

Design and Fabrication of Compact Paper Recycling Machine

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Abstract: Due to lack of proper waste collection channels we lose a major portion to landfills. The amount of imported waste paper is greater than indigenously collected paper. So, instead of throwing away the waste paper in trash, recycling can be adopted. In institutes like offices, schools, colleges and industries the paper recycling machine can be used to reduce paper waste and cost saving. The main benefit of recycling is double decrease of the environmental load.

Designing automatically operated compact recycling machine which can be used to simply the process and reduce the production cost of paper. The machine is designed with essential sections to carry out the process. The 3-D modelling is done in CATIA and the machine will be fabricated accordingly.

Key Words: Compact machine, drying, modelling, paper recycling, pulping, sheet formation.

INTRODUCTION

Paper is an essential part of our lives. We use paper in everyday chores. It is used for documentation of the data and packaging. The paper and pulp industry is one of the major manufacturing industries and also a significant employment provider across the globe.

The papermaking process is believed to have its origin in China about 100 AD by Cai Lun during the rule of Han Dynasty. He created a sheet of paper using mulberry and other best fibres along with fishnets, old rags and hemp waste. Modern papermaking began in the early 19th century in Europe with the development of the Fourdrinier machine, which can produce a continuous roll of paper rather than individual sheets. These machines are considerably large, up to 150 m in length, produce up to 10 m wide sheet, and running around 100 km/h. In 1844, Canadian inventor Charles Fenerty and German inventor F.G. Keller had invented the machine and associated process to make use of wood pulp papermaking. This would end the nearly 2,000 year use of pulped rags and start a new era for the production of newsprint and eventually almost all paper was made out of pulped wood. The first paper recycling mill was named

The Neckinger Mill and was setup by Matthias Koops in 1826.

The paper making process is essentially a very large dewatering operation where diluted solution of pulp suspension with less than 0.5% solid fibre is used. The process of paper recycling consists of following sections: - pulping, forming, pressing and drying. In the process of pulping, paper is soaked in large pulpers which contain water and chemicals. The pulpers shred the paper into smaller pieces and heating of the paper mixture further increases the rate of breaking down of paper into paper fibres. The paper mixture turns into a mushy mix, known as pulp. Deinking is also done in this section. It removes ink and glue from the paper fibres by floatation process with the help of foam. In the forming process fibres in diluted pulp stock form the sheet through drainage due to gravity. In press rolling, additional water is removed by mechanical pressure applied through the nips of a series of presses or rollers. In drying section steam heated cylinders are used to evaporate excess water. Final moisture level between 6% and 7% is a critical step of papermaking.

The paper manufacturing industry faces major problem of unavailability of raw material. The primary raw material being wood is of great environmental concern. So industries have focused on using waste paper as raw material. In paper recycling process we utilise of used paper instead of wood for fibre. Shredded paper is used for making pulp in recycling process.

According to the discussion on collection and recycling in India: 1 ton of recycled paper saves about 17 trees, 2.5 barrels of oil, 4100 kW-hr of electrical energy and 4 m³ of landfill. And 1 ton of waste paper recycling results in saving 70% of raw material, 60% of coal, 43% of energy and 70% water. Apart from this paper recycling also offers opportunity for providing additional income and employment.

The Indian paper industry uses wood, agricultural residues and waste papers as raw material. In the early 70s the share of raw material used was only about 7% whereas in 2011 it was about 47% in total production. In 2011 about 550 paper mills in India used waste paper as primary fibre source for paper. These papers were acquired

indigenously as well as from foreign exports. In 2011 waste paper utilisation of paper in paper mills of India was about 3 million tonnes, which translates into a total recovery of only 27% of the total paper consumption.

Table 1: Shift in raw material consumption pattern [13]

Year	% Share		
	Wood	Agro residue	Waste paper
1970	84	9	7
2000	39	31	30
2011	31	22	47

This recovery rate is very low compared to other developed countries like Germany-73%, Sweden-69%, Japan-60% and USA-49%. Due to lack of indigenous waste paper, Indian mills rely

heavily on imported waste paper to meet the raw material demand. According to an estimate, India imports around 4 million tonnes of waste paper annually, which is about 57% its total requirement; this is estimated to be over 11 million tonnes by 2025.

The reason behind India's low recovery rate is due to loop holes in the segregation process of waste paper from household, offices and other waste generating sources. According to Table 2 and 3, only 20% of writing and printing paper office and household are recovered and only 50% of packaging papers are recovered and only 30% of newspapers are recovered. So, there is a large potential for recovery of waste paper in India. The unrecovered waste paper is used for land filling. The current scenario of paper recycling in India asks for a better solution for increasing the recycling rate. So, in this project we aim to design and fabricate a compact paper recycling machine.

