International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 03 | Mar 2022 www.irjet.net p-ISSN: 2395-0072

Waste Minimization in Die Cutting Industry Through Implementation of Green Manufacturing Technologies: A Case Study

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Abstract - *This Project work aims to implement green manufacturing in the die-cutting industry This project work selects one of the die-cutting industries in TTC Industrial Area Navi Mumbai, Maharashtra, India. It has been observed that before implementing the practice of green manufacturing the industry produces a considerable amount of waste and invested somehow more amount for processing die-cutting for various metal and non-metal printed boards This work includes information about various green practices and the recent research work carried out by different researchers is included in the second chapter of this paper. The third part included the earlier practices in the die-cutting industry and the information about implementations of green manufacturing techniques. The experimental techniques and the results are elaborated in chapter four. Finally, the discussion and conclusion of the work are enlisted in chapter fifth part.*

Key Words: **Green manufacturing, die-cutting industry, waste management, green manufacturing techniques, green design**

1.INTRODUCTION

1.1 Definition of G.M

“Green '' is an adjective that is defined as "regarding or supporting environmentalism and tending to preserve the quality of the environment (as per being. Recyclable, biodegradable or pollutant-free)". This definition alone is broad, but when applied to the fabrication of the general idea of environmentally friendly manufacturing.is a process or system that has a minimum, non-existent or negative impact on the environment.

A definition adapted from that proposed by the US Department of Commerce focuses on sustainable manufacturing. The development of manufacturing products using materials and processes that minimize negative environmental effects, save energy and natural resources, are safe for employees, communities and consumers and economically sustainable. “The word "green" may also be used as a verb which would then refer to the process of reducing the environmental impact of one or more manufacturing processes. Examples of greening a manufacturing system include reducing the quantity of hazardous waste generated. Reduce the consumption of coolant during machining, or change the energy mix to include more renewable energy sources.

1.2 Origin and overview of GM

The GM concept emerged in Germany in the late 1980s and early 1990s. According to Bylinsky (1995), they set up an effective global system manufacturing standard instilling that any company that wants to compete on a global scale must begin to manufacture products that will comply with green regulations of the European market. From the 1980s onwards, sustainable manufacturing activities began to focus on waste reduction in production. After that, the paradigm for sustainable manufacturing was changed, moving from a product-driven process, focusing primarily on reducing of resources, energy and toxic materials, as well as development and use of renewable materials expressed by Seliger et al. (2008). Fischer et al. (1997) provide a similar view, outlining a number of ways organizations have dealt with this issue, few of which are designed for reusability and recycling, minimizing waste, emissions and raw material consumption.

1.3 Importance of GM

In the product life cycle, once a product has moved from the drawing board into production, its environmental attributes are largely fixed. For this reason, it is necessary to support the design function with Environmental impact assessment tools and methodologies have been developed to enable a comprehensive assessment of each phase of construction. Liu et al. (2005b) state that Sustainability has become the key policy to achieve environmental management and protection. Even with continuous development, resource utilization can be done. An understanding of the causal relationship between GM and corporate environmental performance, for example, green technology activities, is therefore required. Environmental problems are a worldwide concern due to the rise of industrial activities. To protect the world, it is necessary to adopt a preventive approach. The very source, GM, DfE, and life cycle analysis (LCA) are now being pursued, insist Rivera-Becerra and Lin (1999). Environmental globalization has force companies to become more efficient. GM is the only obvious solution for

today's manufacturing scenario, according to Zhu et al., (2007).

2. INTRODUCTION TO DIE CUTTING AND PRINTING INDUSTRIES

2.1 History of the printing industry

"In 1440, a German called Johannes Gutenberg invented a printing press process that, with refinements and increased mechanization, remained the principal means of printing until the late 20th century. The inventor's method of printing from movable type, including the use of metal molds and alloys, a special press, and oil-based inks, allowed for the first time the mass production of printed books" (GREAT@2007). Gutenberg gave birth in 1436 to "an art" that played an important part in the industrial revolution and today is one of the most advanced and technological developments. "He was German, his press was wooden, and the most important aspect of his invention was that it was the first form of printing to use movable type" (GREAT@2007).

2.2 Die cutting process

The die cutting process involves the use of metal dies3 to give paper or substrate products specific shapes or designs that cannot be accomplished by a straight cut on a web press or a guillotine cutter. By using knife-edge cutting blades formed into a pattern or die, a machine presses the die into the material to produce the desired shape. Almost any shape can be created and applied to a diverse array of raw materials. Labels, envelopes, folders, cardboards, and documents are only a few of the many printed products that can be die cut. Web presses often have a rotary die unit that is utilized for die cutting paper and label stocks. Although there are limitations on the types of dies and paper selections that can be provided, rotary die cutting serves as an effective method for longer run quantities of printed materials requiring some type of die cut area. Single sheet products require the use of a flatbed die and a flatbed cutting press to die cut the shape into the paper stock. The speed of this process is slower than a web press, but it does provide die cutting capabilities to a wider variety of paper stocks and printed products" (INTERNATIONAL@2007).

