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Research Article

FABRICATION OF MACHINERY FOR CONTINUOUS FORMATION OF THIN SHEET OF WOUND DRESSING MATERIAL

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ABSTRACT

Objective: Low cost, simple and reliable machinery has been fabricated for the production of collagen sheets in bulk quantities.

Method: Collagen isolated from various sources is made into a paste form (semi-solid with moisture content 60-70%).The prepared paste is loaded in the storage tank of the machinery and processed through conveyors, rollers and finally dried to a thin sheet of wound dressing material with the desired thickness

Results: There is great improvement in the drying time of the paste to sheet, the conventional process requires 3 to 4 days, however when the paste is processed through the machinery the drying time is 180 min. The sheets exhibit good tensile strength when subjected to the machinery. Using the machine collagen sheets can be produced with a thickness of ≤ 1mm and a width of 250mm.

Conclusion: This machinery is useful in the preparation of large amounts of wound dressing materials which can be supplied during National calamities like wars and fire accidents.

Keywords: Wound dressing material, Sheet forming machine, Collagen sheets, Bulk Production.

INTRODUCTION

There are many biological wound dressing materials available based on collagen, fibrin, chitosan etc, some of the wound dressing materials available in sheet form does not require much machinery to prepare the final product. However, for the reconstituted materials which contain more than one component (composites), machinery has to be used to prepare the final product in sheet form. Since most of the materials used in wound dressing are proteneous in nature, these have a tendency to retain the water content that is, they do not liberate water easily neither get dried up easily as compared to a cellulose fiber (wet/moist cellulose fiber when pressed, readily liberates water and gets dried up easily).The other drawback of these proteneous material is, it is difficult to shape these compounds in sheet form, because the materials adhere to the machinery while processing. The method currently in practice to get these sheets of wound dressing materials are collagen extracted from various sources are processed to a paste[1-3] or solution and allowed to dry at room temperature / kept in sunlight to dry naturally . This cross-linking capability of collagen and remodeling of connective tissues results in attainment of wound strength [4]. When this method of drying is adopted it takes a longer time, usually 3 to 4 days for drying to get the end product in sheet form.

The drawbacks encountered during the above processes are:

- The process is a batch process
- The collagen paste is usually sticky by nature and does require a non sticky surface for sheet formation.
- Time taken for drying is more.
- Delay in the process of mass production of the sheets during natural calamities

The emergence of computer has paved the way for machinery development into an era of information. Since this is a highly sophisticated and sterile application the need for developing machinery for such applications is the primary requirement.

A novel machinery is developed in this study, taking into consideration of the above drawbacks to prepare a thin sheet of wound dressing materials that are proteneous in nature.

MATERIALS AND METHODS

Design and fabrication of mechanical set up of the machinery

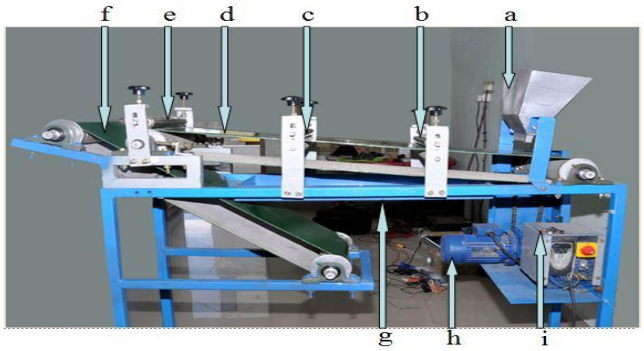

Fig .1: The developed machinery and their labeled parts shown by arrows: a storage tank; b Roller1; c Roller 2; d Conveyor I; e Roller 3;f Conveyor II; g drain tray; h motor; i switch control.

