Design and Fabrication of Automated Paper Recycling Machine: A Review

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Abstract - *The generation of waste paper is quite common especially in the educational institutions like schools or colleges. The recycling of paper is possible to overcome of this problem, recycling the waste paper is best way to protect the wastage of paper instead of disposing off. This has many advantages like saving of cost, along the contribution toward the environment protection. To achieve this, considering the design and fabrication of automated paper recycling machine, to use in schools and colleges. In the current paperwork, a detailed review on the paper recycling machine especially used in educational institutions like schools or colleges is described. Reviews have also considered recovery techniques for pulp paper making.*

Keywords: Design, Fabrication, Pulping, Recycling, Refining, Sorting

I. INTRODUCTION

The recycling of paper from the waste paper in India per yearly basis is only 20% which is very low compared to other countries. Be it a chamber, multi-chamber, or mill-sized baler where you can install recycling bins and collect waste paper on a regular basis for recycling or a large waste paper manufacturer, such as a publisher. It is easily installed to safely store and bale your paper waste which is ready for recycling [1].

Paper is one of the most essential products created by man. Paper recycling reduces capital costs and operating costs for a paper unit, natural wood raw stock. Water consumption is very low here. The primary raw material for pulp fibers derived from wood is a complex chemical process for paper production. There is a lot of energy demand for this fiber and from the perspective of environmental protection, there are many chemical issues that are very problematic in its manufacturing process. Drying, grinding, and defibering processes make changes in the mechanical properties. The main problem in paper recycling is the influence of energy consumption on production [2, 4].

Howard and Bichard, Hartler, McKee, Bovin, and Teder, and Bobalek and Charturvedi have attempted the research work on small scale design and fabrication of paper recycling machine. They have determined the property changes with repeated cycling. Aditya V P et al. [1] developed a paper recycling unit especially to minimize the large quantity of waste paper produced in the educational institute. In their work, the heating coil is operated to vacate the excessive amount of water from the pulp content. Hydropulper has employed to convert the paper and water mix into the pulp. To lower the water content, a heating coil is united to the hydro pulper. Mild-steel with carbon content of 0.3% used for the fabrication of the paper recycling machine. Machine ensures that a cheap and non-complex method of production of paper product.

M. A. Olutoye [2] developed a paper recycling system includes main six components the hydropulper, disc refiner, the head box, the driers, the rollers, and the felt conveyor. The machine was efficiently built, it producing 7.6 kg of recycled paper from 10 kg of used paper.

Oluwole et al., [3] considers the paper recycling machine i.e., the existing one with slight modifications. In that, the high-speed electric motor used to rotate the rotary blades. In their experiment work, produced 25-30 kg of recycling of the paper per hour, and which was turned to high and good efficiency of pulp at the speed of 1440 rpm. The suitable binders are chosen with composite samples to make the pulp in the production of waste paper.

Vrushabh R et al. [4] designed and fabricated a paper recycling machine for the purpose of saving a paper wastage in the schools or colleges. They managed a unit at a fixed position or stationery, else it could be shifted from one place to another.

In the current paperwork, a detailed review on the paper recycling machine especially used in educational institutions like schools or colleges is described. Reviews have also considered recovery techniques for pulp paper making.

Paper recycling process

The recycling of the waste paper process involves sorting of the collected recyclable materials to make new products using of these materials [3]. However, some difference in process occurs for the recycling of other collected materials. The waste paper will be categorized in the recycling process, generally it will be used as feedstocks like the mill is pre-consumer waste and post-consumer waste. The mill breaker is another paper scrap from paper trimming and paper making and is recycled internally in the paper mill. Pre-consumer waste is a material that leaves the paper mill but is discarded before

it is ready for consumer use. Post-consumer waste is an item that is discarded after consumer use, such as old corrugated containers (OCC), old magazines, and newspapers. Paper suitable for recycling is called "scrap paper", often used to produce molded pulp packaging. The industrial process of removing printing ink from recycled paper fibers is known as making deionized pulp [4].

A general discussion on the method of the paper recycling is discussed in the following:

Sorting

To begin the recycling process, sorting of the waste paper such as magazine paper, newsprint, and computer paper is main step because different types of paper are processed differently in the recycling process. Attention is given while collecting and sorting of the waste paper, because it should be free of any clips, staples, and pins.