Invention was that it was the first form of printing to use movable type" (GREAT@2007).

Fig -1: Example of die cutting

3. LITERATURE SURVEY

[1] I.D. Paula, G.P. Bholeb J.R. Chaudhari in "A review on Green Manufacturing: It's important, Methodology and its Application. Introduce an objective to bring the attention of the manufacturer who is manufacturing the product with the mass production. We have seen that a lot of energy is used day by day and lots of waste is available. The waste is hazardous and can lead the human being to a termination point. Toxic hazards are really crucial for human beings.

This paper points out all the waste and the methodology of green manufacturing that we can apply and can reduce wastage and increase the use of sustainable energy. The implementation of Green Manufacturing may not only be good for the environment — it is often good business, as well.

[3] Ahmed M. Deif abstracted in "A SYSTEM MODEL FOR GREEN MANUFACTURING" that Manufacturing systems evolution functions in multiple external and internal factors. With today's global awareness of environmental risks as well as the pressing needs to compete through efficiency, manufacturing systems are evolving into a new paradigm. This paper presents a system model for the new green manufacturing paradigm. The model captures various planning activities to migrate from a less green into a greener and more eco-efficient manufacturing. The various planning stages are accompanied by the required control metrics as well as various green tools in an open mixed architecture. The system model is demonstrated by an industrial case study. The proposed model is a comprehensive qualitative approach to design and/or improve green manufacturing systems as well as a roadmap for future quantitative research to better evaluate this new paradigm.

[4] Aditya M. Belekar introduce in "GREEN MANUFACTURING" that research finding that correlates between problems faced due to manufacturing and its relation with the working of sugarcane factory and foundries. This research technology presented in paper claims about increase in economic progress rate while decrease in resource depletion, waste generation and pollution. The paper presents the green technology used over traditional ways as it promotes green design and development of innovative manufacturing systems. The paper informs about cost reduction and improved quality of product which is useful for industry purposes.

[5] Wadhah Abualfaraa 1, Konstantinos Salonitis, Ahmed Al-Ashaab and Maher Ala'raj studied "Lean-Green Manufacturing Practices and Their Link with Sustainability: A Critical Review" which elaborates rapidly changing and highly competitive market has put companies under a great pressure towards adopting sustainable practices, in terms of keeping a healthy balance among economic, environmental and social performances. In this context, the lean-green manufacturing approach, which combines lean practices

focused on customers' demand, and green practices focused on reducing the business' environmental impact, has gained popularity. Nevertheless, lean-green manufacturing is still a relatively new practice, lacking a clear and structured research definition, and of significant evidence of successful cases in the practice. In this paper, a literature review is conducted to identify the actual possibility of combining lean and green practices, the current trends for implementing such a combination and the potential sustainability improvements such implementation can lead to. It is the authors' intention that the findings analyzed in this paper can contribute to the state-of-the-art of lean-green manufacturing and provide practitioners with a useful tool towards developing effective strategies for its deployment.

Earlier practice and implementation:

In high-volume die cutting operations, fully automatic machines are used. The material to be cut is automatically fed into the press and located in the proper position. The steel die is pressed through the material and the pressure is released. The cut piece is removed along with any scrap material, and the next piece is indexed to repeat the process. (Flexographic, 1980, 26)

There are different kinds of dies used during the die cutting process (it depends of the kind of machine) (Flexographic, 1980, 26):

• Mallet Handle die: This was the first kind of die created. They were originally fashioned by a blacksmith to the desired configuration of the product to be produced. After the cutting edges were hand-sharpened and heat treated, a handle was attached to the back of the die which could be struck with a mallet to force the die through the material to be cut.

• The clicker die: As the Mallet handle dies, the Clicker die's blade is bent or fabricated to conform to the design configuration. No external support is required to prevent the cutting knives from bending.

• The steel rule die: This is probably the most commonly used with most of the web and sheet fed equipment. Here the cutting knives are flexible and relatively thin. They must therefore be embedded in or otherwise supported by a thicker, solid material such as plywood.

• The male-female die: It is made of two distinct (upper and lower) sections. Each section is made of hardened steel blocks which must be mated with extreme accuracy in order to accomplish the scissor type cutting action inherent to this form of die cutting. It is most useful in the production of tags and labels.