Storage tank

The purpose of the storage tank is to store the paste .Our design implements a hollow tank with a storage capacity of 2 kg of the paste. A small vent of 10mm thickness and a mechanical arrangement for opening and closing of the tank is provided at the bottom of the storage tank ensures free flow of the paste. On the sides of the storage tank is placed a handle. The purpose of this handle is to spread the paste evenly before it goes into the rollers thereby ensuring uniform pressing through the rollers and also prevents the paste from spilling to its surface.

Conveyor

There are many types of conveyors available [5] however in the present design a two conveyor system is used. The first conveyor is primarily used for uniform distribution of the paste, responsible for pressing of the sheets and preventing the paste from overflowing. The second conveyer is used for transferring the paste to a stainless steel rack for drying. 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.This rotation of the conveyors is accomplished by placing the belt in a cross pulley arrangement. The speed of the conveyor can be adjusted manually by a switch. Its range varies from 18 rpm to 30 rpm.The Computer Aided Design for the design of Conveyor, Roller, and storage Tank was developed using solid works and its mechanical implementation of the fabricated machinery is shown in Fig1.

Rollers

The purpose of the roller is to press the paste/material to a sheet form and remove the excess water present in the material. There are 3 rollers attached to conveyor which can be adjusted manually to a height of 3mm, 2mm, and 1mm thickness. The distances between each of the rollers are about 40cm apart which is controlled by motor shown in the Fig 1 and labeled appropriately. Since the prepared paste is sticky in nature in our study we have pasted a thin sheet of cellulose acetate 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. Cellulose acetate is also known as zylonite is the acetate ester of cellulose. The entire process of roller operation is estimated to be approximately 5 min. The outcome of the process is approximately a thin wet sheet with a thickness of ≤ 1mm approximately. The arrangement of the roller and conveyor is placed slightly at an elevated angle. This arrangement ensures the easy flow of water when it is removed from the material and collected in the drain tank shown in the Figure.1

RESULTS AND DISCUSSIONS

The fabricated machinery for the preparation of thin sheets of wound dressing materials is illustrated in Figure.1.In our study we have placed 2 kg of the prepared collagen paste[6] in the storage tank .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 marked in Fig 1.All the 3 rollers are adjusted manually for 3mm, 2mm and 1mm thickness of the output. 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 marked in Fig 1.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 4 minutes. The length of the wet sheet formed is 30cm in length and this sheet is transferred to conveyor II. From the conveyor II this sheet is transferred to the stainless steel for drying.The wet sheet is dried over fan and the time required to dry these sheets is appoximately 180 min.The thin sheet obtained is approximately 30cm in length and the output of the sample sheet obtained from the developed machinery is shown in Figure 3.The mechanical properties of the thin film of collagen sheets obtained using the machinery developed is summarized in Table 1.

Our results show that the three thin collagen sheets produced using this machine exhibited good tensile strength with thickness of ≤ 1mm (Table1).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 and due to the delay in the drying process there is a possibility of bacterial contamination of the sheets which is totally eliminated in our study, since the time required to make thin sheets of wound dressing material is approximately 180 minutes. During natural calamities this machinery is very useful as it prepares required number of sheets in a short time.

Fig 2: Illustrates the collagen paste

Fig 3: Shows the sample collagen sheets rolled down from the developed machinery

Table 1: Mechanical Properties of Thin film of collagen sheets obtained from the Developed Machinery.

Sample	Thickness(mm)	Tensile Strength(Mpa)	Elongation at break (%)
1	0.16	29.50 ±1.52	6.80 ± 0.90
2	0.10	40.44 ± 2.85	11.00 ± 1.92
3	0.12	35.17 ± 2.41	6.20 ± 0.90

CONCLUSION

With the recent development in computer technology, developing applications for multidisciplinary research has significantly improved over the past decades. This novel machinery developed finds its application in the thin sheets of wound dressing material based on collagen used for wound management purpose. The application requires a highly sterile atmosphere and the developed machinery/instrument is relatively low in cost and can be used in laboratory as well as for the production of large scale of wound dressing materials.

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