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# Design and Development of Paper Recycling Machine

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**Abstract:** In any big institution, especially educational institutions like schools or colleges, generation of large quantity of waste papers is quite apparent. And effective use of recycled paper is also possible (craft papers, registers etc). So, instead of disposing off the waste papers into trash, recycling them makes sense. This not only helps the institute in cost saving but will also ensure its contribution towards the protection of the environment. Designing automatically operated small-scaled paper recycling plant, which can be used in schools and colleges, ensures that a cheap and non-complex method of production of paper product is guaranteed. Accordingly design of the machine unit has been prepared with all necessary component specifications.

## I. INTRODUCTION

Recycling saves the natural wood raw stock, decreases the operation and the capital costs to paper unit, decrease water consumption and last but not least this paper processing gives rise to the environment preservation. A key issue in the paper recycling is the impact of the energy use in manufacturing. Paper is one of the most important products ever invented by man. The primary raw material for the paper production is the pulp fibers obtained by complicated chemical process from natural materials, mainly from wood. This fiber production is very energy demanding and at the manufacturing process there are many of the chemical matters which are very problematic from the view point of the environment protection. The paper recycling, simplified, means the repeated defibering, grinding and drying, when the mechanical properties of the secondary stock are altered, the chemical properties of fibers, the polymerization degree of pulp polysaccharide components, mainly of cellulose, their supra-molecular structure, the morphological structure of fibers, range and level of interferences bonds.

## II. PAPER RECYCLING PROCESS

The paper recycling process basically involves the generic recycling process of collecting the recyclables, sorting them by their types, processing them into raw materials and manufacturing new products using these recycled raw materials. Nevertheless, there are some variations from the process of recycling other materials. Three categories of paper can be used as feed stocks for making recycled paper mill broke pre-consumer waste, and post-consumer waste. Mill broke is paper trimmings and other paper scrap from the manufacture of paper, and is recycled internally in a paper mill. Pre-consumer waste is material which left the paper

### A. Sorting

To start the paper recycling process, the waste paper needs to be sorted, such as by newsprint, computer paper, magazine paper etc, as different types of paper are treated differently during the paper recycling process to make different types of recycled paper products. For example, finer paper with multi-colored ink would require additional processing. Effort is taken to ensure that the waste paper is free of any pins, clips, staples etc.

### B. Pulping

During this stage of the paper recycling process, the sorted paper is usually soaked in huge pulpers, which contain water and chemicals. The pulper shreds the paper up into smaller pieces. The heating of the paper mixture also breaks the paper down more quickly into the paper fibers. The paper mixtures turns into a mushy mix, known as a pulp.

### C. Pulp screening and cleaning

The third stage of the paper recycling process is known as screening and cleaning. The pulp is forced through screens with holes of various shapes and sizes to remove small contaminants such as bits of plastic and globs of glue. In addition, the pulp may also be spun around in large cone-shaped cylinders. Heavy contaminants (e.g. staples) are thrown out of the cone via centripetal forces, while lighter contaminants collect in the center of the cone and are removed.

#### D. Deinking

The next stage in the paper recycling process involves deinking – removing the ink from the paper fibers of the waste paper. Sticky materials (referred to as “stickies”) like glue residue and adhesives are also removed at this stage. Deinking is achieved by a combination of mechanical action (eg. shredding) as well as chemical means (eg. additional of chemicals). Small particles of ink are rinsed from the pulp with water, while larger particles and “stickies” are removed with air bubbles in a process known as flotation. With flotation, the paper pulp is fed into a flotation cell, where air and soap-like chemicals called surfactants are injected into the pulp. The surfactants cause the ink and “stickies” to dislodge from the pulp and stick to the air bubbles as they float to the surface of the mixture. The inky air bubbles create froth which is then removed, leaving the clean pulp behind.

#### E. Refining, Color Stripping and Bleaching

During refining, the pulp is beaten to make the recycled fibers swell, as well as to separate the individual fibers to facilitate paper making. If the recovered paper is colored (eg. color printed paper), color stripping chemicals are added to remove the dyes from the paper. From this processing, brown paper is obtained. If white recycled paper is to be produced, the pulp would need to be bleached with hydrogen peroxide, chlorine dioxide, or oxygen to make it whiter and brighter.

#### F. Papermaking

In the last stage of the recycling process, the cleaned up pulp is ready to be made into recycled paper.

The recycled fiber can be used alone, or blended with new wood fibers (ie. virgin fibers) to give it extra strength or smoothness.