• Rotary dies: Because of their curve configuration, they are more difficult and time consuming to build and therefore more expensive. They are normally used on a web press. The die is fixed to a metal roller.

The function of any die cutter is to operate the die and to control the flow of material as it enters and exits from the die area.

[6] Yilei Wang et al. "A green method of preparing a natural and degradable wound dressing containing aloe vera as an active ingredient" has described how to make products environmentally friendly with reduced production of hazardous waste while ensuring product functionality is becoming a crucial and burning issue in the manufacturing industry. This research developed a natural, degradable and environmentally friendly hydrogel wound dressing using aloe vera (AV) as an active ingredient. The hydrogel wound dressing was prepared using all natural ingredients, comprised of sodium hyaluronate (SH), dopamine (DA), chitosan (CS), and AV, and using a green natural deep eutectic solvent (DES) as a green solvent. The result of this study is as follows:

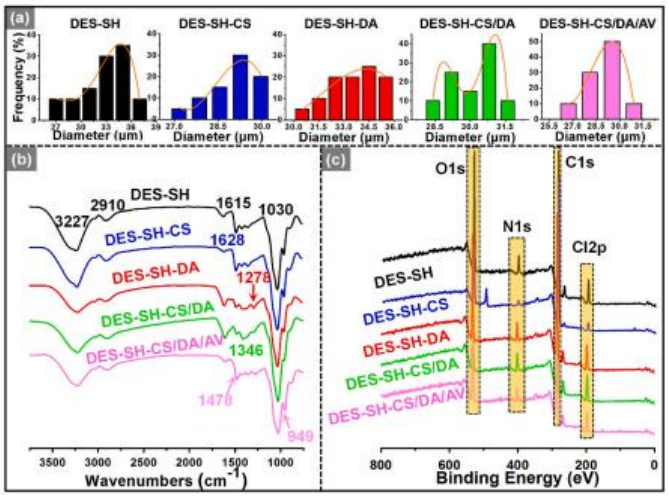


Fig -2: . (a) FE-SEM pore size distributions, (b) FT-IR spectra and (c) XPS spectra of DES-SH, DES-SH-CS, DES-SH-DA, DES-SH-CS/DA and DES-SH-CS/DA/ AV hydrogels.

[7] AlexBadgett et. al. "Methods identifying cost reduction potential for water electrolysis systems" introduce statistic of cost reduction for water electrolysis. The study also used Techno-economic analysis (TEA) is a valuable tool for understanding how to inform research directions that could make hydrogen from electrolysis cost competitive with that produced by conventional means like steam methane reforming.

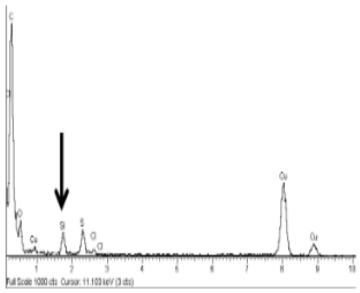
[8] Subramanian Senthilkannan Muthu et al. "Eco-Impact of Plastic and Paper Shopping Bags" focused on study of the eco-impact of plastic and paper bags using the life cycle impact assessment (LCIA) technique under three different options

TABLE V. Comparative results of eco-impact of plastic and paper bags.

Total Points	Without Usage and Disposal Criteria	China Option 1	China Option 2	China Option 3	HK Option 1	HK Option 2	HK Option 3	India Option 1	India Option 2	India Option 3
Paper Bags (Pt)	**126**	72.9	85.5	73.0	78.0	77.9	78.1	90.6	98.1	90.7
Plastic Bags (Pt)	**36**	19.3	24.3	19.5	20.7	25.0	21.0	16.0	24.5	16.3

Table -1: Comparative results of eco-impact of plastic and paper bags. [8]

[9] Muhammad Arshad et. al. "Green Bio composites from Nanoengineered Hybrid Natural Fiber and Biopolymer" describes the presence of other material will adversely impact the environment



Energy dispersive X-ray (EDX) spectrum of POSS modified fiber showing presence of silicon on the surface

Fig -3: EDX spectrum [9]

[10] Neeraj Bhanot et. al. "Sustainable Manufacturing: An Interaction Analysis for Machining Parameters using Graph Theory" investigate sustainability in manufacturing through graph theory for the below table 2

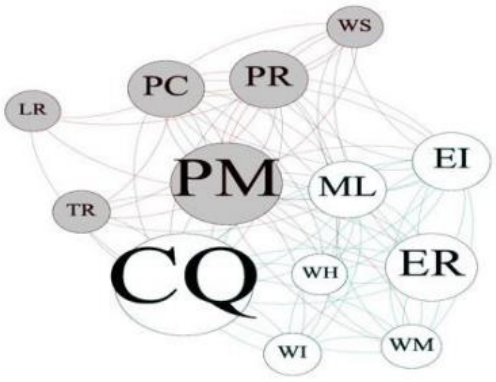


Fig -4: Graph theory of machining process [10]

