first step towards CAD is the problem identification. In this study the material in the form of a paste is to be converted into sheet. Therefore it is proposed to design a conveyor roller system. The next step is to analyze the design using CAD. This step is a very crucial step, since fixing the dimensions of all the components, assembling them into a single component and arriving at a suitable design are done in this step. From the final design parameters of the previous step
the initial prototype model of the machinery is constructed. The integrated testing
are all constructed in this step. Repeated analysis is carried out to arrive at the final
design. It can be inferred from the flow chart that repeated analysis and building the
prototype using CAD reduces the time and cost for design implementation.

2.5.1 Selection of the CAD software for the automated continuous sheet
forming machinery

Numerous CAD software tools are available across the globe like CATIA, Auto Cad, PRO-E, Solid Edge, Solid Works etc. There is a relative advantage of one
software over the other and are application specific. CAD provides several
advantages like generating sketches and 3D models of the machines, includes
simulation and structural analysis of the model. Solid Edge, Catia and SolidWorks
are software’s that provides all the features desired to develop and analyze the
machine stresses and forces even before actual making of the physical model. Thus
the CAD technology helps designers develop good extendibility to design at ease.

SolidWorks is a Three Dimensional (3D) software tool that runs on
Microsoft Windows. Dassault Systemes Solid Works Corp, a subsidiary of Dassault
Systèmes, S. A. (Vélizy, France) are the developer's of this tool. This tool is widely
used by individuals to large companies and are used by the manufacturing industry.
This 3D design tool provides designers the necessary skill to sketch their ideas,
experiment with features and dimensions, create models and implement a detailed
drawing. Final design is obtained from initial sketch on papers and implementing in
SolidWorks environment to build and combine the parts together in one assembly.
Before sending to build the prototype the 2D drawing is made. The other features of
solid works include tool for design validation , product data management tools,
design communication tools and CAD productivity tools.

2.5.2 Implementation of the design using solidworks software

The designing of the machine was done by using SolidWorks software. Solid
works helps designer’s to visualize a machinery in three Dimension. Based on the
identified dimension listed above, each and every component designed are integrated
into a single component to obtain the Isometric view of the machinery and is illustrated in Fig.2.5.

Fig.2.5. Isometric view of the machinery developed in Solid Works.

This software help designer’s to visualize the top view, side view, front view and dimensions of the machinery shown in Fig.2.6,2.7,2.8,2.9.

Fig.2.6. Top view of the machinery

Fig.2.7. Side view of the machinery simulated using solidworks
Fig. 2.8. Front view of the machinery

Fig. 2.9. Dimension of the machinery simulated in solid works

With solid works software designers have a chance to change the design at runtime. Any small change in the arrangement can be modified and can be transformed visualize virtually and the same to its implementation.
2.6 PROTOTYPE FABRICATION OF CONTINUOUS SHEET FORMING MACHINE

Fig. 2.10. Fabricated continuous collagen sheet forming machine

The various components of the prototype of machinery are summarized in the Table

Table 2.2. Various components of prototype machinery

<table>
<thead>
<tr>
<th>Part No</th>
<th>Part Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hopper</td>
</tr>
<tr>
<td>B</td>
<td>Roller 1</td>
</tr>
<tr>
<td>C</td>
<td>Roller 2</td>
</tr>
<tr>
<td>D</td>
<td>Conveyor 1</td>
</tr>
<tr>
<td>E</td>
<td>Roller 3</td>
</tr>
<tr>
<td>F</td>
<td>Conveyor 2</td>
</tr>
<tr>
<td>G</td>
<td>Drain tray</td>
</tr>
<tr>
<td>H</td>
<td>Motor</td>
</tr>
<tr>
<td>I</td>
<td>Switch control</td>
</tr>
</tbody>
</table>
2.6.1 Hopper

The material selected for fabrication of the hopper is GI sheet. These sheets provide good resistance to corrosion since the raw material ie, the collagen paste is rich in moisture. The design implements a hollow tank with a storage capacity of 2 Kg. It has a small vent of 10mm to allow uniform flow of the paste. The uniformity in the flow is regulated by a mechanical arrangement provided inside the tank and can be controlled by manual operation in the Fig.2.10 (a).