The pulp is mixed with water and chemicals, such that the pulp is 99.5% water. This watery pulp mixture then enters the head box of a paper making machine, and is sprayed in a continuous jet onto a huge wire mesh-like screen moving very quickly through the paper machine

### III. MANUFACTURING PROCESS

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

#### A. Metal Cutting

Metal cutting or machining is the process of by removing unwanted material from a block of metal in the form of chips.

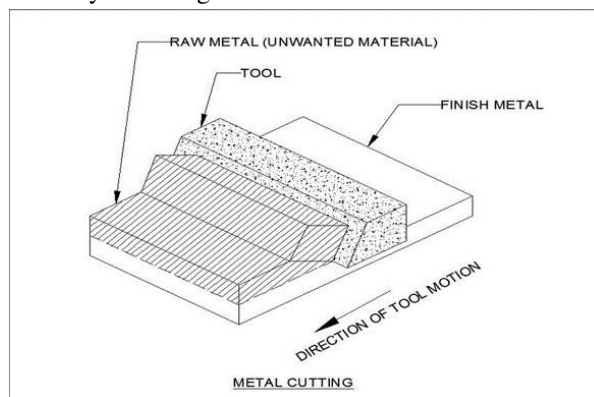


Figure: 1 Metal Cutting

Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured away is in small sized pieces, called chips. Common cutting processes include sawing, shaping (or planing), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for the fracture can be understood by just a simple model called for orthogonal cutting.

#### IV. COMPONENTS AND DESCRIPTION

The major components involved in the fabrication of the automatic paper recycling machine are as follows.

- 1) Frame stand
- 2) Stirrer
- 3) Pulper
- 4) Heating element
- 5) D.C Motor
- 6) Bearing with bearing Cap
- 7) Pneumatic cylinder
- 8) 5/2 Direction control valve
- 9) Flow control valve
- 10) Connectors and hoses
- 11) Air Dryer

#### V. WORKING PRINCIPLE

The raw material for the paper recycling plant unit is paper pulp slurry and the waste papers. It is a mixture of approximately 50% pulp and 50% water. Generally, for big paper recycling plants, the source of raw material is the waste paper pulp from paper industry. But, as the machine unit fabricated under this project is of small scale and is meant for reusing and recycling the waste papers generated in a school or college, pulp slurry can be prepared locally. Additives can also be added to slurry to obtain certain desired properties of the paper.

First the raw materials are fed into the hopper. This process is made by D.C motor with stirrer unit so that the correct amount of raw materials is fed properly and consistently. The raw materials (waste paper) moves from the hopper to the sieve drum which contains a pulper inside it. The pulper is simply a set of blades which rotates at speed greater than the normal one so that the raw materials fed are crushed into small granules. The pulper is operated with a D.C motor which is located at the top side of the drum. When the D.C motor is rotated, the pulper rotates with it thereby undergoing the crushing action.

Once when the crushing operation is over, the granules are converted to a container for adding some additives which helps to reduce the recycling time. Then finally a stirrer is used to stir the granules thereby adding required amount of water slowly. Thus the water addition and the stirring operation are performed side by side.

Then, finally the stirred granules are poured in a bed and a punching machine is used to flatten any excess water is squeezed out. The material which is bound by the press is made to dry at room temperature. This drying operation cannot be done in an oven or a heater since this temperature will be very high for the paper material and there is a chance of product getting spoiled and hence the room temperature is preferable.

