PAPER RECYCLING MACHINE

A Final Year Project Report

Presented to

SCHOOL OF MECHANICAL & MANUFACTURING ENGINEERING

Department of Mechanical Engineering

NUST

ISLAMABAD, PAKISTAN

In Partial Fulfillment

of the Requirements for the Degree of

Bachelor of Mechanical Engineering

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Titled: "PAPER RECYCLING MACHINE" be accepted in partial fulfillment of the requirements for the award of BS Mechanical Engineering degree with grade ___

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ABSTRACT

The purpose of the project is to design and fabricate the eco-friendly, compact portable and economical paper recycling machine that utilizes the waste or used paper to recycle it and making various products like cardboard , tissue paper, paper of various grades and sizes etc. On industrial scale there are several paper recycling plants, recycling the used paper but not one of this kind of machine exist in Pakistan that recycles paper instantaneously. Annually tons of paper got wasted or shred away due to its confidentiality, some might get burnt leading to emission of greenhouse gases thus contributing towards global warming. By recycling of used paper not only we will reduce the carbon footprint and pollution (one of the SDGS) but also contributing towards sustainability making world better place. The recycling of paper will lead to a sustainable environment reducing carbon footprint. The paper machine can be utilized in schools, offices, public/private universities, recycling their own used paper like exam papers, documents, report, manuals, research paper. Small scale Recycling machine do exist in other countries, but they are far too expensive and not sure if large firms can also bear the cost. So, this is an effort manufacture recycling machine at indigenous level so that each and every sector can gain the maximum benefit, and later on setup can be made for the mass production of machines.

ACKNOWLEDGEMENT

First of all, we would like to thank ALLAH Almighty for giving us a chance and helping us bring this project to a completion. Second, we would like to extend heartfelt gratitude to our supervisor, Dr. Rehan Zahid, whose knowledge and thoughtful guidance enabled us in this project, MRC technicians, Lab Engineers for their valuable advice. They also assisted us in machining of parts, their welding and fabrication of parts. We would like to thank our subject professors in SMME whose teachings built our concepts used in this project. At the end, we would like to thank our families for their unconditional support and prayers that helped us go throughout our Final Year Project duration.

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ABBREVIATIONS

CAD	Computer Aided Design
kWh	Kilo Watt Hours
NUST	National University of Sciences and Technology
PMO	Project Management Office
LCP	Low Consistency Pulper
HCP	High Consistency Pulper
NC	Normally Closed
NO	Normally Open
GND	Ground
Rs.	Rupees

CHAPTER 1: INTRODUCTION

Problem identification

Everyday tons of paper utilized everywhere ranging from schools to colleges, offices to banks, large organization to corporate firms, from hotels to shopping malls form printing press to publish houses, shopkeeper utilizing it to track record of sales a layman using it for daily chores in short paper is part and parcel of one's life. The paper after its usually gets burnt if not shredded. The burring of paper causes pollution and global warming leading to emission of greenhouse gases. Thus, there was need to recycle paper at small scale to lessen the greenhouse emission and also promoting the slogan reduce reuse and recycle.

Motivation

For 2.5 million years the Earth's climate has fluctuated cycling from ice ages to the warmer periods but in the last century the planet's temperature has risen unusually fast about 1.2 to 1.4 Fahrenheit. Scientists believe its human activity that's driving the temperature up, a process known as global warming, ever since the industrial revolution began factories power plants and eventually cars have burned fossil fuels such as oil and pull releasing huge amounts of carbon dioxide and other gases into the atmosphere.

According to NASA studies the extent of the Arctic Sea has declined about 10 percent in the last 30 years as long as industrialized nations consume energy and developing countries increase fossil fuels consumption. Researchers predict that temperatures will increase about two to ten degrees Fahrenheit by the end of the century. what's less certain is what rising temperatures mean for the planet some climate model predicts subtle changes others forecast rising sea levels which could flood coastal areas around the world weather patterns could change making hurricanes more frequent severe droughts could become more common in warm areas and species unable to adapt to the changing conditions would face extinction

Planting trees and saving the existing ones can help us save the battle, but we can save the trees only if we are able to recycle the major chunk of products that are made from trees.

Paper Usage at NUST

NUST uses 15 tons of paper every year which include exam papers, assignment papers and a large amount of A4 type office papers. According to the data collected from PMO and research conducted by IESE, 5 tons of paper is wasted every year at NUST.

It takes 24 trees to make 1 ton of paper. So, 5 tons of wasted paper means 100 trees gone to waste every year only to fulfill the paper demand at NUST

A big chunk of this wasted paper is burnt, some is mixed with inorganic waste and the rest is sold to waste-paper processing sites individually by workers.

So, we have a vision to produce a machine that can be kept inside not only in NUST but in all the universities and offices, even at homes where paper is used in abundance. And instead of disposing

off all that paper or burning them or selling them, we can re-use them by recycling and save our time and money.

Requirement of small-scale machine

There is currently no paper recycling machine project in any Pakistani university. Certain websites and dealing centers in other countries produce paper recycling machines, purchasing such machines is not the smartest solution due to the high cost of office-sized compact machines. Furthermore, if paper is recycled in off-site factories, a slew of issues must be addressed, including transportation costs and time.

Last year, a group of seniors attempted to build a machine that would demonstrate the basic process of paper recycling. They were able to design the machine's foundation. As a result, we have a basic design and a direction for the concept, but it has several flaws in terms of quality of results, paper recycling technique, and machine design.

CHAPTER 2: LITERATURE REVIEW

Paper Composition

Paper is composed of plant material specifically fibers. Additives like filling material and chemicals are added to improve its strength ,texture and surface. Similarly, chemicals like rosin is added to make it water resistant.

Table 1: Paper Composition by %

Raw Material		Approx. Weight %
Fiber Material	Recovered Fiber	40
	Chemical Pulp	40
	Mechanical Pulp	10
Minerals	Coating Pigments	4
	Fillers	3
Chemical Additives	All Kinds	3

Paper Production and Recycling

For the past two decades, paper has been recycled all over the world. It is currently recycled in either huge mills or office-sized machinery. The task of recycling paper in bulk has been performed by massive paper recycling mills. They perform the following four tasks: -

- Screening
- Pulping

- De-inking (can be skipped depending on the final product required)
- Paper forming

Since the recycled paper obtained through the four processes above does not have the same strength and brightness as virgin paper, it is used to make packing cartons, tissue paper box interiors, books, or magazines, and is sent to the press to make newspapers. Furthermore, only 1 ton of wastepaper may be recycled out of 1.2 tons, with the rest separated using deinking procedures.

These paper recycling facilities range in size from 100 acres to 300 acres, such as the Bulleh Shah Paper Mill in Kasur, Pakistan, which is spread out over 240 acres and produces 240,000 tons of paper and 210 million corrugated boxes yearly.

General Paper Recycling Processes

A Paper Mill generally comprises of the following processes for recycling paper and the details of each of the process will be discussed

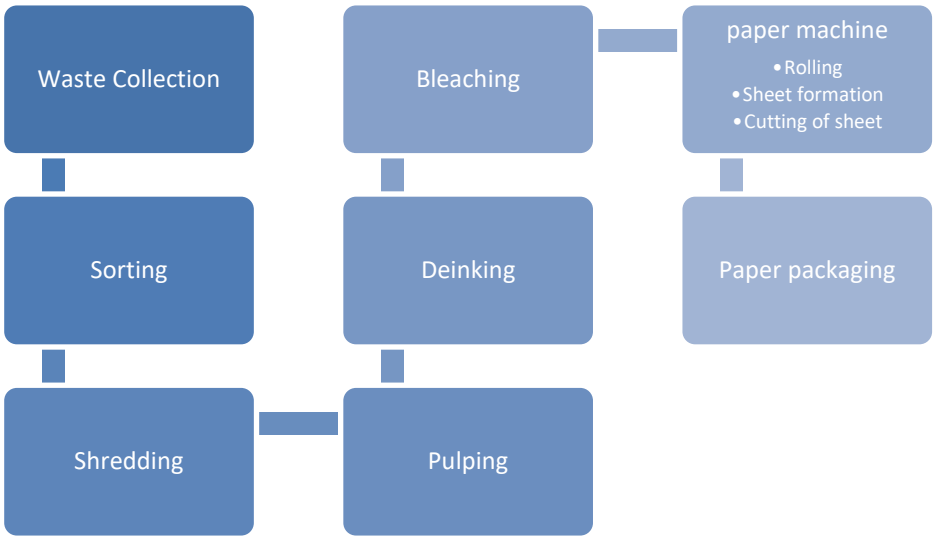


Figure 1: Generic recyling process.

Screening

Screening distinguishes impurities based on size, shape, and deformability. It works by creating a barrier for large impurities (slots or holes) while allowing fibers to pass through.

When wastepaper reaches paper recycling centers, it isn't just paper. Plastics, glass, metals, and stones have all been mixed together. They must be separated before being sent for further

processing. The simplest method is to use a rolling drum with paddles and cams. The paper is pushed forward as the waste mixture passes over the rolling drum because it is lighter than the pollutants and is very thin and flat, whilst the heavier and thicker particles are separated and remain behind the drum. On the conveyer belt, there are star-shaped screens. Glass falls through the star screens and is gathered in bins below, as it is heavier than plastic, metals, and paper.

An eddy field is formed by an alternating magnetic field producing magnetism in the metals present in the mill. The metals are propelled off the belt by the eddy field.

Plastic would be the only contaminate left. The remaining lot is put through a hot alkaline water solution to remove the plastic. The plastic is removed by running the paper through a fiber-sized mesh screen after it has been spun to lose fiber owing to maceration. A second bucket is used to collect paper.

Paper de-fabrication

The separated paper is sent through a coarse crusher, which shreds it down to a few millimeters in size. A hopper then feeds this paper through a dry de-fabricator. A revolving rotor and a static stator are then used to defibrate the paper to a micron size. The ink particles, like the paper, have been finely crushed at this point and may be easily removed. The de-fabricator also generates air flow, which carries the minute paper fibers to the ink separator.

Pulping Process

A Pulper is a device whose main objective is to convert wastepaper into a slurry of well separated fibers and other wastepaper components. Pulping is the process of converting paper into small fibers with the help of water and high-power rotors.

The pulping operation is the first and probably the most critical operation in paper recycling. Proper pulping is a requirement if unit operations downstream (cleaning, flotation....) are to be effective. Incorrect pulping conditions can irreversibly damage fibers making them inappropriate for papermaking uses.

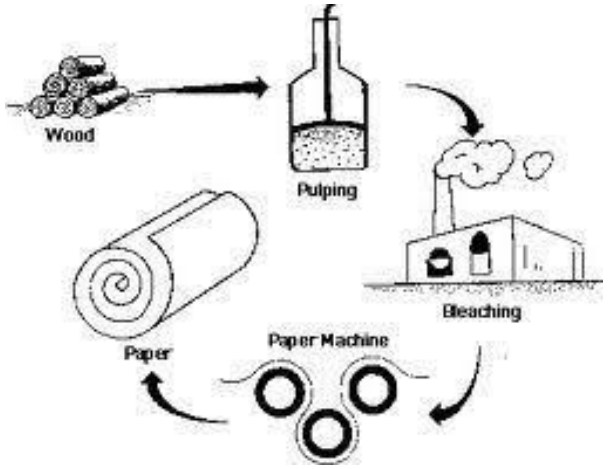


Figure 2: Simplifed Paper Making Process.

The main function of the pulper is to disperse wastepaper into separated fibers in water. However, the pulper has several sub-objectives that are also important to the overall recycling process.

1. Detach contaminants from fibers.
2. Mix paper with water and chemicals at the correct ratios.
3. Maintain contaminants as large as possible to aid in subsequent removal processes.
4. Avoid damage to the fibers (fiber cutting).
5. Removal of large debris from system.

Basic Pulping Categories are

- Batch vs. Continuous Pulping
- Low vs. high Consistency

Batch Pulping: The feed wastepaper, water and chemicals are all charged at the beginning of the process and are removed all at once at the end of the process. The batch process is repeated

Continuous Pulping: The feed wastepaper, water and chemicals are continuously added to the pulper and at the same time, the pulped product is also being continuously removed.

Low Consistency Pulper: A low consistency pulper has a circular rotor. The rotors spin at a rapid rate of 16–20 ms^{-1}. The shear forces of the rotating rotor cuts the paper. The mechanical de-

fabricating forces are high, yet moving the water consumes a lot of power. In order to improve mixing, vortices are created in the mixture and baffles are employed.

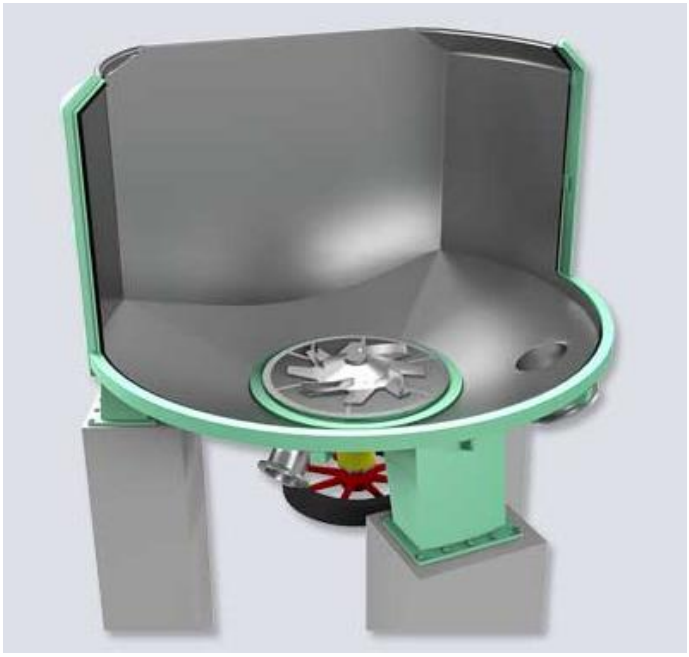


Figure 3: Cross section of low consistency pulper.