2.6.2 Conveyor

There are two conveyors in the machinery. The first conveyor is primarily used for uniform distribution of the paste, responsible for pressing of the sheets and preventing the paste from overflowing as indicated by arrow in the Fig.2.10 (d). The second conveyor marked in Fig.2.10 (f) is used for transferring the paste to the dryer arrangement. Both the conveyors are operated by a single pulley attachment driven by motors. The arrangement of the conveyor is such that when the switch is ON, the first conveyor moves in the clockwise direction while the second conveyor moves in the anticlockwise direction. The speed of the conveyor can be adjusted manually by a switch. Its range varies from 18 rpm to 30 rpm. The conveyor material used in the machinery is a fabric belt type with a glassy finish such that during sheet formation the material does not stick on the conveyor.

2.6.3 Roller

The three rollers marked in the Fig.2.10 (b), (c), (e) are used to press the paste/material to a sheet form and remove the excess water present in the material. These three rollers can be adjusted manually to dimensions of 3mm, 2mm, and 1mm thickness. The distances between each of the rollers are about 40cm apart which is controlled by motor, since the prepared paste (HimaBindu et al 2010, Ramanath et al 2012) is sticky in nature. In our study we have pasted a thin sheet of transparent sheet on both the conveyors and rollers. The purpose is, it prevents the paste to stick to the surface of the roller and conveyor and thus forms a thin sheet of wound dressing material. However its disadvantage is when these films are over heated they
tend to melt. The entire process of roller operation is estimated to be approximately 10 min. The outcome of the process is approximately a thin sheet with a thickness of \( \leq 1 \text{mm} \) approximately. The entire arrangement of the roller and conveyor is placed slightly at an inclined angle.

### 2.6.4 Motor

The motor marked in Fig.2.10 (h) is the prime source of the energy to run the belt conveyor system. It produces the mechanical work by taking current and this mechanical work is given to head pulley or tail pulley of the conveyor by means of the gear box drive. The motor used in this study is an AC motor with the following specifications:

- Input: 415V - 50Hz.
- RPM: 1500 RPM, 0.25 H.P.

### 2.6.5 Drain tray

The Drain Tray marked in Fig.2.10 (g) is provided to ensure that during sheet formation the excess water released from the sheet does not overflow on the conveyor instead fall into the drain tray.

### 2.6.6 Frame

A frame made of mild steel with dimension 1000 mm \( \times \) 1200 (length \( \times \) width) is fabricated for the machinery.

### 2.7 WORKING PROCESS OF THE BELT CONVEYOR SYSTEM.

The fabricated continuous collagen sheet forming machinery is shown in Fig.2.10. The raw material is stocked in the hopper and falls on the conveyor. The rollers are adjusted manually to dimensions of 3mm, 2mm and 1mm. when the motor is switched on the conveyor starts moving. The paste passes through roller 1 to form sheet of thickness 3mm. The water liberated is collected in the drain tray.
The sheet further passes though roller 2 and roller 1. This sheet is transported through conveyor 2 for drying.

2.8 CHALLENGES IS SHEET FORMATION

The paste when subjected through rollers tend to stick to the surface of the rollers and the conveyor which is due to the sticky nature of the paste. To overcome this problem a thin transparent polyethylene sheet was pasted on the surface of the rollers and conveyors. The advantage of this method is it ease the formation of proper sheets easily.