Processing: Pulping

In the huge pulpers, the sorted paper is soaked which contain water and chemicals. The pulper slice the paper into smaller pieces. The paper fibers break more quickly during the heating of the paper mixture. The paper blends shift into a mushy mix, known as a pulp [5].

Processing: Pulp screening and cleaning

Pulp screening and cleaning is the third step in the paper recycling process. Removing of globs of glue and contaminants like plastic bits with the pulp are achieved, when these are subjected to pass through the holes of various shapes and sizes. The pulp contain staples which are thrown out of the cone by the centripetal forces, while at the center the lighter contaminants are collected and are easily removed [5].

Processing: Deinking

Removing of the waste paper fibers is the next step in the paper recycling process. At this stage, the eliminating of sticky materials like glue residue and glue from the deinking process. The method of removing large sticky particles know as buoyancy with air bubbles. In the paper pulp, soap like chemicals and air are fed with the help of buoyancy process. Whereas, the small particles in the pulp are washed with water. Surfactants cause the ink and "sticks" to eject from the pulp and adhere to air bubbles while floating on the surface of the mixture. The ink air bubbles create foam, which is then removed, leaving a clean pulp.

Processing: Refining, Color Stripping and Bleaching

During processing, the pulp is crushed to inflate recycled fibers, while the individual fibers are isolated to ease paper making. when the recovered paper is colored, paint chemicals are added to remove the dyes from the paper. From this process, the brown paper is obtained. To produce white recycled paper, the pulp must be made white and bright with hydrogen peroxide, chlorine dioxide, or oxygen.

Processing: Papermaking

Papermaking is the final step in the paper recycling process. The ready clean pulp can be used for the paper recycling process. The new made fiber used as alone or to need more smoothness and strength, it can be mixed with wood fibers, later it mixed with the chemicals and water. This mixture is sprayed continuously in the form a jet onto the mesh screen through the head box of the paper machine. Thereafter, here water starts to drain from the pulp. The recycled fibers will bond together. The sheet then proceeds rapidly through a sequence of felt-covered press rollers which press out more water from the pulp [6].

II. COMPONENTS AND DESCRIPTION

In the literature, it has been found the following components were commonly used in the fabrication of the automatic paper recycling machine.

- Frame stand,
- Stirrer,
- Pulper,
- Heating element,
- D.C Motor,
- Bearing with bearing Cap
- Pneumatic cylinder,
- 5/2 Direction control valve,
- Flow control valve
- Connectors and hoses,
- Air Dryer

Frame Stand

Frame stand supports or fix all other components mentioned above, with suitable arrangement. Commonly, the mild steel material is chosen to make the frame stand.

Stirrer

A stirrer or mixer is an instrument called a stir bar (also known as a "flea") for quick sinking in the liquid, thus blending it. It is just a rod with a flat bottom and is utilized to mix two distinct materials when liquefied by glass material. Magnetic stirrers are also available in the market. Magnetic stirrers are usually employed in chemistry and biology laboratories where they can be operated in hermetic sealed vessels or systems without the need for intricate rotary seals. They are chosen over gear-driven motorized stirrers because they are more peaceful, more efficient, and have no moving external parts (other than a simple bar magnet) to break or erode. Magnetic stir bars generally work well in chemical containers, since they do not significantly affect the glass magnetic field.

The stir bars associated very slowly with thick suspensions or viscous liquids. This requires an additional mechanical stirring is favorably preferred.

Pulper

In farming, the pulp is a machine developed to remove pulp (i.e., soft meat from farming products). For example, when the coffee is produced, the ripe, red cherries are harvested from the coffee bushes and need a soft pulp drying before and after fermentation (otherwise potentially uncontrolled fermentation/rot will occur). In the case of coffee, pulping is usually done in a hand-cranked or engine-powered pulper; The beans are unplugged into a high hopper and then snap through a narrow slot in which the pulp comes into contact with a rotating jagged drum. Again, in the case of coffee, the sticky beans caused by this process are washed, fermented, washed again, dried before further processing (milling to remove the skin), and then fried. In the paper industry, the pulp is a machine employed to clean virgin pulp (slabs or sheets), waste paper and breakage, dinking, and pulp. It breaks down the fiber from the mechanical operation. Post-consumer waste is re-pulsed, which is one of the recycling processes. In waste paper processing, waste paper is first crumbled to make granule particles and crushed virgin pulp, and then other processing techniques are carried out. The pulper drum is located inside, which is rotated with the help of a rotating handle. This can be automated by returning the handle with the motor, but it also raises the cost of the project.