Pulper with High Consistency: These employ a helical rotor to pulp the material. Instead of vortices, a circular pattern is formed from top to bottom. Although the rotor rotates at a slow speed, shearing forces are significant when the paper crumbles and is dragged towards the rotor. The rotor is rather huge and takes up a lot of space.

Figure 4: Cross Section of high consistency pulper.

Table 2: Comparison of Pulper types

	Low Consistency Pulper	High Consistency Pulper
Percent Consistency	3 – 6	12 – 15
Percent Rotor/Tank Volume	0.1	8
Specific Power in Kw	6	22
Percent No Load Power	70 – 80	50 – 60
Speed of Rotor in ms^{-1}	16 – 21	8 - 15

Washing

A separation device that rinses small particulate contaminants away from fibers is called de-inking washer.

De-inking washer

- Dilute pulp with wash water
- Disperse small contaminant in water phase
- Remove contaminant laden water

The washing stage of wash deinking involves the use of dispersants to wash off the printing inks. When the pulp slurry is de-watered, medium to fine particles are rinsed off. This method is best useful for eliminating particles less than 30 m in diameter. When manufacturing deinked pulp for tissue, this technique is repeated on a regular basis. This step is far more efficient than traditional washing and dewatering phases

Deinking

Deinking is an important step in developing a sustainable papermaking technology. The primary objective is to remove the ink coating from the fibers. This work is based on particle physical characteristics and their differences. As a result, deinking printed paper necessitates many stages. Screening, cleansing, washing, and flotation are examples of this. Cleaning and screening are used to remove large particles ranging from 100 to 300 m, while washing and flotation are used to remove particles smaller than this.

A worry about reusing paper pulp is that the fibers quality is degraded with each cycle and subsequent recycling the fibers turn out to be excessively short and frail to be helpful in making paper. Traditional deinking disposes of large particles from these ink systems.

Flotation Deinking

The flotation process is developed based on mineral flotation. The table given below shows the difference between the two processes. This process is carried using air bubbles in slurry. Flotation is done to remove hydrophobic elements and is carried out in a flotation cell. The slurry is diluted to about 1-3% consistency.

Table 3-A: Comparison between flotation deinking and mineral flotation

Parameter	Flotation Deinking	Mineral Flotation
Particle surface energy	Ranges from low to medium to high, usually very complex	Energy is fairly uniform
Size of Particle	Broad Distribution	Broad Distribution
Density of Particle	Very Low	Higher than water
Properties of Pulp	Heterogeneous	Homogeneous
Characterization of Final Product	Brightness of Paper Sheet	Done using chemical analysis
Particle separation from Stock	Re-pulping in the presence of chemicals	No chemicals are required

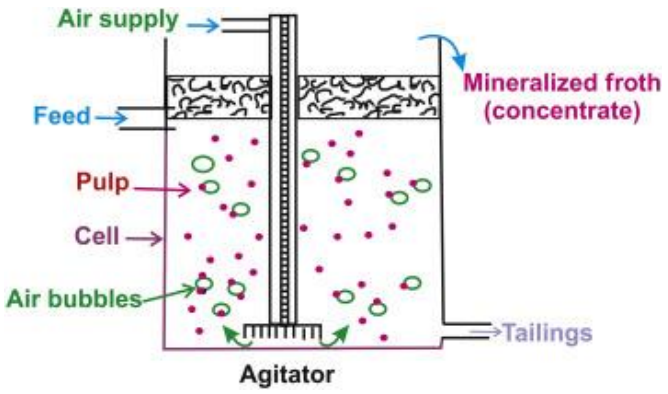


Figure 5:Floatation Deinking.

Air bubbles are introduced into the fiber slurry. The relative motion of the slurry as compared to air bubbles forces the ink to float as foam to the top which can then be removed from the tank and collected.

The pulper cuts the paper to smaller fibers, water and chemicals are added. The pH is normally adjusted to ensure efficient deinking. Chemicals used for deinking are:

- Sodium hydroxide for pH control
- Hydrogen peroxide for bleaching
- The brightness of pulp being deinked is increased by hydrogen peroxide and sodium dithionite.

The following chemicals are added together with air bubbles to improve deinking:

- Sodium hydroxide is added to swell the fiber and detach ink
- Sodium silicate is added to assist dispersion of ink
- Alum assists in frothing of ink particles
- Increased in temperature improves the deinking process.

Paper Forming

The paper forming section is the final unit of the machine. Here the de-inked paper pulp will be converted into recycled products. The section consists of the following basic parts:

- Sizing Slit
- Mesh Belt
- Forced Convection Fans
- Rollers

The basic functioning part of the Paper Forming Section is the Conveyor Mesh Belt. Its function is to carry the pulp from the deinked section to the product side while allowing the pulp to dry easily.

Some of the most widely used conveyor belt types are as follows:

1. Slider Bed
2. Metal or “Piano Hinge” Conveyor
3. Roller Bed
4. Incline & Decline Conveyor
5. Horizontal Belt Conveyor
6. Brake and Meter Belt Conveyor
7. Wire Mesh Belt Conveyor

Wire Mesh Belt has holes or mesh that facilitate air ventilation. This type of belt conveyor is therefore ideal for transporting wet substances that need to be dried. Components that otherwise are impossible to be handled using standard duck or PVC belts are transported using this type of conveyors. The wire mesh is placed on roller or longitudinal runners. In addition, toothed pulleys are used to clasp onto the wire mesh belt.

The Belt Conveyors are made of different Materials. A few Belts highlight materials including Rubber or a Fabric, for example, Nylon, Polyester, Neoprene, or Nitrile. Belt properties decide the transport line's essential applications. For instance, Mining and Milling Industries generally utilize rubber to deal with mass materials including Raw Ore and Aggregates. Markets generally use PVC transport lines, and air terminals may utilize neoprene, polyester, or elastic for gear taking care of.

These materials can have a variety of coatings, thicknesses, and forms to express a variety of qualities. Some provide nutritional well-being assessments, while others can withstand severe temperatures. Other common characteristics of general-purpose belts include high or low friction diameters, as well as explicit mass organization. Particulates can pass via a few belts instead of riding along the transport structure.

Industries may utilize Filter Belts to empty overabundance fluid out of parts or to sift through poisons. Water treatment organizations regularly utilize these kinds of transport frameworks amid Water Treatment Processes. Makers may utilize Metal or Synthetic Fibers to make Filter-Capable Belts.

- Woven Metal Belts**:** Woven Belts include interlinking chains of metal or wiring intended to permit wind current as a thing moves along. Organizations normally utilize Woven Belts to encourage drying, cooling, and warming procedures in the nourishment, gadgets, and glass-

working enterprises, among others. Producers may offer Prefabricated woven belt plans or may specially craft a Woven Belt to meet a client's particular application needs.

- Hinged Belts**:** Hinged Belts frequently include metal development. The Hinged Quality of the belt gives it a level, strong surface fit for turning around the pulley framework through interlocking pivots. Organizations use Hinged Belts for little item, scrap, and reusing applications. Metal-Hinged Belts are solid and can confront thorough use.

- Plastic Interlocking Belts**:** Plastic Belts furnish makers and material handlers with a secluded choice to metal and fabric-based belts. Organizations may utilize Plastic Belts in sustenance taking care of and bundling forms or in the car business. Secluded plastic belts function admirably in applications that require visit cleaning and belt substitution.

The material characteristics and style of the belt used are inextricably linked to its application. For this condition, a permeable, corrosion-resistant, and heat-resistant belt is required, which allows the pulp to interlock on the belt while depleting the water. The Austenitic steel material is highlighted in the SS 300 Series. These are unattractive tempered steels with high levels of Chromium and Nickel and low carbon dimensions. They're noted for their intimidating presence and corrosion resistance.

Chromium (18-30%) and Nickel (6-20%) are the most common alloying additions in these flawless analyses. Type 304 is the most commonly used alloy among all hardened steels. The crystalline structure of stainless-steel transforms to "Austenite" when nickel is supplied in a rate-referenced manner. This increases corrosion resistance and changes the structure from Ferritic to Austenitic. Austenitic evaluations are the most commonly used Stainless Steels, accounting for over 70% of total production, and are thus widely available. The most often determined assessments are Amalgam 304/304L followed by Alloy 316L.

Rollers

The steam-heated rollers may remove any residual water following the mesh belt drying portion. Simple cylinders are used to transfer steam at a high temperature through. The surface of the rollers is heated by the flowing steam. The dry pulp travels through a gap between the outer surfaces of two steam rollers revolving in opposing directions. The residual water content of the recovered product is evaporated by the heated surface of the rollers.

Calendar rollers are used in tandem with steam rollers. Rubber or felt material is generally used to cover them. When no soaking is necessary, rubber-coated rollers are employed. Felt, on the other hand, has the ability to absorb water in the same way as a sponge does. Felt is a textile substance made from fibers that have been processed. Natural fibers like as wool or animal fur can be used to make it. Alternatively, synthetic fibers such as petroleum-based acrylic acrylonitrile or rayon

made from wood pulp can be used. Blended fiber, which is manufactured by combining several types of fibers, is very popular

Figure 6: Calendar Rolls.

Dry Paper Machine Concept:

Paper recycling mills cover a lot of area and consume hours to recycle paper since they have to produce in bulk. To counter this difficulty, an office sized paper recycling machine has been built by Epson, the Paper Lab A-800.The Paper Lab is a dry type of paper recycling machine based on dry method as compared to wet processing method, on which large industries usually operate, which can recycle 720 sheets of A4 sized paper in one hour or 1 sheet within 5 seconds.

Another advantage of this compact paper recycling machine is that it can produce A4 sized paper of any required color after feeding a white used A4 paper.

The paper lab makes use of the following technique for recycling paper:

- Dry type de-fabrication
- Separation of inked particles
- Re-fabrication

However, the Paper Lab is a very expensive machine and costs $60,000. The processes in the Dry Type Paper Recycling Machine (Epson Paper Lab A-800) are explained below:

De-Fibrator

The used paper is put into a coarse crusher, which reduces it to a few millimeters in size. This paper is then fed into a dry de-fabricator through a hopper. The paper is then defibrated to a micron size using a rotating rotor and a static stator. By this time, the ink particles, like the paper, have been finely crushed and may be readily removed from the paper. The de-fabricator also produces an air flow, which the small paper fibers ride to the ink separator.

For the dry type of de-fabricator, for example, it is possible to use a dry type used paper defibrating unit equipped with a disc refiner, a turbo mill (made by Turbo Kogyo Co., Ltd.), a ceren miller (made by Masuko Sangyo Co., Ltd.), or a wind generating mechanism.

Cyclone

The crushed paper fibers move into the ink separating unit. The paper fibers are crushed so fine that the ink particles are distinct from the non-inked white part of the paper. Here the cyclone comes into play. The inked parts of the paper fibers are heavier than the non-inked parts. The cyclone uses air to separate the ink particles from the non-ink particles. The velocity of the air is to a minimum where the lighter non-ink particles are carried to the other end of the cyclone and the ink particles, being heavier, fall down and are rejected. Although this method wastes a lot of paper with ink particles, but the non-ink particles are pure white paper, and it helps in keeping the quality of the paper high.

Forming

The de-inked paper particles move to the paper forming unit. Here the particles are sprayed with hot steam and a binding material. The newly created paper paste then moves onto a conveyer belt. The first unit on the conveyer belt is the sizing unit where the thickness of the paper paste is adjusted to the desired amount. Steam rollers are installed on the later stage of the belt. The paper paste is compressed between hot steam rollers and the belt, evaporating the absorbed water. A moisture detector is attached which detects the quantity of moisture in the paper. Once the moisture content is decreased to 4% by weight of the paper, it is moved to the calendaring unit where the paper surface is smoothened, and the paper is finally cut to required size.