2.9 PROCESSING OF CONTINOUS SHEET FORMATION RESULTS AND DISCUSSION

In this study 1 Kg of the prepared collagen paste is placed in the hopper. The mechanical arrangement placed inside the storage tank allows uniform flow of the paste to fall on conveyor I. When the motor is switched ON the conveyor starts moving and the paste is allowed to pass through the rollers. When the paste passes through roller 1, the paste elongates in length to form a wet sheet with a thickness 3mm. During this process approximately 20% of the water present is drained and collected in the drain tray. The sheet further goes through Roller 2 which gives an output thickness of 2mm. At the output of Roller 2, further approximately 20% of moisture content is eliminated in the wet sheet. The wet sheet finally moves through Roller 3 to produce an output of 1mm thickness with a moisture content of only 20%. The time taken for the removal of water content and formation of 1mm thickness of wet sheet is approximately 4min. The length of the wet sheet formed is 30cm in length and this sheet is transferred to conveyor II. The wet sheet is dried naturally under fan or sunlight. The time taken for drying of the sheet is approximately 8 hours. The thin sheet obtained is 30cm in length and the output of the sample sheet obtained from the developed machinery is shown in Fig.2.15. This study further focuses that there is a great improvement in drying time of the wet sheet. The conventional process usually requires 3 to 4 days to dry these wet sheets. To arrive at the optimum values of sheet formation, a series of experiments were
conducted to improve the drying time of the sheet. This is accomplished by repeatedly subjecting the sheets through the rollers. The sheets were subjected through the rollers once, twice, thrice, four times and five times and the readings was recorded. A plot on the number of iterations Vs drying time of the sheet were studied and are discussed below.

Fig.2.11. illustrates the plot of number of times the sheet is subjected under the 3mm roller Vs drying time of the sheet.

**Fig.2.11. Number of iterations Vs drying time when paste is subject to 3mm roller**

It can be observed from the above graph that the number of iteration corresponds to the thinning of the sheet. This technique is adopted because thinning of the sheet improves the drying time. It is inferred from the plot that the time required to dry the sheet from the 3mm roller is 8 hours.

Fig 2.12. illustrates the plot of number of times the sheet is subjected under the 3mm and 2mm roller Vs drying time of the sheet.
Fig.2.12  Number of iterations Vs drying time when paste subject to 3mm roller and 2mm roller

It is observed from the above figure that there is an improvement in the drying time of the sheet as compared to the previous result since the sheet is processed under two rollers and it is approximately 7.6 hours.

Fig.2.13. illustrates the plot of number of times the sheet is subjected under the 3mm, 2mm, 1mm roller Vs drying time of the sheet.

Fig.2.13. Plot of number of iterations Vs drying time when paste subject to 3mm roller, 2mm and 1mm rollers
The figure above illustrates that there is a marginal improvement in the drying time of the sheet as compared to the earlier result since the sheet is processed under three rollers and the drying time is approximately 7.1 hours.

Fig. 2.14. illustrates the plot of number of times the sheet is subjected under the 3mm, 2mm roller back forth Vs drying time of the sheet.

![Graph of number of iterations vs drying time](image)

**Fig. 2.14.** Plot of number of iterations Vs drying time when paste subject to 3mm roller and 2mm rollers back and forth

In this method the sheet is passed through roller 3 and roller 2. The conveyor reverses the direction and the sheet passes through roller 2 and roller 3. The entire process of the conveyor operation is considered as one iteration. Similarly it was repeated for 5 iterations i.e. the sheet is subjected under roller for ten times. The sheet developed by this method has shown enhanced results compared to all the earlier results reported by Ramnath et al 2012. The drying time of the sheet is around 3.6 hours.

It is noticed that in all these methods the sheets developed are processed through the rollers and dried under normal sunlight or fan. This method of sheet formation has shown improved results compared to the earlier result of developing
sheets by the batch process which requires usually 3-4 days to develop the sheets. The study further confirms that the thinning of the sheet by the machinery improves the drying time of the sheet and uniformity in sheet formation is maintained throughout the process as the sheets are processed under the rollers. Further, this method of sheet formation ensures the sterility in the development of the sheets.