Heating Element

The heating element is one which is used to heat the place in which the element is placed. The heating element is one type of the special type of the element, which converts the power source into the heat energy. The heating element is given the input A.C. power supply for acquiring the necessary heat in the element and to achieve the eating of the surrounding element or the metal. In this project we use the silencer for the heating through the heating element.

The heating element transforms electricity into heat through a resistor or joule heating process. The current passing through the element faces resistance, which directs to the heating of the element. Like the Peltier effect, this process is independent of the current flow direction.

Figure 1: Pulper

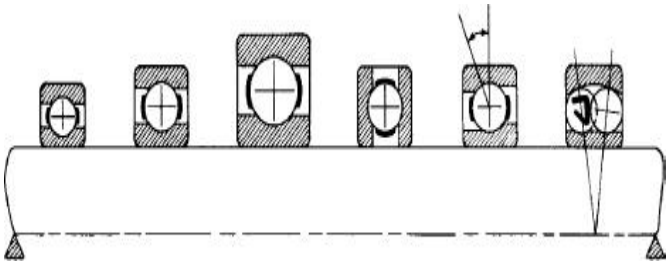
D.C. Motor (Permanent Magnet)

An electric motor is a machine that transforms electrical energy into mechanical energy. Its action is founded on the principle that when the current-carrying conductor is positioned in the magnetic field, it experiences the magnetic force that is directed by Fleming's left-hand law. When the motor is in operation, it produces torque. This torque can induce mechanical rotation. DC motors are categorized as shunt-wound or chain-wound or compound injury motors.

Types of Ball Bearings

Ball-bearing usually consists of four parts: inner ring, outer ring, balls, and cage or separator. To improve contact area and carry larger loads, the balls move in curvilinear grooves in the rings.

The radius of the groove is slightly larger than the radius of the ball and should furnish some degree of radial play. The bearing is allowed to alter itself to a small degree of angular misalignment between the mounting shaft and the mounting. The separator keeps the balls evenly spaced and prevents them from touching each other on the sides where their relative speeds are high. Ball bearings are made in a variety of sizes and sizes. Single-line radial bearings are produced in four series of extra light, light, medium, and heavy for each bore.



100 Series 200 Series 300 Series Axial Thrust
Figure 2: Angular Contact Self-Aligning Bearing

The heavier chain bearings are represented by 400. Most, but not all, manufacturers use a numbering system so that the last two digits are multiplied by the boring 5 in millimeters. The third number on the right indicates the serial number. Thus, the 307 bearing refers to the mid-series bearing of the 35-mm bore. For additional digits that may be in the bearing's catalog number, see Manufacturer's Details [7].

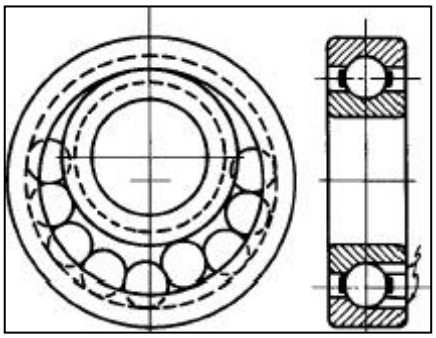


Figure 3: Conard Bearing

Some manufacturers list two rows of balls with deep groove bearings and bearings. For bearing designs of quality bearings and components (QBC), refer to pages dedicated to this purpose. The radial bearing is the maximum axial stress that can be carried.

However, when the load is directed along the axis, the pressure type of the bearing must be used. Fundamental and axial loads of both angular contact bearing care. The self-assembling ball bearing takes care of a large number of angular misalignments. An increase in radial power can be secured by using deep grooves or a two-line radial bearing. Radial bearings are divided into two general categories based on the assembly method [8]. These are the Conrad, or non-filling notch type, and maximum or filling-notch type. In the Conrad bearing, the balls are placed as shown in Figure 3.

Pneumatic Cylinder

Automation is broadly defined as the substitution of manual effort with mechanical power. Pneumatics are an attractive medium for low-cost automation, especially for sequential or repetitive operations.