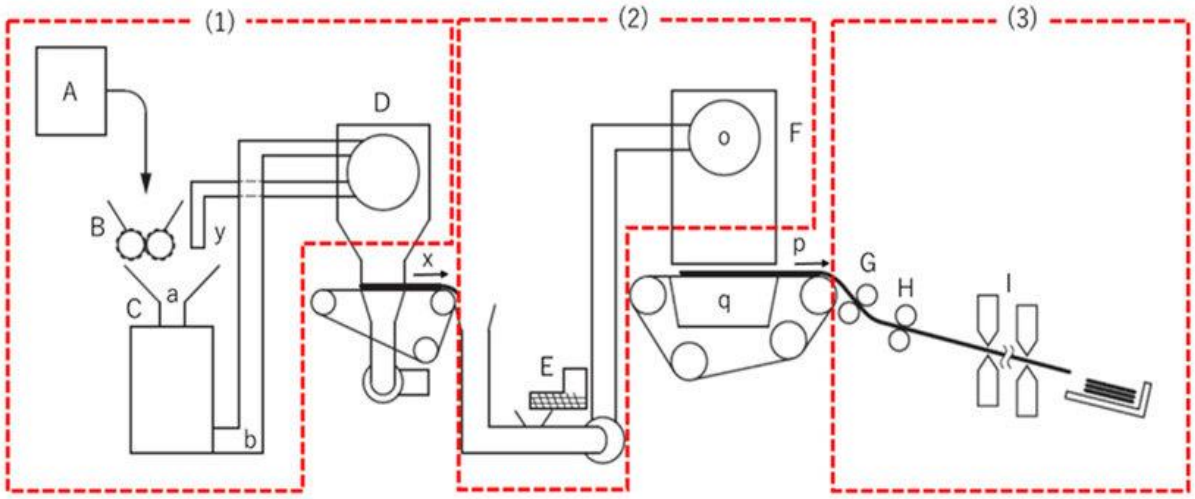


Figure 7: Schematic of Dry Type Paper Recycling Machine.

Conveyor Systems

They are mainly used to transport material from one place to another with minimal effort. It finds its application in many industries. The conveyor system can be classified according to the power source. They can be

- Powered
- Non powered

Non powered include gravity roller conveyor system etc.Further more conveyor can be horizontal, curve or inclined depending upon the requirement. There various types of conveyor system are

- Belt
- Roller
- Magnetic
- Screw
- Vertical
- Wheel
- Chain

Figure 8: Types of conveyor system.

Anatomy of conyeyor belt

The conveyor belt mostly consist of following parts

- Belt
- Drive Mechanism
- Pulleys
    - Head Pulley: the drive unit is attached to it
    - Tail Pulley: to maintain belt alignment and tightness

- Idlers: They are to support the belt when the length of belt is much larger.Usually there are different type of idlers

- Loading and Discharging Mechanism: to transport the material from one place to another this mechanism is utilized.

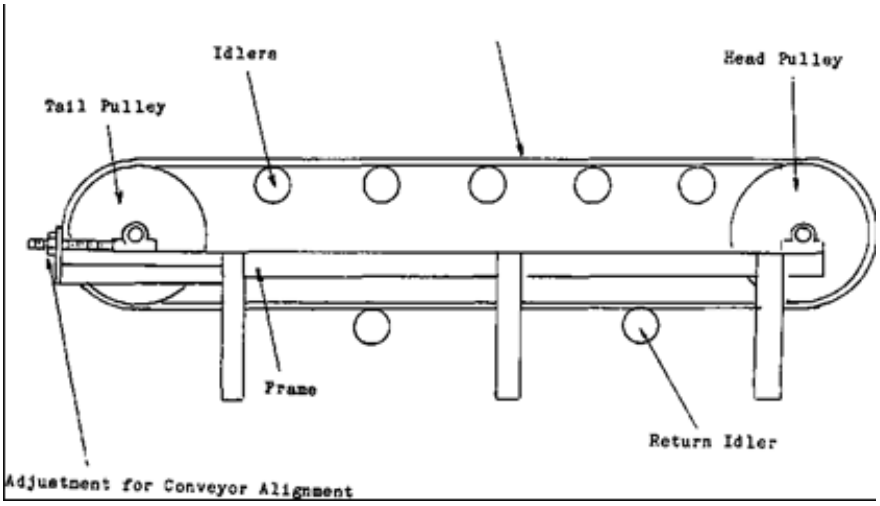


Figure 9: Conveyor Components.

CHAPTER 3: METHODOLOGY

Based on our findings in the literature review, there are two broad classifications of paper recycling methods:

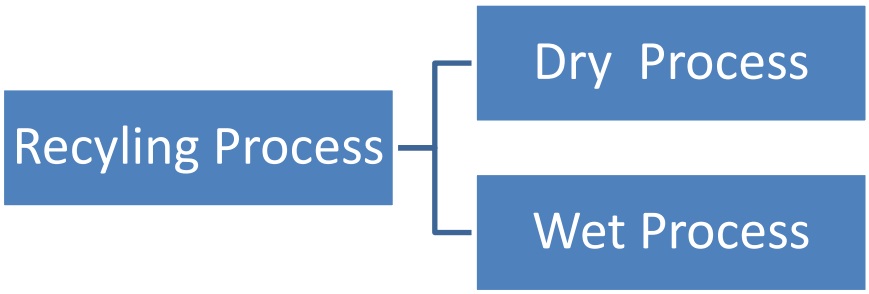


Figure 10: Recyling Processes.

The decision to adopt the wet process for the recycling of paper based was on the following factors

- Greater feasibility as compared to dry process
- Simplicity as compared to dry process
- Cost efficient
- This process requires low maintenance of equipment

Optimization of the process

Firstly, experiments were performed to optimize the paper recycling process and find the optimum recipe to recycle the paper. As described earlier, wet process is chosen to recycle the paper. Wet process involves shredding the wastepaper and adding it to appropriate quantity of water along with some chemicals. This mixture, with the help of pulper is converted into a slurry, known as pulp, with shearing force of the rotor blades. The pulp is then concentrated to remove the extra water. After that, water is removed from the concentrated pulp to obtain the recycled product. Optimization means finding the appropriate recipe for making different grades of paper, cardboard. Several experiments were performed to find the recipe. The detail of the experimentation is further discussed below.

Parametric Study

In our experiments, we used a blender as pulper. Shredded paper was added to the water in different quantities with different chemicals to compare the result and find the optimum recipe. Quantity of water was kept constant (1 L). Slurry thus obtained was passed through a wire mesh to remove the

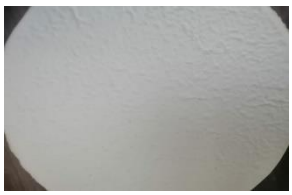
extra quantity of water and concentrate the pulp. Solar energy was then used to dry the pulp and get the final recycled product.

In the wet paper recycling method, binders are added so that the fibers separated during the pulping could properly bind in the recycled product. The mostly commonly used binders in recycling industries that are easily available are Calcium carbonate and titanium dioxide. We have performed the parametric study using both the binders.

The problem of Sticking of the pulp with the rollers and mesh was solved by using an anti-sticking agent polydiallyldimethyl ammonium chloride (DADMAC).

Table 4: Paper Recipe optimizing experimentation

Experiment	Quantity of shredded paper	Binder used	Anti-sticking agent	Result
1	10 g	$CaCO_3$	No	
2	10 g	$CaCO_3$	DADMAC	
3	15 g	$CaCO_3$	DADMAC	

4	10 g	TiO2	No	
5	10 g	TiO2	DADMAC	
6	15 g	TiO2	DADMAC	

Note:

The time for pulping in all the cases was 1 minute. The quantity of binder used is 0.1% of the amount of paper

Based on the parametric study, it was found that the best results were obtained when CaCO3 was used as a binder, The optimum consistency of the pulp was found out to be 1.5% (15 g paper in 1L). Also, the use of anti-sticking agent was necessary as it helped to prevent sticking of pulp on the mesh.

Based on the experimental study carried out, we found the optimum recipe of the pulp. The realization of the manual process in the form of a recycling machine is discussed below.

The recycling machine consists of the following subunits:

- Pulping unit
- Pulp concentration unit
- Forming unit

Implementation Procedure

The approach for the process for our machine keeping is quite simplified when compared with generic process. Since our approach is to keep the process time consumption as low as possible and also process should be economical. Therefore, simplified methodology has been adopted and machine comprises of following three steps mentioned in the chart below

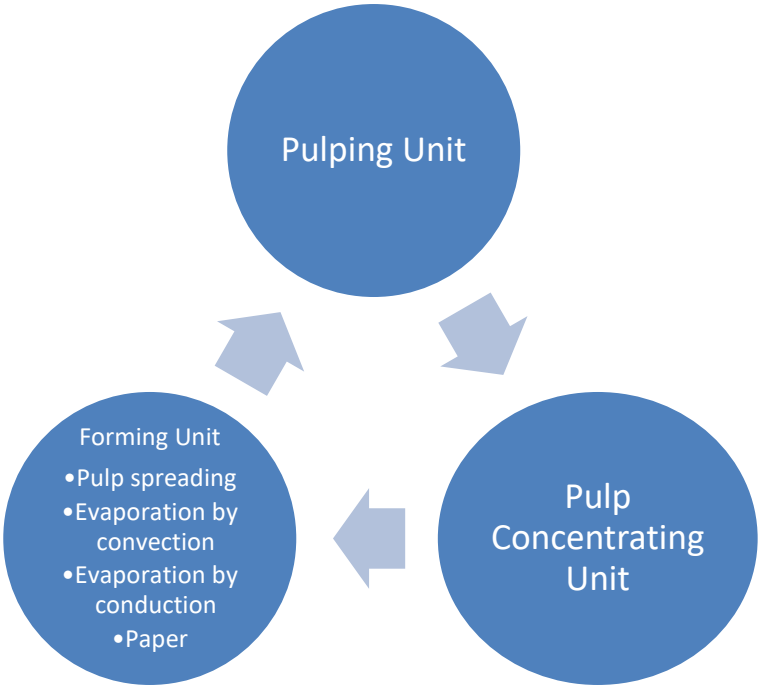


Figure 11:Simplified Process Diagram.

The process starts with the pulping of the shredded paper. Shredded paper is fed to the pulper along with a specific quantity of water. The pulp is then transferred to the concentration unit from the pulper in order to remove some water. Chemicals ($CaCo_3$, TiO_2, DADMAC) are also added in the concentration unit for binding the paper fibers and prevent sticking of pulp onto the belt. After the concentration, the pulp is poured on an inclined plate which carries it to the conveyer belt of the forming unit. Before the belt, pulp passes through sizing slit to control the thickness.

After entering the forming unit, pulp passes through a roller. There is a mechanism to control the thickness of pulp by changing the position of roller vertically. Roller helps in the uniform spreading of pulp on the conveyor belt.

After spreading of the pulp on conveyer belt, the belt is stopped. Electric convection fan heater will aid in partially dry up the pulp at this point for 2 minutes in order to remove the moisture from pulp. After the electric blower, a press mechanism is installed to remove the water content from the pulp and to smoothen the surface, A linear actuator is attached to the structure will aid in the motion of press mechanism up and down. This pressing action removes water as well as smoothens

the surface of the pulp. A uniform metallic plate is placed at the bottom of the belt so as to support the belt against the downward pressing force, This was the last stage of forming unit, the process of recycling is a cyclic process and process can be repeated again and again as desired.

The main objective of this project is to overcome the shortcomings in the previous machine. The main drawbacks in the previous machine were the quality of paper, and large energy consumption in the forming unit and large time consumption process. In the upcoming sections, the process and improvements are discussed in detail.

Model and Design Calculations

In this portion, detailed design, and calculations of each part of the machine are discussed.

Pulper

Shredded paper is fed to water in the pulper and rotor blades defiber the paper to make the pulp.

The pulping will be carried out in 4 batches, each batch having a capacity of defibering 30g of paper. The calculations are as follows:

Weight of 1 A4 paper	= 5g
Number of A4 paper	= 6
Weight of 6 A4 papers	= 6*5 =30g =0.3kg
Weight of water per batch	= 2kg =2L
Total volume of container	= Water volume + Paper volume

Volume of paper required is calculated as:

A4 paper width	= 21cm
A4 paper height	= 29.7 cm
A4 paper thickness	= 0.005 cm
Volume of 1 paper	= 3.1185 cm3
Volume of 6 papers	= 18.71 cm3 = 0.18 dm3
Total Volume required becomes	= 2+0.18 = 2.18 L
Volume of container after clearance	= 2.3 L

The pulper container is nearly cylindrical with:

Mean radius of container =6.3 cm

Height of container =25cm

Pulper Material:

The material chosen for the pulper is stainless steel in order to avoid corrosion.

The thickness of container was chosen on the basis of thickness of stainless-steel sheets available.

Density of SS = 7.7g/cm^3

Thickness of container = 0.15cm

Outer mean radius = 6.45 cm

Volume of SS used = pi*(ro^2 – ri^2) *h = 150.21cm^3

Weight of SS used = 147.18*7.7 = 1.2 kg

The design of the pulper is as shown in the fig.

Figure 12:Pulper.

A 500W motor is used to rotate the blades.

For the side hole in the pulper fitting i.e., ball floating valve is installed to allow the flow of pulp slurry when required the diameter of hole is 1-1/2in or approx. 40mm diameter was used the ball valve is shown

Figure 13: Floating ball valve.

Pulp concentration Unit

From the pulper, the pulp is transferred to the concentration unit. Binders are added into the unit after the addition of four batches of pulp. A stirrer run through a motor installed at the top of the concentration unit is used to mix the binders with the pulp. After thorough mixing, the valve at the front with a small wire mesh is opened to remove the excess water. Experimentally, we found that almost 60% of water is removed at this stage.

The concentrated pulp thus obtained is transferred to the forming unit via the inclined plate by opening the second valve at the front.

Forming Unit

The final unit of the recycling machine is paper forming unit. In this unit we obtain the final recycled paper. As described above, pulp from the concentration unit is transferred to the conveyer belt via an inclined plate.

There is a wire mesh at the top of a container that is at the end of inclined plate. It removes approximately 20% of initial water content and the pulp is then transferred to the belt. Conveyer belt, made up of German canvas begins to move and pulp after passing through a roller, spreads on the belt. The conveyor belt is coated with a Teflon sheet as it is exposed to high temperatures.