#### VI. CAD MODEL 2D AND 3D MODEL

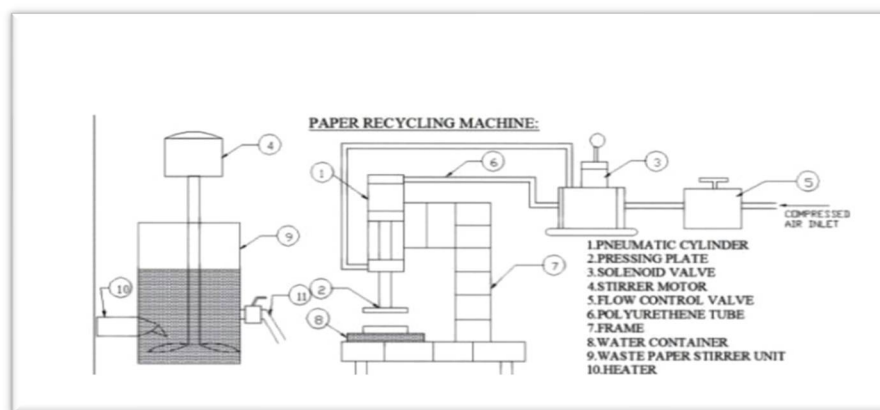


Fig.1.2D layout model



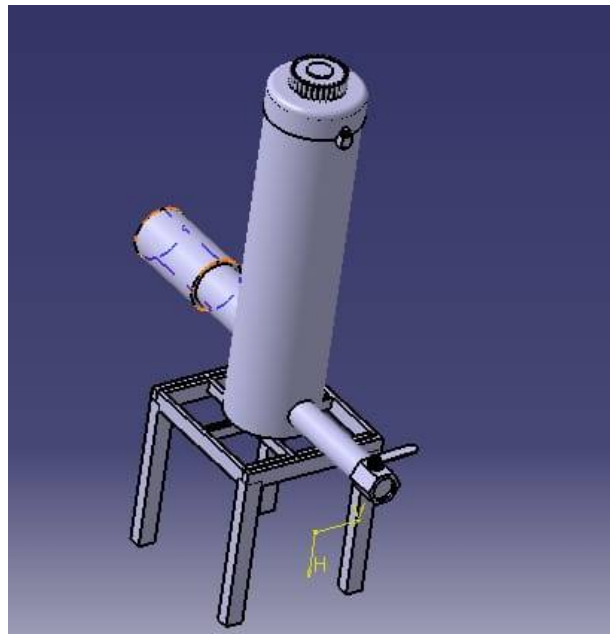


Fig.2 . 3D Model

#### A. Heating Coil Insulation

Heat loss without insulation:

Average temperature of absorber plate ( $T_p$ ) = 353 K

Ambient temperature ( $T_a$ ) = 298 K

Heat-transfer co-efficient ( $h$ ) = 20 W/mK  
Resistance ( $R$ ) =  $1/hA$

$$= 1/(20 \times 2)$$

$$= 0.025$$

$$\begin{aligned} \text{Heat transfer (Q)} &= \Delta T/R \\ &= (T_p - T_a)/R \end{aligned}$$

$$= 55/0.025$$

$$= 2200 \text{ W}$$

Thickness of insulation required when the heatloss is reduced by 99%

$$0.99 = \frac{(\text{Heat loss without insulation} - \text{Heatloss with insulation})}{\text{Heat loss without insulation}}$$

#### B. Heat Loss With Insulation

Thermal conductivity of glass wool ( $k$ )

$$= 37.2 \times 10^{-3} \text{ W/mK}$$

$$Q = 0.99(220 - \text{Heat lost with insulation})/2200 \quad \text{Heat loss with insulation } Q_1 = 44 \text{ Watts}$$

$$R = \Delta T/Q_1$$

$$= 55/4$$

$$= 1.25$$

$$R = 1/A [ (L/K) + (1/h) ] \quad 1.25$$

$$= \frac{1}{2} [ (L/37.2 \times 10^{-3}) + (1/20) ]$$

$$\text{Thickness of insulation (L)} = 91.14 \text{ mm}$$

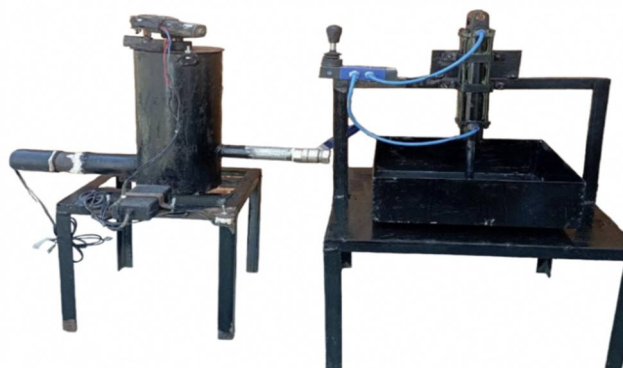


Fig 3 Fabrication Model

## VII. CONCLUSION

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning and purchasing while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries. We are proud that we have completed the work with the limited time successfully. The “Design And Development Of Paper Recycling Machine” is designed with satisfactory conditions. We can able to understand the difficulties in maintaining the tolerances and also the quality.

Recycling of waste paper is beneficial not only from the economic point of view but also for the protection of the environment. It promotes conservation of one of our very important natural resources-trees. Considering this, a small scale manually operated automatic paper recycling machine has been designed which can recycle wastepaper for various productive purposes. The very low cost of running the machine, make it quite economically viable.

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