Many factories and plants already have a compressed air system, which is capable of providing both energy or energy requirements and control systems (equally pneumatic control systems can be economical and conveniently applied to other types of energy).

The main advantages of an all-pneumatic system are generally the economy and simplicity, the latter reducing the performance to a lower level. This can have great benefits in terms of safety [9].

Double Acting Pneumatic Cylinder

The cylinder is a double-acting cylinder, which means that the air pressure acts alternately (forward and backward). The air from the compressor passes through the regulator, which regulates the pressure to the required amount by adjusting its knob. The pressure gauge is attached to the controller to show the line pressure.

The compressed air is then routed through a directional control valve to supply air alternating to either side of the cylinder. The two hoses take the direction of the directional control valve and are connected to the two ends of the cylinder by connectors. One of the outputs from the directional control valve is taken to the flow control valve by the cylinder [10].

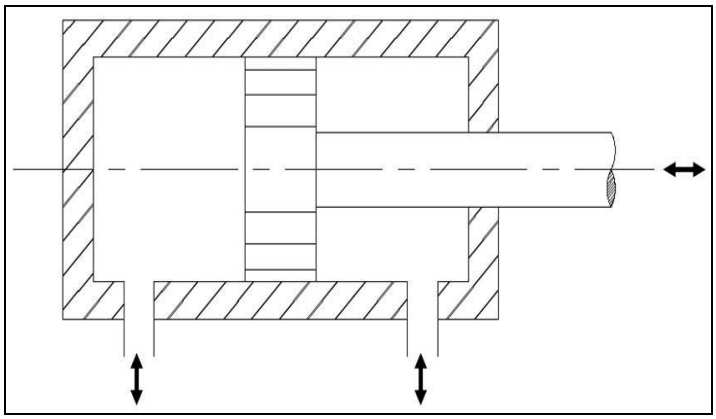


Figure 4: Double acting pneumatic cylinder

Air cylinder is an operative device in which the compressed air state input energy converts pneumatic energy into mechanical output power by reducing the air pressure to atmospheric pressure.

5/2 Direction Control Valve

The pneumatic system in a predetermined sequence with the cylinder's toe-to-toe and fro-motion, the fluid power is controlled and reversed [11].

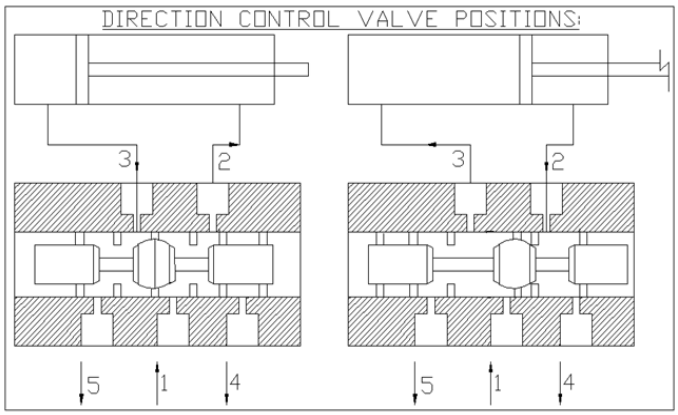


Figure 5: 5/2 direction control valve

Connectors and Hoses

In our pneumatic system, two types of connectors are used; One is a hose connector and the other is a reducer. Hose connectors usually include an adapter hose nipple and a cap nut. These types of connectors are made of brass or aluminum or hardened steel. Cutters are used to interconnect between two tubes or hoses of different sizes. They can be installed directly, tee, "V" or other configurations. These reducers are made from other materials such as gunmetal or hardened steel.

Air Dryer

It is made of nylon metal. The fan (impeller) turns inside the shell. The shell is so designed that the air is forced out. Blower fixed with stand. The heating element is fixed below the blower unit. The hot air is toward the ground [13].

III. CONCLUSION

Recycling waste paper is beneficial not only from an economic standpoint but also for the protection of the environment. This will stimulate conversation about our major natural resource's trees. Considering this, a detailed literature review was conducted on a small-scale automated paper recycling machine that is conveniently used in organizations. The recycling of paper is possible to overcome of this problem, recycling the waste paper is best way to protect the wastage of paper instead of disposing off. This has many advantages like saving of cost, along the contribution toward the environment protection. The very low cost of running a machine, which makes it economically profitable.

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