As the pulp completely spreads on the belt, the belt halts and an electric blower is turned on to remove the water content in the pulp. While the convection fans will be turned on for partial evapoaraion of water for 2 minutes. Then conyeyor will move forward to carry the pulp to heated press mechanism. By the time press reaches the other end i.e below the heated press, press will be

lowered with the help of linear actuator mechanism to evaporate the remaining water and further to smoothen the surface of pape.

Conveyor Belt

The conveyor system is a belt powered system driven by dc gear motor that consist of two end rollers on which is belt wrapped. The driving mechanism for the conveyor belt I is through motor connected with driving pulley while on other end is belt tension adjusting mechanism to control belt tension and sag related issues. Almost every conveyor requrie the use of tensioning arrangement due to various reasons

- To avoid slippage of belt
- To compensate for the change in length of belt (elongation)
- Ensure proper loading of belt

The conveyor belt utlized for our machine is made of German Canvas material for its durablity and water resistance. The dimenison are given in table

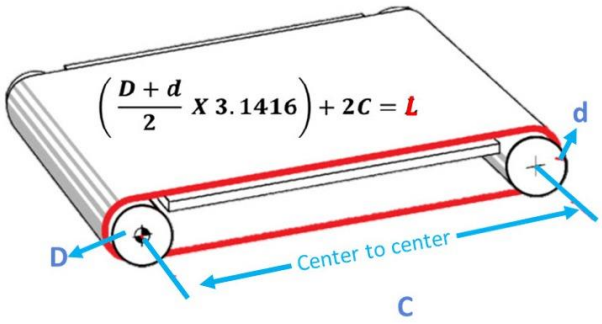


Figure 14: Conveyor Belt.

Table 5:Belt dimensions

Belt Dimensions	
Centre to center distance	1525mm
Total length	3250mm
Diameter (D)	63mm
Diameter (d)	63mm

Width	178mm

The tension adjustment mecahnsim utilized is jack screw mechanism and is useful in the case when the length of conveyor is not very large.

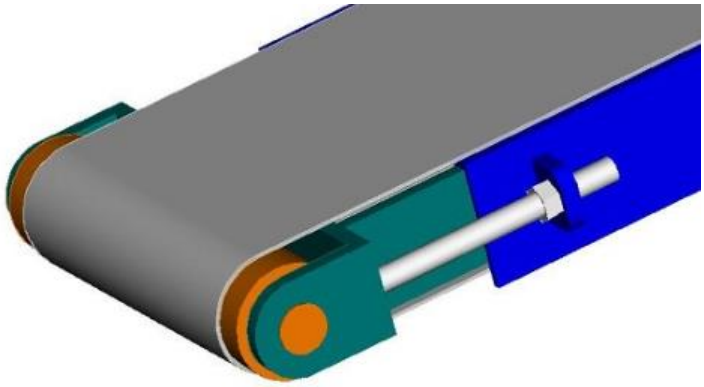


Figure 15: Screw jack Mechansim.

With roller shaft is mounted with bearing enclosed in its housing to ensure smooth running and reduce metal to metal contact and consequently the friction. The bearing is enclosed in housing the details of bearing and housing are given below.

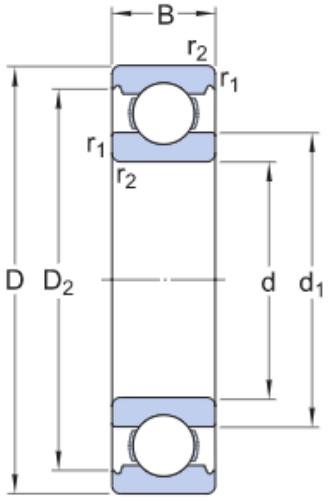


Figure 16:dimension for bearing.

Figure 17: Ball bearing.

Table 6: Specification of Bearing

	SKF 6003
Bore Diameter d	17mm
Outer Diameter D	35mm
Width B	10mm
Cage Material	Steel

Conveyor motor

The dc gear motor is used to run the conveyor system. The decision of the motor was based on the load requirement i.e., slurry mass and the weight of the belt itself, the geared motor by preferred for its high output running torque and it also offer better speed variation than Ac motor. On the other hand, using dc will not have fulfilled torque requirement. From the motor performance curve the the the conditions for max performance can be determined

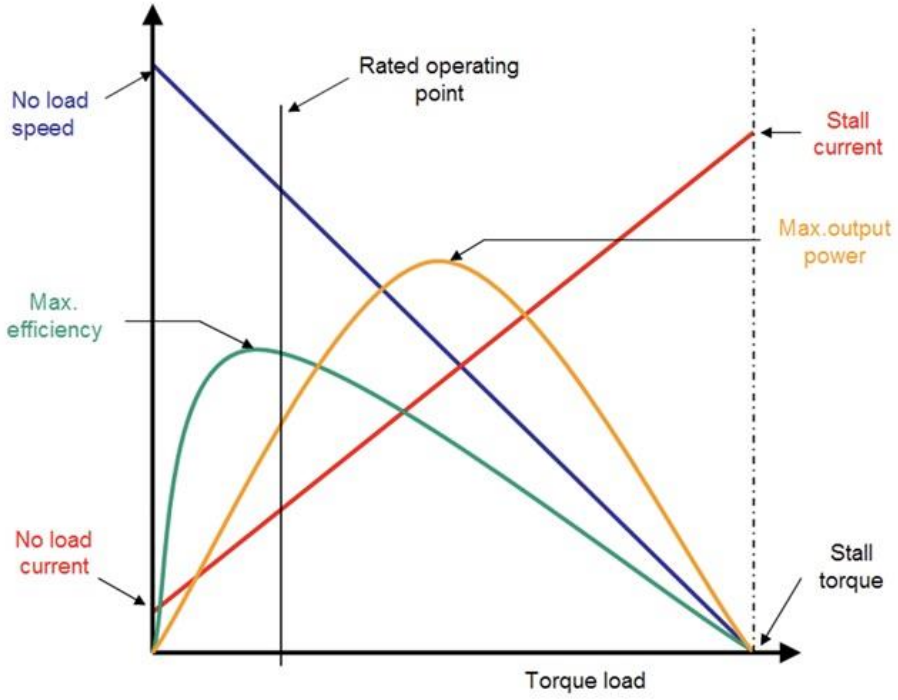


Figure 18:DC gear motor performance curve.

the motor specification for the conveyor belt is shown in the table

Table 7:Dc gear motor specs

Dc gear motor	
Power	24 Watt
Rpm	60 rpm
Torque range	2-4 Nm

Figure 19: Dc gear motor**.**

The speed with which conveyor will move is given by the equation

Radius of shaft = 8.5 mm

$\omega = 5.6\, rad/s\ 60\ prm\ appox$

$V = r * \omega$

V= 5 cm /s

Press Mechanism

For drying of pulp and water removal the heating mechanism utilized is based upon joule heating also known as resistive heating, the effect of getting thermal energy by passing current through the conductor. The power (thermal energy) produced by conductor is directly proportional to current passing through the conductor and its resistance it is given by formula

$$P \propto I^2 R$$

Most commonly nichrome wire is utilized as a heating element as it has higher resistivity comparative to other conductors and allows small current to pass through it.

Table 8: Nichrome wire Composition

Nichrome-60 wire (NiCr60 Type Alloy 675 Nickel Chrome Alloy)	
Element	**Composition**
Nickel	57-58%
Chromium	16%
Silicon	1.5%
Iron	Balance

Joule heating is utilized in various industrial processes and electric appliances like electric heaters. The conductor becomes hot when current is passed through it. This is due to fact that electrical energy is converted into heat energy and increases the temperature of conductor. The increase in temperature is due to the collision of moving electron with each other and with molecules of atom. Collision of flowing electron produces heat which results in increase in temperature and the effect is known as heating effect of current Electric current produces more heat in insulators than in conductors the reason is because they oppose the current passing through them, examples of insulators are tungsten ,nichrome, plastic etc.

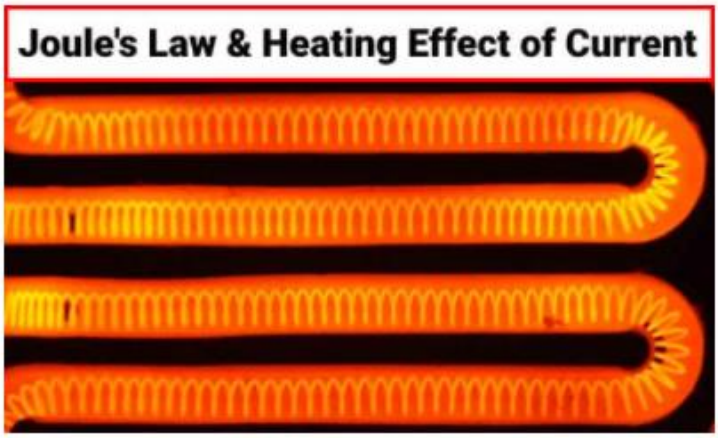


Figure 20: Resistive Heating.

The heating mechanism for our machine is also based on joule heating, heated press of square shaped that will function much similar to electric iron. Like electric iron heated press comprises of

- Pressure plate
- Heating element
- Sole plate

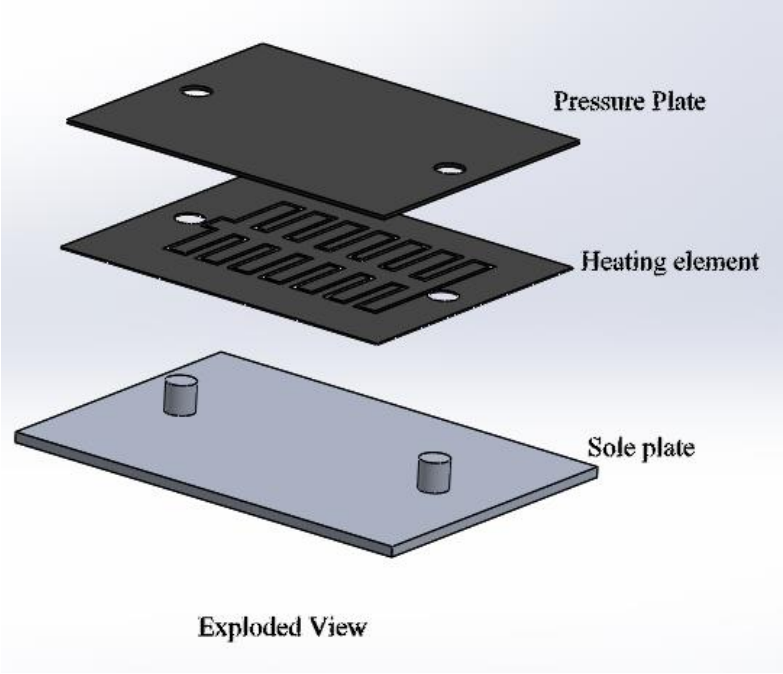


Figure 21: Heating element.

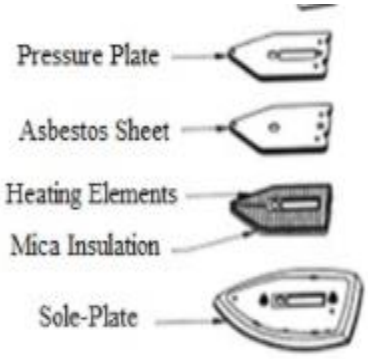


Figure 22: Electric iron parts.

Table 6: Heating Element Dimensions

Component	Thickness (mm)	Dimensions (mm)
Sole plate	5	297*210
Pressure plate	5	290*200
Heating element	1	290*200

Heating element lies in between the pressure and sole plate. Pressure plate is made up of mild steel of thickness 0.5cm while the sole plate of thickness 0.5cm. An insulator, asbestos is placed in between the plates and 3 elements are placed for heating effect. When Electric current is passed through the element, it will heat up thus producing desired similar effect. The heat will be conducted through sole plate to the pulp mixture for water removal. The press mechanism function in two ways i. e Removal by Mechanical Pressure and evaporation by thermal energy for removal of water from pulp. About 20 % of water will be removed by force of press and the rest by evaporation by suppling required thermal energy. In addition, water removal will also be assisted by force convection through convection fans on both sides of conveyor. The convection fans consume 1500 KWh of energy while they will be run for 2 minutes Firstly, there will be evaporation by forced convection followed by mechanical pressure removal of water and then evaporation by supplying the desired energy through conduction heating mode.

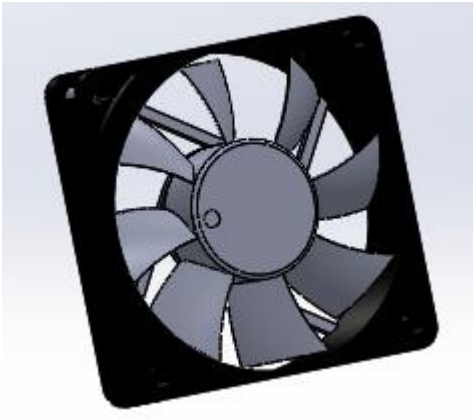


Figure 23: Convection Fan.