Table 2: Current Waste Paper Collection Mechanisms in India [13]

Source	Item collected	Collected by	Quantity collected (in million tonnes/annum)
Collection from households	Old newspaper and magazines	Weekend hawkers	1.50
	Notebook and textbooks		0.50
Annual scrap contracts of printers, publishers and converters	Paper trimmings, print rejects, overprint/misprint sheets and other waste	Contractors	0.25
Scrap contracts with industries, office, libraries	Old corrugated cartons, examination answer sheets, library records, old office and library records etc.	Contractors	0.50
Total			2.75

Table 3: Recovery Potential for Waste Paper [13]

Grades of Paper	Potential Source of Generation	Generation/Consumption %	Type of Waste	Collection Rate %
Writing/Printing				
Copier Paper	Offices	50	Post Consumer	20
	Business Establishment	40		
	Others	10		
Cream Wove	Printing House	20	Pre-Consumer	100
	Paper Traders	5		
	Households	20	Post Consumer	20
	Schools/Colleges	10		
	Offices	25		
	Business Establishment	10		
	Others	10		
Packaging Paper	Converting House	15	Pre-Consumer	100
	Households	20	Post Consumer	50
	Offices	5		
	Business Establishment	50		
Others	10			
Newspaper	Publishing House	20	Pre-Consumer	100
	Distributors	5		
	Households	40	Post Consumer	30
	Offices	10		
	Business Establishment	15		
Others	10			

LITERATURE SURVEY

Antonio Davila (1988) states in his paper that plastics as a contaminant not only scratch the sheet but may also cause breaks in pressing and drying section. He concluded that most effective method for quantifying plastic contaminants with the exception of polyacetate is screening.

Gary M. Scott and Said Abubakr (1994) studied that recycling efforts of recovered paper and waste woods are hampered by the degradation by repeated paper making process. They concluded that fractionation is successful at separating recycled paper into two or more fractions with different fibre properties.

Shaun Anthony Reardon (1994) covers different parameters related to paper making such as achievable machine speed, Specific steam consumption, boundary conditions, etc. In his method numerous variables have been researched and the mathematical model has been tested against actual machine data and found to predict moisture content within several percent.

Said Abubakret-al (1995) their paper investigates the use of fractionation to increase the utilisation of office recovered paper by upgrading the quality of fibre. They found that the long fibre component resulting from fractionation was significantly upgraded compared to the short fibre fraction.

Gary M. Scott and Amy Smith (1995) studied the sludge composition, separation, treatment and disposal methods needed to be addressed. They concluded that better use solid residue from the pulp and paper manufacturing process will become more of a concern in next 7 years.

Antonio Davila et-al (1996), studied the effect of interchanging the sequence of floatation and washing on three recovered fibre furnishes were examined. They concluded that deinking sequences are dependent on the type of furnish used for recycling, it also depends on the size of ink particle that the recycler desires to remove.

C. Jiang and J. Ma (2000), their paper investigates about floatation process in detail which is widely used in industry for deinking almost all types of papers. It also tells about chemicals used in floatation process, factors affecting the floatation. They figured out that floatation process is a widely used process for deinking in mass productive industries. In modern time there are various conventional methods are also used for deinking.

Patricia Lynn Brown (2004), his study describes the condition of OSU, still water campus and determines the output of white paper into the waste stream. The case study gives idea about the percentage of white paper discharge into the stream.

Zhong Zhuang et-al (2005), his review paper studied paper pulp industry in China based on industrial level data. He concluded that lack of high quality

raw material remains main constraint for Chinese pulp and paper industry.

M.A. Olutoye (2005), designed and studied manually operated paper recycling machine was design. His study suggested that development of manually operated paper recycling machine is much cheaper than the automated industries.

R.A. Venditti (2006), By research and experiment he evaluate new type of surfactants based on renewable materials for used in ink removal for recycled paper via flotation deinking. He comes on conclusion after study that the alteration of model ink surface can be investigated by measuring contact angle of water on the model ink after exposure to different surfactant solution.

ZeljkaBarberic-Mikocevic (2007), in this work he experimented Recycling of paper printed with color laser printer XEROX PHASER 770 has been investigated. The recycling was performed by chemical deinking with double stage flotation with the usage of non ionic surfactant. The efficiency of the process has been increased by double stage flotation.