The press mechanism will be driven byelectronic linear actuator which will reciprocate up and down. Actuator mechanism is nothing but lead screw mechanism driven by gear motor.The reciprocating motion is achieved via DPTD, double push double throw switch to reverse the polarity of it. The lead screw will reciprocate moving the press up and down as desired.The actuator was powered through 12 V adaptor. The schematic diagram of switch is shown below

Figure 24:DPTD Switch.

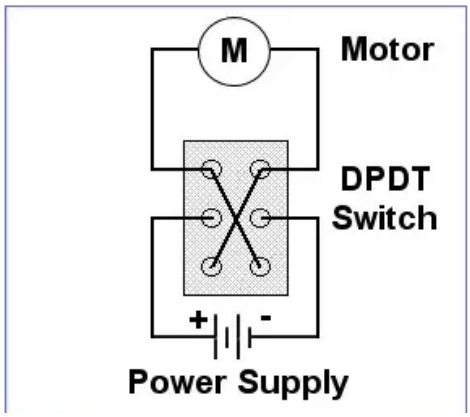


Figure 25: Switch Circuit.

Heating element

In the press mechanism, 3 heating elements are used, each having a power of 700W.

Total power =3*700=2100W

Linear Actuator

The press mechanism will be driven by a linear actuator as shown:

Figure 26: Linear Actuator.

Table 9:Actuator Specification

DC Electric Linear Actuator XYDHA12	
Stroke length	100mm
Volts	12
Current	1 amp
Extended length	305mm
Retracted Length	205mm
Speed	10mm/s
Max Load	750 N

Mass of the press is 4kg and the rated load capacity of the actuator is 75kg. So, the actuator can easily lift the load of the press mechanism.

Teflon sheet

To protect the conveyor belt from the heating effects of press it is covered with layer of Teflon sheet ,also known as Polytetrafluoroethylene (PTFE) sheets can come in various thickness to prevent it from burning or wear out. It is a synthetic fluoropolymer non-stick sheets that acts as a kind of insulator between the heating medium and the substance to be heated and prevent it from burnout effects. It can also be used as a sealant . The main features of tis sheet are

- Non-stick
- Greater Thermal and Flame Resistant
- Non wet
- Resistance to wear

Teflon sheet specs for covering the conveyor belt is mentioned in the table

Table 10: Dimension of PTFE Sheet

PTFE sheet	
Length	130 inches
Width	7 inches
Thickness	0.5mm

Figure 27*:*PTFE sheet.

Wire Calculations
Nichrome 60 (Alloy 675) is selected as a heating element. The composition of the wire is given in the table

Table 11: Nichrome wire Composition

Nichrome-60 wire (NiCr60 Type Alloy 675 Nickel Chrome Alloy)	
Element	**Composition**
Nickel	57-58%

Chromium	16%
Silicon	1.5%
Iron	Balance

Nichrome Wire Dimensions

Length l = 1.8m

Diameter of wire d= 0.45mm (AWG 25)

Area =A $= \pi \frac{d^2}{4}$ =$1.6 * 10^{-7} m^2$

Resistivity of wire =0.000112 ohm.cm

Resistance R = $\frac{p*L}{A}$ = 13 ohm

Press Force

Mass of press mechanism M= 4.5 Kg

Weight = M*g = $4.5 \times 9.81 = 44.145$ N

Velocity of press with which it comes down = 1cm/s

Travelling distance of press = 90mm

Force of press exerting on paper F= $mv = 4.5 \times 0.01 = 0.045$ N

Area of pulp A = $0.06 m^2$

Pressure exerted by press on paper =P $= \frac{F}{A}$= 0.75 Pa

Motor Specification for Press

Power required to move press $p = Fv$

Force = weight of press = 44.145 N

Velocity = 1 cm/s

So,

$P_r = 44.14 \times 0.01 = 0.44$ W

Motor operating voltage V= 2.5 V

Rated current I = 0.49 amp

$P_m = VI = 2 \cdot 5 \times 0.49 = 1.225$ W

Since

$$P_m > P_r$$

So, motor can easily lift the load of the press mechanism.

Paper Remover

Following the press heating procedure, we proceed to the final part, which involves two calendar rollers and a paper remover. The paper is further pressed and finalized by the rollers, and the paper is then taken from the belt using a specifically constructed metal sheet in the last stage. It is attached to the machine's walls and put at the end of the belt. Due to the pressing, paper tends to stick to the belt surface, therefore the paper remover is built with a minimum distance from the belt. When the paper reaches this point, it detaches from the belt and slides across its surface to the final rollers, exiting the machine.

Electical Circuit

Arduino

The machine different components will be controlled via microcontroller Arduino UNO, connected with relay module for timely on & off of different components i.e., heated press, conveyor belt, blower etc. .. Arduino consist of digital and analog input and output pins (I/O pins) it has in total 14 pins out of which 6 are analog. It is programmed in IDE channeled through USB “B” type cable. It can be powered through either USB cable or adapter of 9-12 volt.

Figure 28: Arduino UNO.

Relay Module

All the components will be timely turned on and off via Arduino relay module programmed through Arduino Relay is a type of electrical switch which allows the current to pass through multiple devices at the same time thus controlling electrical devices. It Is powered through low voltage 5V or 3.3 V depending on requirement operates with ardunino. The process can be assumed to be a cyclic process that repeats itself after the completion of whole process

Figure 29: 2 Channel Relay.

Usually there are three ports on the relay Normally Open (NO), Normally closed (NC), and ground, circuit can be attached in either of the two pins with the difference being is that NO channels work when controller gives the signal is HIGH while NC operates when the signal is LOW*.The relay devices are available in various channel size i.e., 1,2,4,8 etc.The circuit diagram for the circuit and the code is shown below

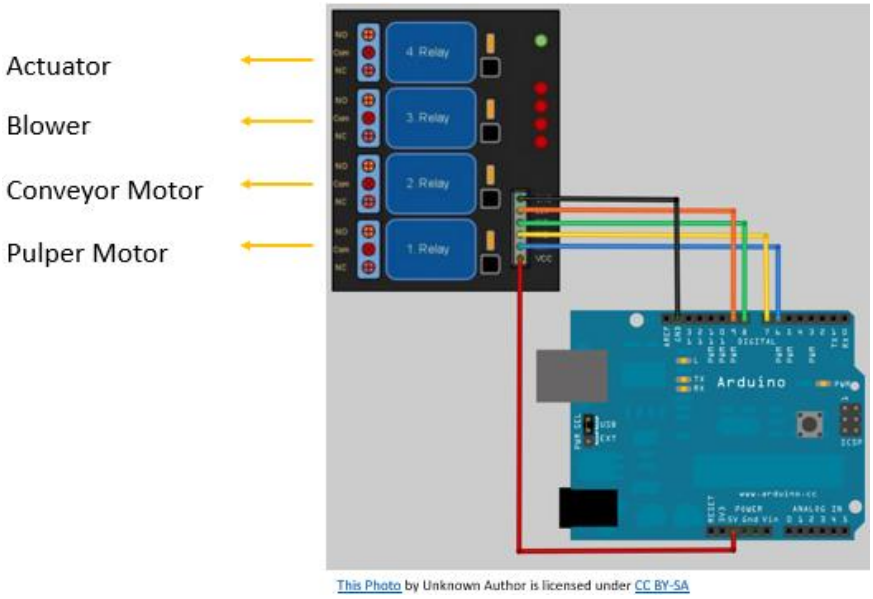


Figure 30: Circuit diagram for machine.

```
int ch =4;
  int relay []={8,7,4,2};
void setup() {
  // put your setup code here, to run once:
pinMode(8,OUTPUT); // Blower (1st Relay)
  pinMode(7, OUTPUT);   //Conveyor motor (2nd Relay)
  pinMode(4, OUTPUT);   //Pulper (3rd Relay)
  pinMode(2,OUTPUT); //Actuator (4th Relay)
   void loop() {

   Serial.begin(9600);
   Serial.println("----STARTING THE PRM----");
   //1 st Part
   digitalWrite(4, LOW);//Pulper ON  // turn the LED
   digitalWrite(2, HIGH);
   digitalWrite(8, HIGH);
   digitalWrite(7, HIGH);
   Serial.println("TURNING PULPER ON");
   delay(5000); //  delay
   Serial.println("Transfering Pulp on conveyor");
   delay(1000);
   //2nd part
   digitalWrite(4, HIGH);// MOTOR ON  // turn the LED
   digitalWrite(7, LOW);
   digitalWrite(2, HIGH);
   digitalWrite(8, HIGH);
   Serial.println("Starting Conveyor MOTOR");
   delay(20000);
   //3rd Part
   digitalWrite(8, LOW);  //BLOWER ON  // turn the LE
   digitalWrite(2, HIGH);
   digitalWrite(5, HIGH);
   digitalWrite(7, HIGH);
```

Figure 31: Ardunio Code.

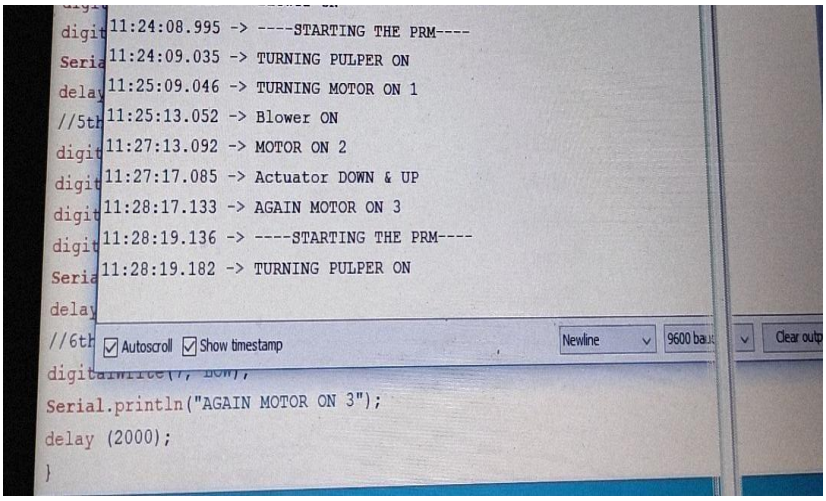


Figure 32: Serial Monitor Result.

CHAPTER 4: RESULTS AND DISCUSSION

Discussion

The paper recycling process is a batch production process producing 6 papers per batch. The recycled paper obtained through our simplified process was satisfactory. Different size of paper can be recycled by using various mold sizes according to requirement. The texture and surface finish of paper can be further improved by adding various and additives. The basis weight which is grams per square area(g/m^2), different grades of paper have different grammage and it can vary by changing consistency of pulp. The consistency of recycled paper in our case was kept in between 10-15 %. Moreover the strength of paper can also be improved by addition of rosin .So, to get the better quality of paper pulp consistency, grammage of paper are the main element along with addition of additives which needs to optimized depending upon the grade requirement of paper. Time consumption in the recycling process is given in the table below.

Table 12: Paper Recycling Time Consumption

Process	Time Consumption
Pulping	1 min
Drying (Blower)	2 min
Drying (Heating Element)	2 min
Rolling	30 sec
Cutting	30 sec

Energy Consumption

In this section, the energy consumption in the forming unit of the recycling machine will be discussed. To begin with, it is important to note that a batch type process with a 1.5% pulp consistency is used. A 1.5% consistency implies that if there are 100 parts of the pulp by mass then there will be 98.5 part of water and 1.5 part of paper in the mixture.

Amount of water in the pulp is calculated as:

$$Paper : Water$$

$$15\ g : 985\ g$$

$$120 : 7880\ g$$

This amount of water is contained in two batches: 30g per batch.

We found by experimentation that almost 80% of the water is removed when pulp is passed through a mesh screen in the concentration unit and the container at the end of inclined plate. So, 20% of water will be retained:

Amount of water retained=20% * 7880g

=1576g

In the pressing section, there will be further 20% reduction in water content. So.

Water retained after pressing=80% * 1568g

=1260g

Now, the heat energy required to remove the given quantity of water is composed of two parts.

Q1=Heat energy needed to increase temperature of water to 100 degree Celsius

Q2=Latent heat of vaporization

Thus,

$$Qt=Q1+Q2$$

Taking ambient temperature to be 25 degrees Celsius, the heat required to take water to its boiling point is calculated by using energy balance.

$$\dot{W} + \dot{Q} + \dot{m}_{in}\left(h_{in} + \frac{Vin^2}{2} + gz_{in} \right) = m_{out} + \left(h_{out} + \frac{Vout^2}{2} + gz_{out}\right)$$

In this case, there is no change in the displacement.

$$z_{out} = z_{in}$$

Moreover, there is no external work involved ($\dot{W}=0$) and the water content in the pulp is stationary, thus

$$V_{in} = V_{out}$$

As we know.

$$H_{in} = C_p T_{in}$$

$$H_{out} = C_p T_{out}$$

In our case there is no evaporation involved ($\dot{M}_{in} = \dot{M}_{out}$), so the energy balance equation is reduced to:

$$Q_{in} = mC_p(T_{out} - T_{in})$$

Using this relation, we will calculate the heat energy requirement to remove the water from pulp.