Freedonia Group (2008) studied the different chemicals used in paper manufacturing. This paper stresses on fillers, binders, coating pigments, bleaching and deinking.

Amol A. Kalage, et-al (2009), studied the application of FPGA based solution to be used on design stage of the algorithm for fast realization. The system reduces the time and algorithm was working as expected without any modification in hardware.

Government of India. (2011), it discusses the scenario of paper recycling in India. It concludes that only 27% of waste paper is recycled in India and about 57% waste paper is imported for recycling process.

Ajit K Ghosh (2011) studied a process in which Contact drying with steam heated cylinders method of drying is used. Besides conductive heat transfer between hot cylinder surface and the wet web, the role of air that is either the drying medium or surrounds the drying atmosphere is very significant. Final moisture content of finished product is between 6% and 8%.

IvetaČabalová et-al (2011), studied the environmental effect of paper recycling. Concluded that use of this model can bring indirectly benefit to the environment as well as improve the quality of waste paper reaching the recycling unit. Repeatedly used fibres do not fully regenerate their properties, so they cannot be recycled again and again.

Kirabira John Baptist et-al (2013), studied various pulp materials from wood as the major source of pulp for paper making to non wood materials such as agricultural food crop residues, grasses, shed tree leaves, fibrous shells of fruits and others. There is a turning point in terms of raw material for the

manufacturing of pulp and paper. He concluded that there is a need to identify more non-wood materials with high potential for pulp and paper production.

Vikram Daandekar, et-all (2014), studied twin roll press system and concluded that It helps to develop a new pulp feeding system which will wash the dirty pulp compare to existing pulp feed system. It introduced the design concept of twin roll press pulp wash which is cost efficient.

Dr. Ravi Goyal, Anurag Joshi, et-all (2015), studied cold rolling mill roll deformation, it covers different parameters affecting the roller and contributing to the damage occur to it. Deformation due thermal breakages, fire cracks, fatigue, wear and friction of rolls.

Devendra Kumar and R.K. Mandloi (2016), his study presents the review of belt conveyor design modifications and latest technologies or methodologies used in different application. Belt conveyors are widely used as continuous transportation equipment.

Vijaykumar C. Venugopal (2016), his paper gives various process of deinking like pulping, conventional deinking, enzymatic deinking, flotation deinking, ultrasonic and sludge treatment deinking. The deinking process is an attempt to incorporate promising results at the laboratory stage into existing conventional processes in order to achieve efficiency.

Vrushabh R. Rathod et-al. (2016), designing manually 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. The fabricated machine can serve dual purposes, it can be manned permanently at a stationary position or it could be shifted from one place to another as the case may be.

Jitesh D. Kapse, Nitesh T. Chandekar, et-all (2016), his paper aims at fabricating small scale automated paper recycling machine. It concludes that paper recycling machine consumes less time than manual operating machine.

Metin Yılmaz (2016), Paper industry in analyzed in regard to recycling and strategic plans are suggested. Proper sorting of waste paper at origin would decrease the cost of chemicals and energy consumption.

PROBLEM DEFINITION

In India only about 30% of total waste paper is recycled. The problems that exist are:

- Paper mills do not have all the process of paper recycling incorporated in one.
- Separate process plant leads to delay in delivery of raw material for next stage due to transportation.

- Paper mills require large floor area.
- Due to large floor area paper mills are located at outskirts of city away from waste generation zone.
- So transportation costs are high.

So we need to come up with a solution to overcome above problems and increase the percentage of paper recycled.

OBJECTIVES

- To design a compact machine this integrates all the processes of recycling.
- To reduce the delay between waste paper collection and recycling.
- To do 3-D Modelling and fabrication of the machine.

METHODOLOGY

The steps in paper recycling process are:

- Pulping:** Shredded paper along with warm water is fed into the pulper. Pulper blends the solution of paper and water along with binder and deinking and whitening agents. In pulper paper fibre are separated from each other and a thin solution of paper pulp is formed.
- Forming:** Pulp from the pulper flows down through valve on the felt conveyor. Some fraction of water is drained due to gravity through felt mesh.
- Press Rolling:** Felt conveyor moves through series of rollers and due to pressing by rollers water is squeezed out. Sheet of recycled paper will be formed. Roller pairs will be followed by idler rollers. Only one roller will be driver roller and rest will be driven due to motion of felt.
- Drying:** After sheet formation felt will be passed through a heated roller and then to air blower section, which will evaporate the water left in the sheet and finally dry sheet will be obtained.