The mass of water retained in the pulp after the initial pressing is:

$$m = 1260 = 1.26\ Kg$$

The other parameters are.

$$Cp = 4.2\frac{KJ}{kg}$$

$$T_{out} = 100^0C$$

$$T_{in} = 25^0C$$

Now, the heat energy needed to increase temperature of water to 100 degrees Celsius is calculated as:

$$Q1 = 1.26 * 4.2 * 75 = 396\ kJ$$

As the latent heat of vaporization is $2260\ kJ/kg$

$$Latent\ heat\ of\ vaporization\ for\ 1.26\ kg\ of\ water = 2260 * 1.26 \quad = 2847\ kJ = 2.8MJ$$

Thus, the total heat required to remove the water is:

$$Q_t = Q_1 + Q_2$$

$$Q_t = (396+2834)KJ = 3243\ KJ$$

$$Q_t = 3.24\ MJ$$

Cost Calculations

Firstly, we calculate the power requirement to run the blower heater. Blower will run for 10 minutes. The power rating of blower is 1.5 KW

$$P = \frac{E}{T}$$

$$1500 = \frac{E}{600}$$

$$E=0.9\ MJ$$

Now, the heat energy requirement left for the heated press is:

$$E = 3.2\text{-}0.9 = 2.3\ MJ$$

Now to determine the electricity units (KWh) consumed, we multiply the power(1.5KW) by 0.16 as we run require it for 10 minutes only.

$$\text{No of units used}=1.5^{*}\ 0.16=0.24$$

Now, for the heated press:

Heating effect of wire is given by $H = I^2 * R * t$

H = 2.3 M J

Power = 2.1KW

I = 10 amp

R=23 ohm

So, the required time to achieve the desired heating effect is given by

$$t = \frac{H}{I^2 R}$$

And time comes out to be t = 15 min approx.

Now to determine the electricity units (KWh) consumed, we multiply the power(2.1KW) by 0.25 as we run require it for 15 minutes only.

No of units used=2.1 * 0.25=0.5

Total no of electricity units consumed during the operation =0.24+0.5=0.74

Price of one electricity unit in Pakistan= Rs 20

Total cost=0.74 * 20=Rs 14.8

No of paper per batch=6

Thus,

$$Cost\ per\ paper = \frac{14.8}{6} = Rs\ 2.5$$

CAD Models

In this section, CAD models of different components of the machine are shown. Material used for manufacturing these parts are also mentioned. To elaborate the design, engineering drawings, explaining the dimensions are also given in the APPENDIX I.

Pulper:

The CAD model of the pulper is as shown:

Container volume=2.3L

Weight of SS used=1.2kg

Figure 33: Pulper.

Figure 34: Pulper Blades.

Material used for pulper, and blades is Stainless steel in order to prevent corrosion.

Concentration unit
The CAD model of the concentration is as shown:

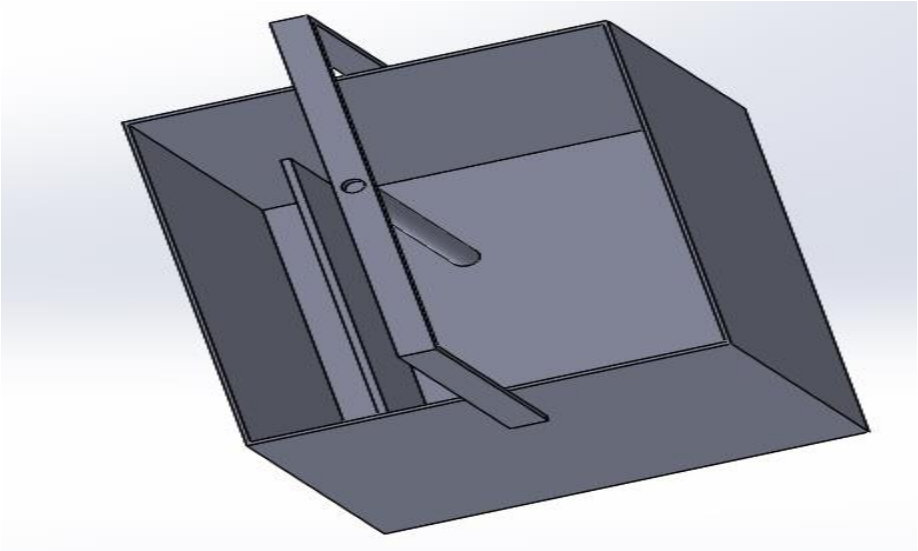


Figure 35: Concentration unit model.

The material used for pulper, and blades is Stainless steel.

Base of the machine:

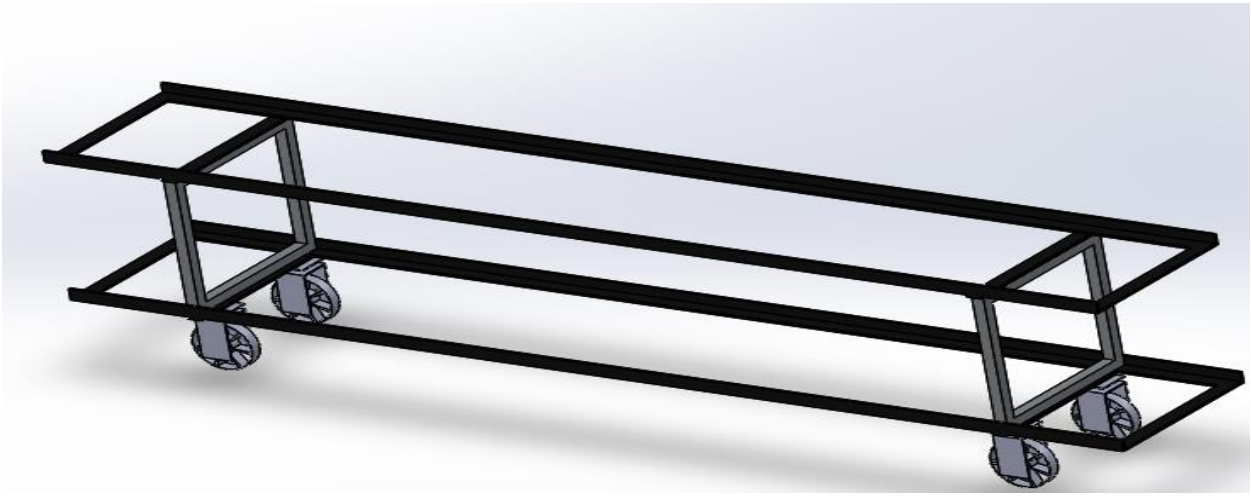


Figure 36: Machine Base.

Material used in manufacturing the base of the machine and wheels is cast iron.

Forming Unit
Forming unit with press assembly is shown:

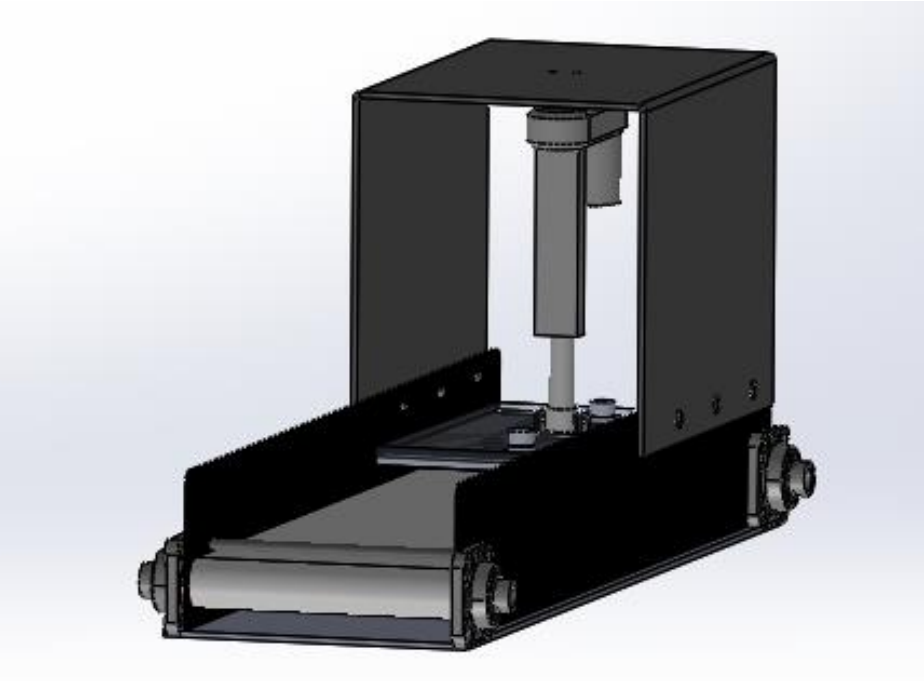


Figure 37: Forming unit.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

Conclusion

In this report, the process to recycle the wastepaper using a compact machine is discussed in detail. The machine employs different subunits including the pulper, concentration unit and the forming unit to give the recycled product.

The wastepaper in shredded form is fed to the pulper along with water. With the help of shearing action of the rotor blades, wastepaper is defibered and turns into a slurry known as pulp. The pulp is then fed to the concentration unit. Binders along with anti-stick agent are added into the concentration unit to bind the fibers. The pulp is then concentrated by opening the valve and removing the extra water.

Then comes the most important section of the recycling machine that is the forming unit. Pulp from the concentration unit is transferred to the conveyer belt via an inclined tray, and after passing through the mesh, the pulp passes through roller. After spreading on the belt, pulp is passed through an electric blower that removes water from the pulp. After 2 minutes, the belt carries pulp under the press mechanism that removes the remaining quantity of water from the pulp and smoothen the pulp surface.

As discussed earlier, the project aims to improve the quality of the recycled product and reduce the operational cost. The quality of the paper is improved by employing the pressing mechanism. It not only improves the surface quality of the paper, but also reduces the thickness of paper. It also removes a significant quantity of water (about 20%) reducing the energy requirement during heating.

Sticking of the pulp with the rollers was also an issue that was affecting the paper quality. In this machine we have used Nylon rollers to prevent the sticking. An Antti sticking agent, DADMAC, is also used to cater the problem.

This machine uses 120 g of wastepaper, 20 A4 shredded papers, to recycle 6 papers in approximately half an hour. This is a compact machine that is ideal to be used in offices, universities, and schools to recycle the wastepaper. It would save the transportation cost and confidential paperwork can also be recycled that would otherwise be burnt.

Recommendations

Solar heaters

Currently, electric blowers and pressing mechanism are used to dry the water content in the paper. As shown in the calculations, approximately 3MJ of heat energy is required to remove the water. Solar energy can be used to power the blowers and the heating element. This would reduce the cost tremendously and would be an environmentally friendly solution.

Steam rollers

Another suggestion is to use steam rollers instead of the simple rollers. It would further help in the water removal and reduce the operating cost. Thickness and quality of paper will also be improved. Rollers with heating element can also be used

Different grades of paper

Different grades of paper basically differ in water content and thickness. A solution could be developed to produce different grades of paper instead of simple writing paper. Slurry composition can change to be tailor need.

Pulp Spreading Mechanism

Quality of recycled paper is highly dependent on the quality of pulp, its consistency and it spreading The pulp can be injected via layer by layer similar to idea of as material of 3d printed material is injected so process of extrusion or some kind of sliding mechanism should be preferred for pulp spreading.

Machine Automation

The conveyor motor speed can be varied by PWM controller. Moreover, the actuator motion can be linked to heating press surface temperature when the desired temperature is achieved, then sensor should respond to actuator to be moved to for the required action.

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APPENDIX I : COMPONENTS DRAWINGS

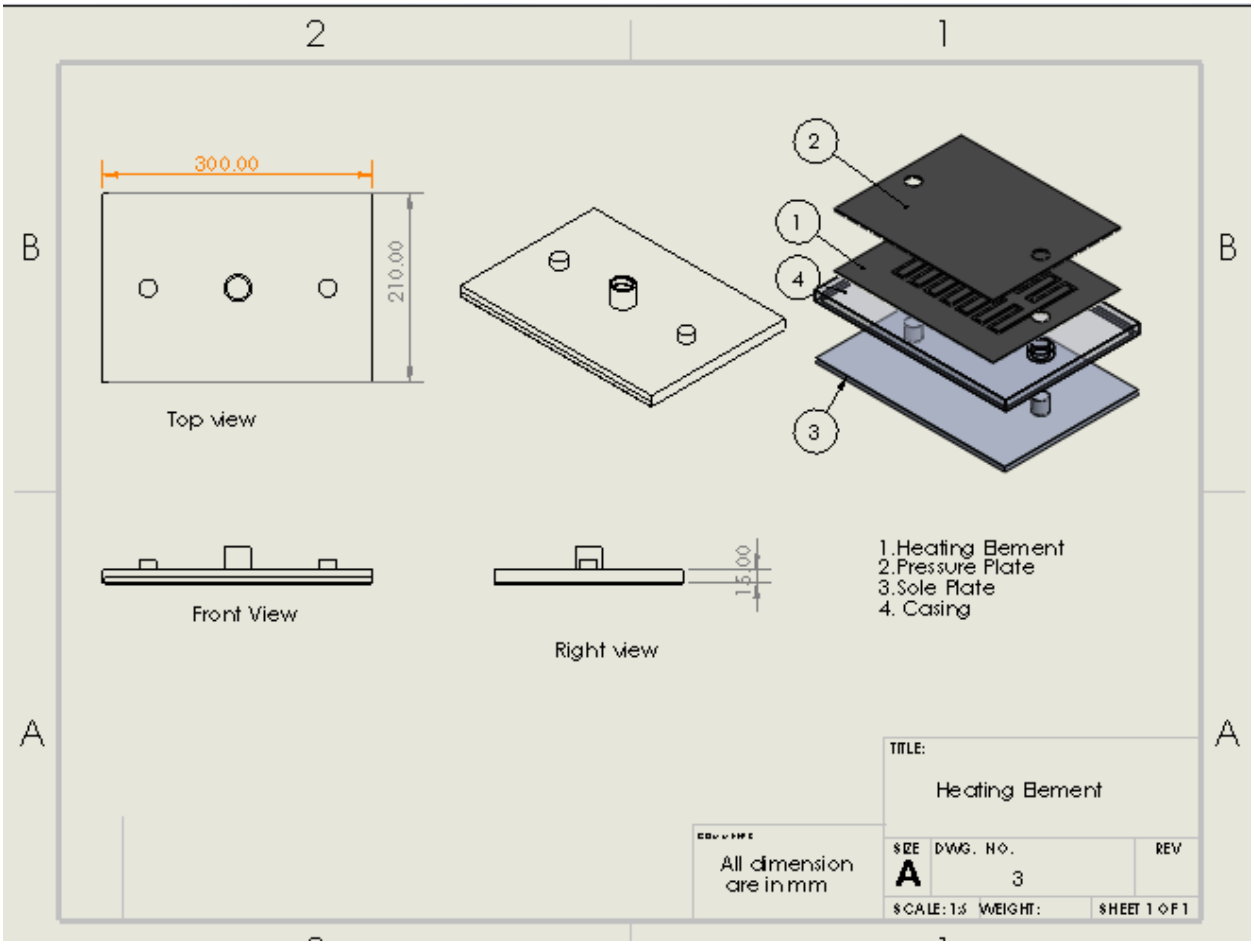


Figure 38: Heating Assembly.