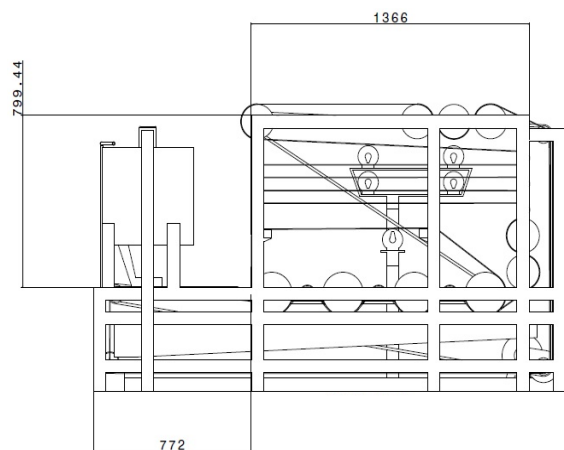


Figure 1: Paper Recycling Machine - Front View

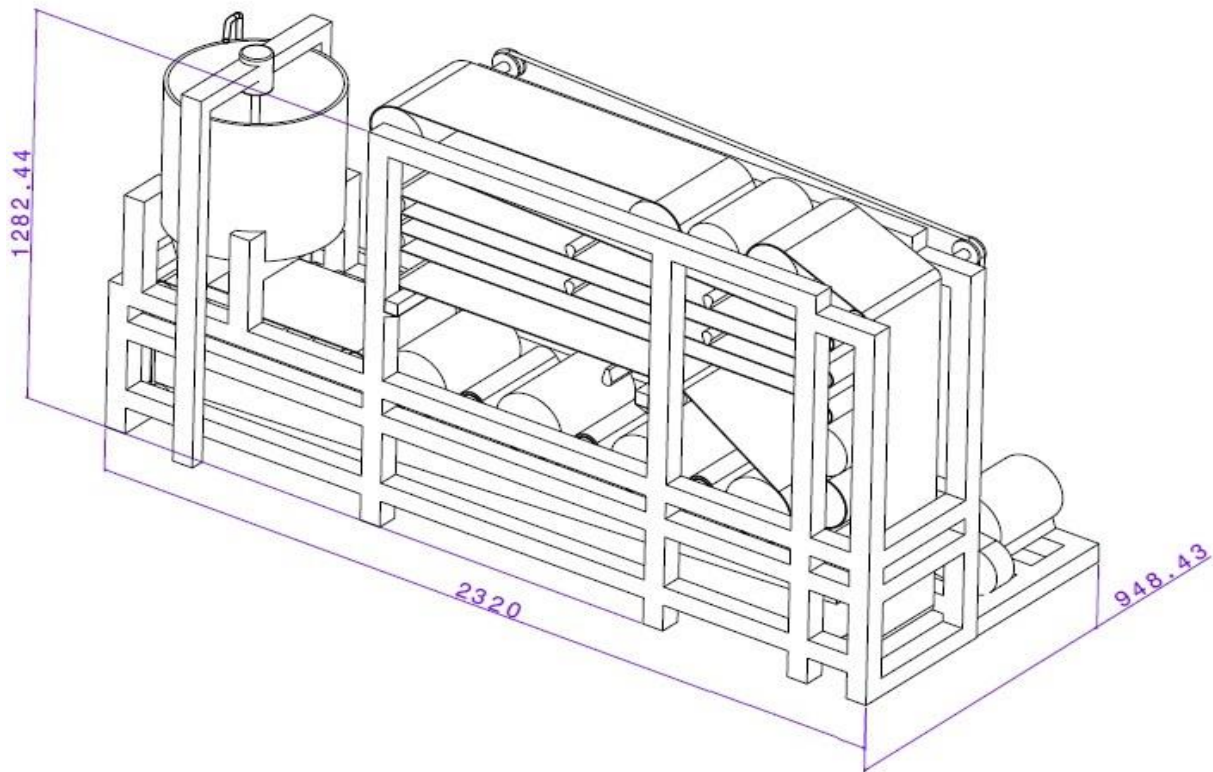


Figure 2: Paper Recycling Machine - Isometric View

CONCLUSION

It has been concluded that the paper recycling machine reduces the time required for paper recycling. This machine can be used in offices, schools, colleges and even small scale industries. Only one operator is sufficient to carry out the entire process. We can increase the quality of paper obtained by adding some easily available chemicals like bleaching powder, talcum powder, sodium hydroxide, etc.

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