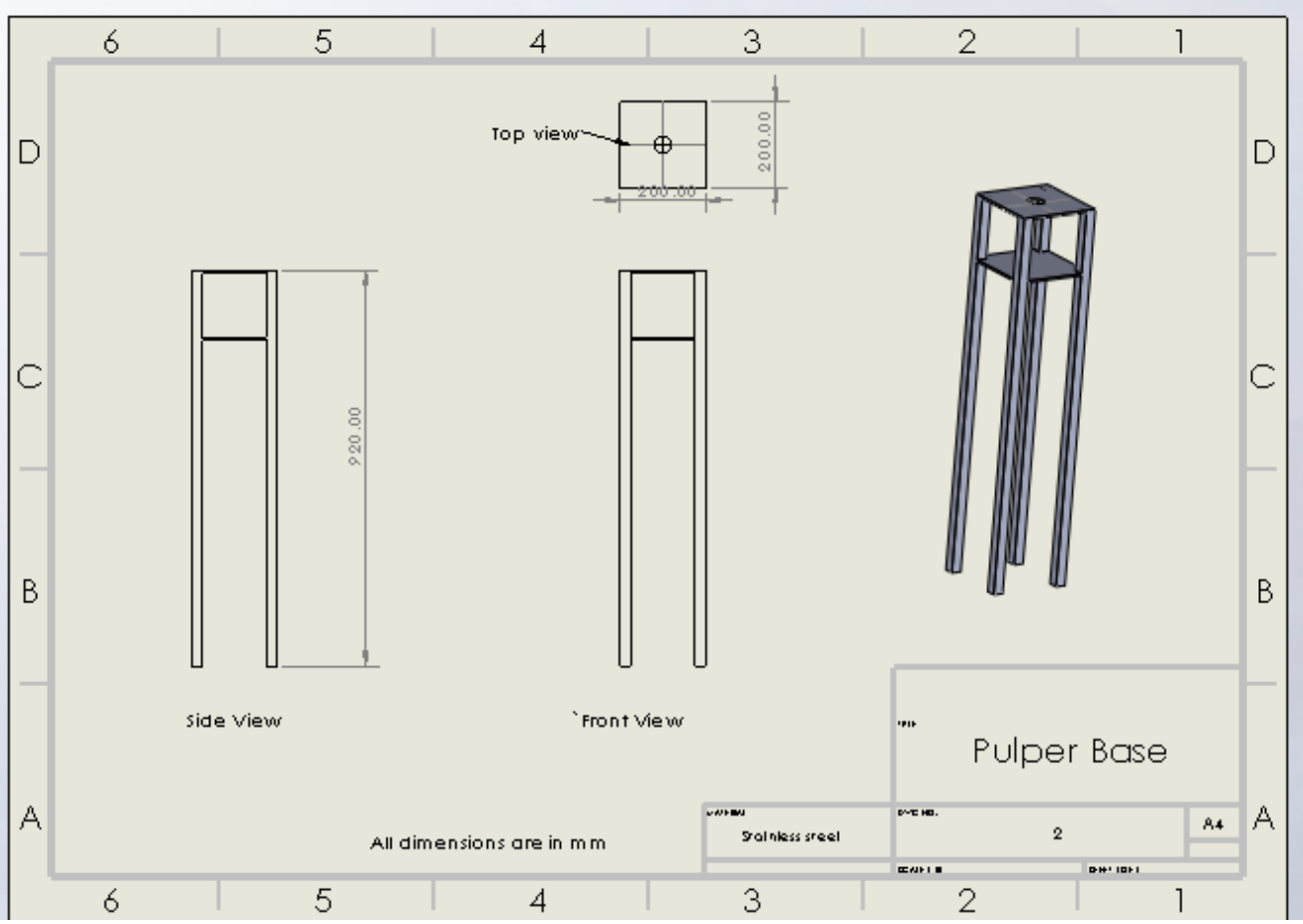


Figure 39: Pulper Base.

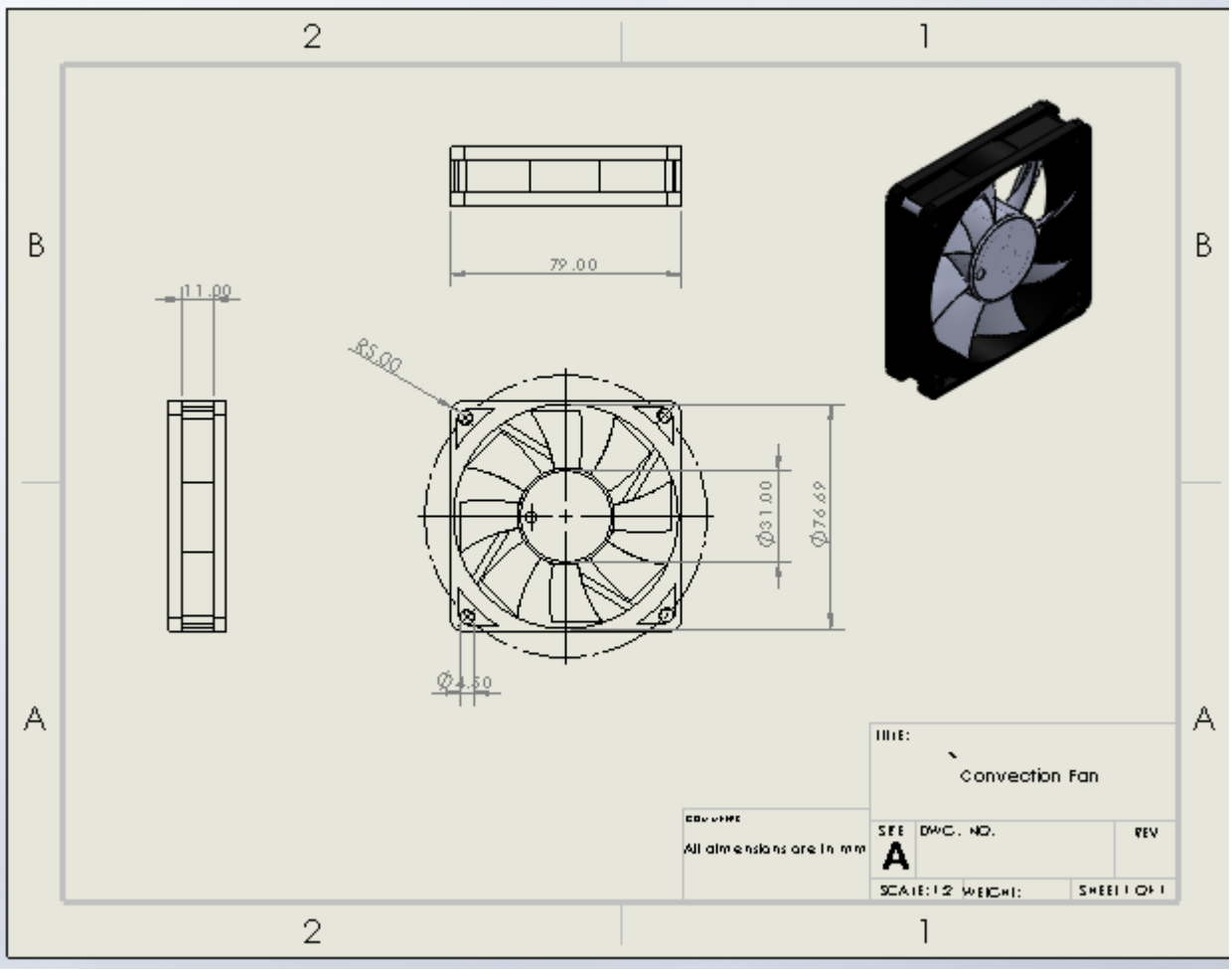


Figure 40: Convection Fan.

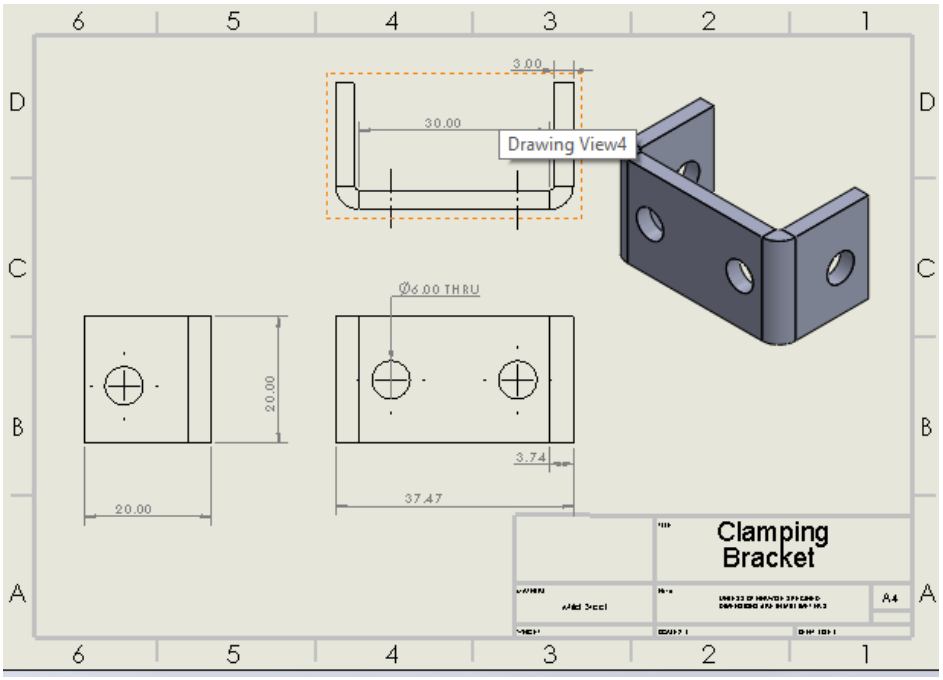


Figure 41: Bracket.

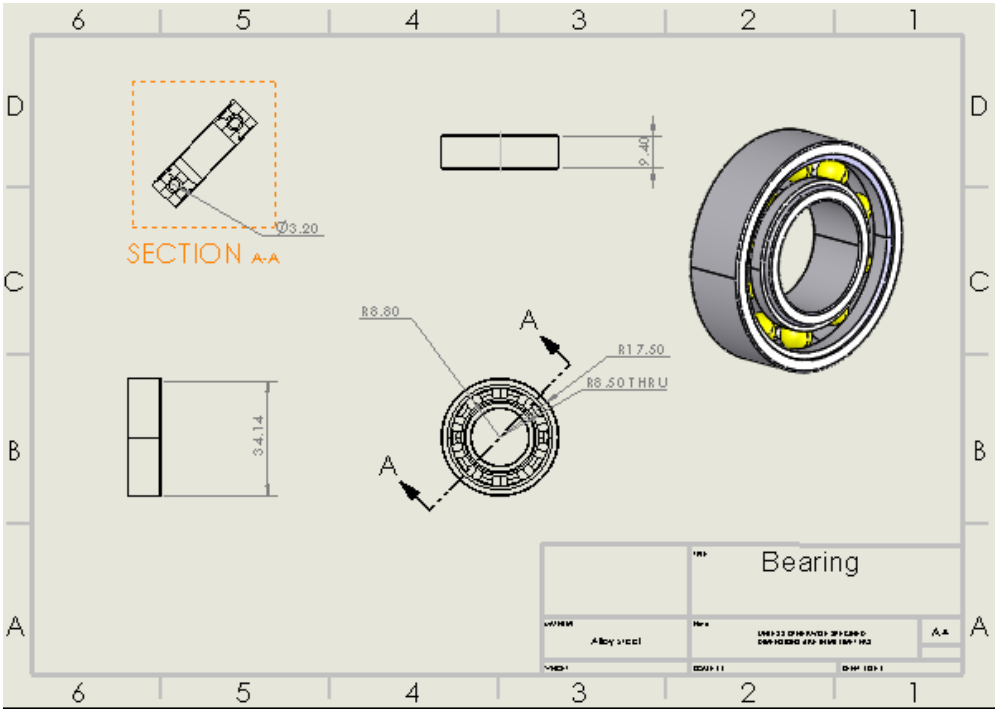


Figure 42: Bearing.

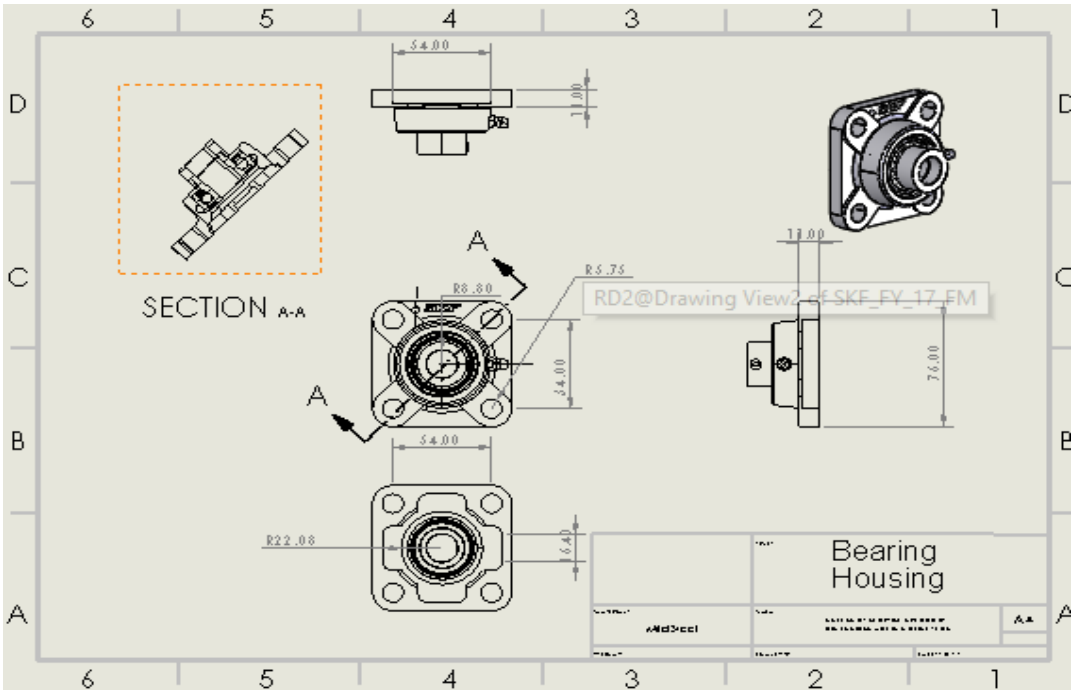


Figure 43: Bearing Housing Drawing.

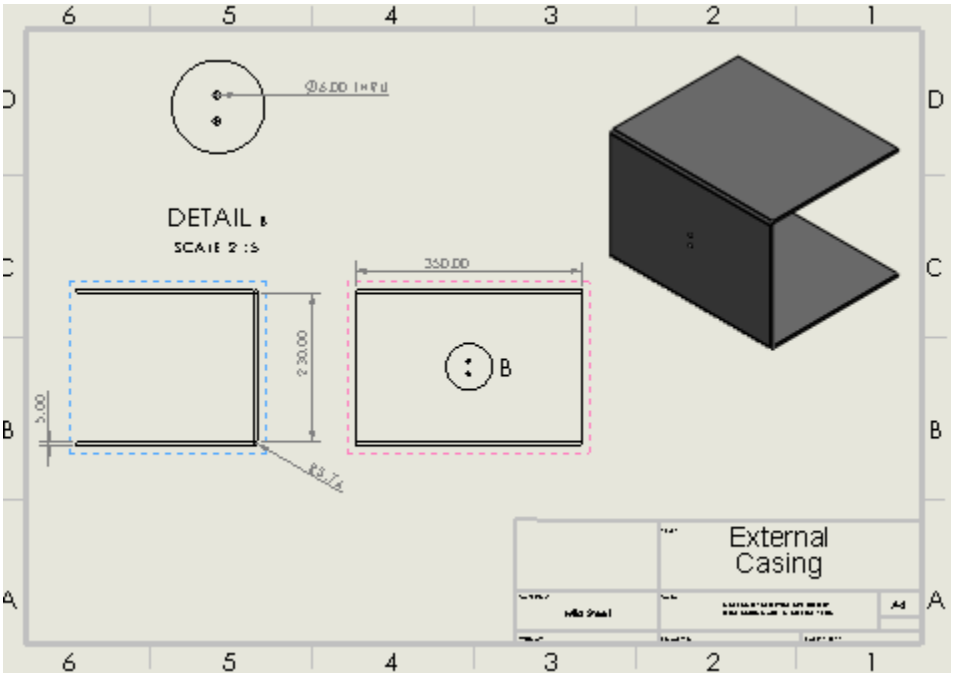


Figure 44: Casing Drawing.

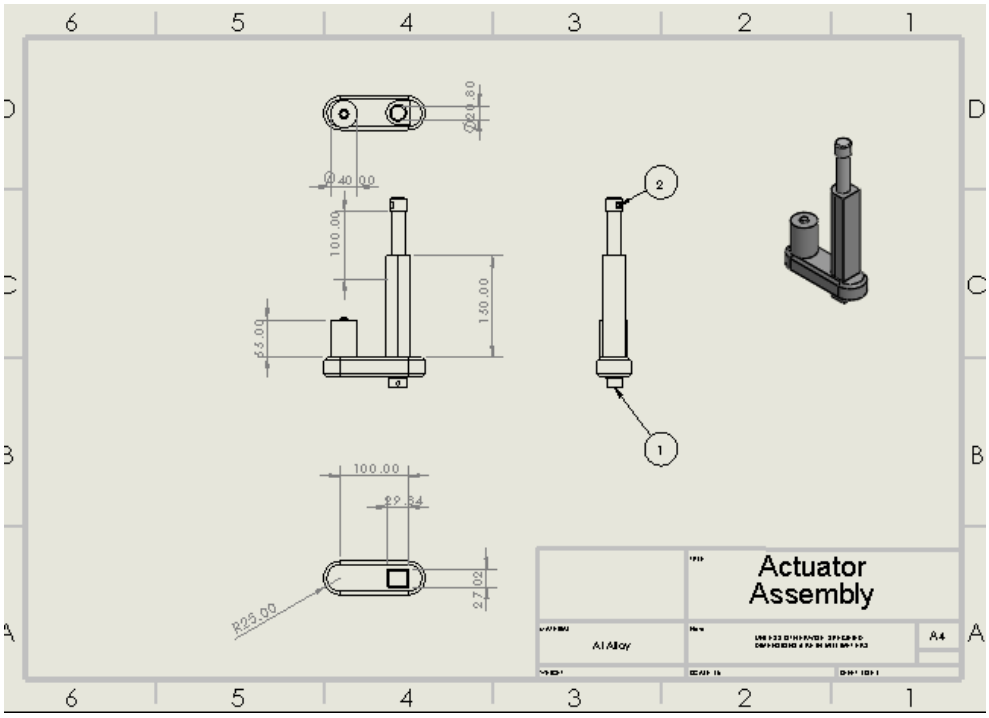


Figure 45: Actuator drawing.

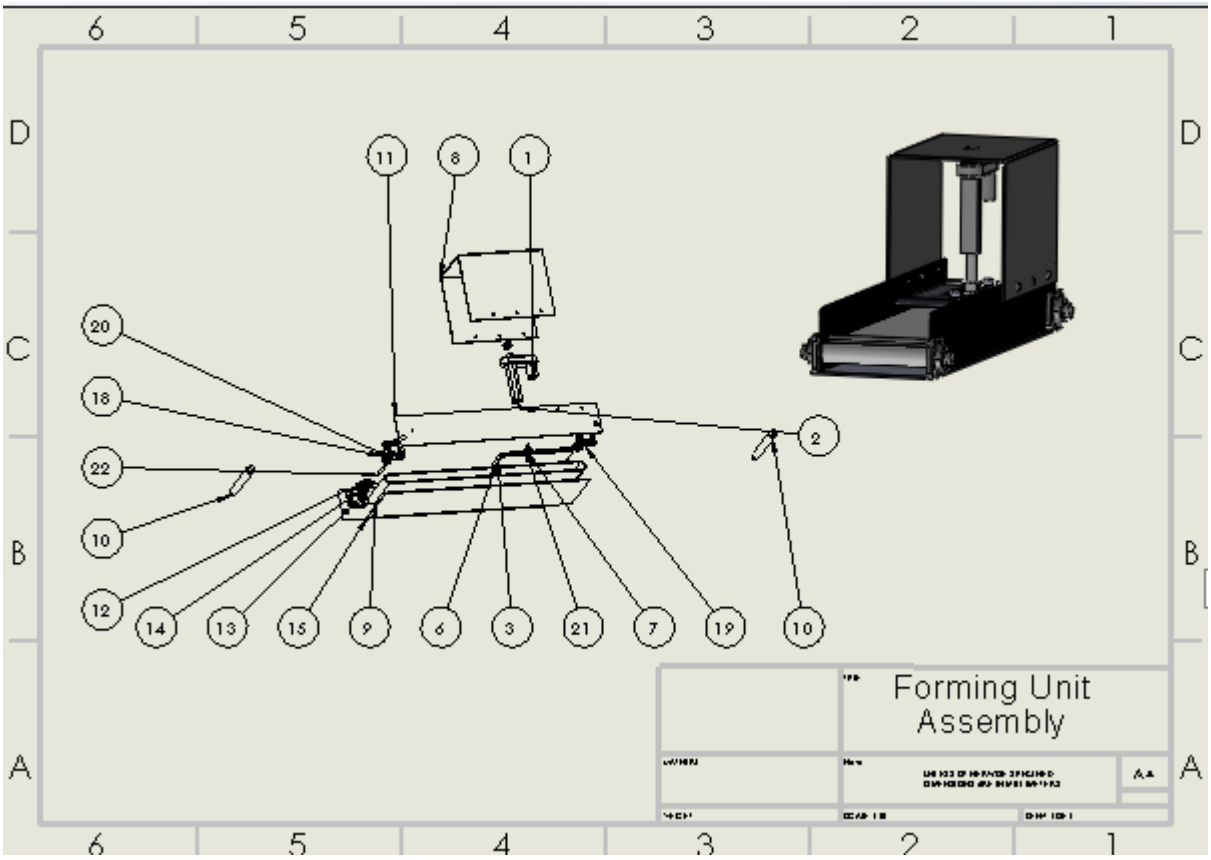
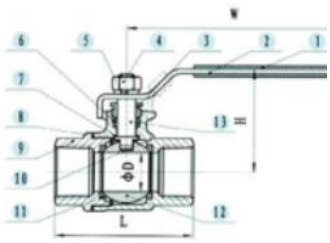


Figure 46:Final assembly.

APPENDIX II :DATA SHEETS



DIMENSION TABLE

ITEM \ SIZE	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
D	15	20	25	32	38	50
H	52	61	65	79	83	97
W	103	123	123	153	153	185
L	58	65	77	90	98	121

MATERIAL LIST

ITEM	DESIGNATION	MATERIAL
1	PLASTIC COVER	PLASTIC
2	HANDLE	SUS304
3	GLAND NUT	SUS304
4	STEM NUT	SUS304
5	THRUST WASHER	SUS304
6	STEM PACKING	PTFE
7	STEM SEAL	PTFE
8	BODY SEAL	PTFE
9	CAP	CF8/CF8M
10	BODY	CF8/CF8M
11	SEAT	RPTFE
12	BALL	CF8/CF8M
13	STEM	SUS304

FEATURES

- 1000PSI/PN63
- Full Port
- Investment Casting
- Blow-out Proof Stem
- Locking Device Handle (Option)
- PED97/23/EC (CE0035) Approved
- Casting Approved AD2000-W0
- Thead:ASME B1.20.1 BS21 DIN2999/259, ISO228-1,JIS B 0203,ISO7/1
- Inspection Testing:API598,EN12266
- Applicable Temperature: -29Deg - 180Deg

Figure 47: Ball Valve data sheet.

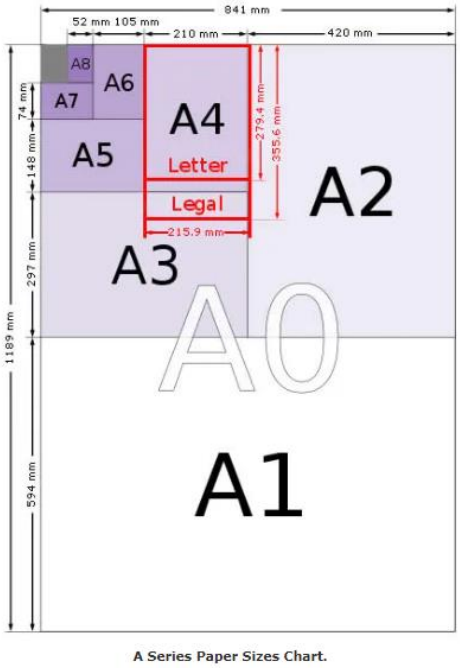


Figure 48: Paper size chart.