Table 5: Connections between Sustainable Manufacturing Parameters

	PC	CQ	PR	PM	WI	EI	ML	WM	ER	WH	WS	LR	TR
Production Cost (PC)	0	1	1	1	0	1	1	0	0	1	1	1	1
Cutting Quality (CQ)	1	0	1	1	1	1	1	1	1	1	0	1	1
Production Rate (PR)	1	1	0	1	1	1	1	0	0	1	1	1	1
Process Management (PM)	1	1	1	0	1	1	1	1	1	1	1	1	1
Water Intensity (WI)	0	1	0	0	0	1	0	1	1	0	0	0	0
Energy Intensity (EI)	1	1	1	1	0	0	1	1	1	1	1	0	0
Materials (ML)	1	1	1	1	1	1	0	1	1	1	1	0	1
Waste Management (WM)	0	1	0	1	0	1	1	0	1	1	0	0	0
Environmental Regulations (ER)	1	1	0	1	0	1	1	1	0	1	1	0	0
Worker Health (WH)	0	0	0	0	0	0	0	0	0	0	0	0	0
Worker Safety (WS)	1	0	1	1	0	0	0	0	0	0	0	0	0
Labor Relations (LR)	0	0	0	0	0	0	0	0	0	0	0	0	0

Table -2 Connection between sustainable manufacturing parameters

4. INTRODUCTION TO COMPANY PROTOLAB

Protolab is one of the leading companies Operating from the city of Navi Mumbai, India, since1993, it has been able to meet customers' needs effectively. Protolab Electrotechnologies Pvt. Ltd. are manufacturer and supplier of Flexible Membrane Switch, Membrane Keyboard, Membrane Switches, 3D Print Thermoformed Dials, Plastic Smart Cards, Packaging Material and many more products. It supplies the range to over 1200 OEM's worldwide across various categories which it manufactures in their advanced infrastructure unit that is spread over 30,000 sq. ft. Its plant is near to the airport, ports and railways, which help them in quick transportation. They are supported by a team of proactive engineers who work as per the set industry norms and implement the out of the box ideas.

4.1 Products Manufactured

A) In order to meet the variegated demands of the clients, it manufactures and exports a wide range of Metal and Polydomes Printed Membrane Keyboards. It is manufactured from top quality raw material by help of the engineering expertise, high tech equipment and techniques. It holds expertise in customizing this Metal and Polydomes Printed Membrane Keyboard to suit the specific requirements of the clients.

Fig -5: Metal and Polydomes Printed Membrane Keyboard

b) This Printed Touch Screen Membrane Keyboard is easy to operate, high in performance, and is extensively used in specific sectors. It is manufactured under the guidance and supervision of quality experts as we make sure that it remains defect-free. It is appreciated for its outstanding features like durability, reliability and optimum performance. Furthermore, we provide this Printed Touch Screen Membrane Keyboard at very nominal rates.

Fig -6: Printed Touch Screen Membrane Keyboard.

c) Plastic Packaging Material used for the packaging of various electrical and other products. It is in the shape of the product and is easily recognizable due to its transparency. This material is processed by our dexterous professionals making use of advanced tools and premium quality basic material. Due to its high strength, smooth textures, moisture resistance, and durability, the product has gained huge demand among our clients. Moreover, we are offering this Plastic Packaging Material at market-leading prices

4.2 Waste Created

Waste created by the company is of various types. it is categorized into two groups solid waste and liquid waste

Solid Waste

This type of waste is created after the processing of manufacturing and die-cutting. But the company is highly focused to generate the minimum waste.

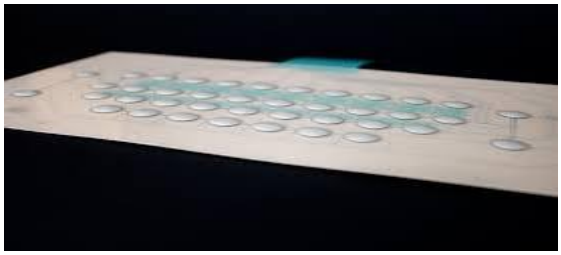


Fig -7: Polydom

Fig -8: Membrane Keyboard

4.3 Liquid Waste

This type of waste is created as additives and coolant is used during processing. This waste is further treated and then delivered into the drainage.

Fig -9: Liquid waste dispose to drainage

5. PROBLEM DEFINITION

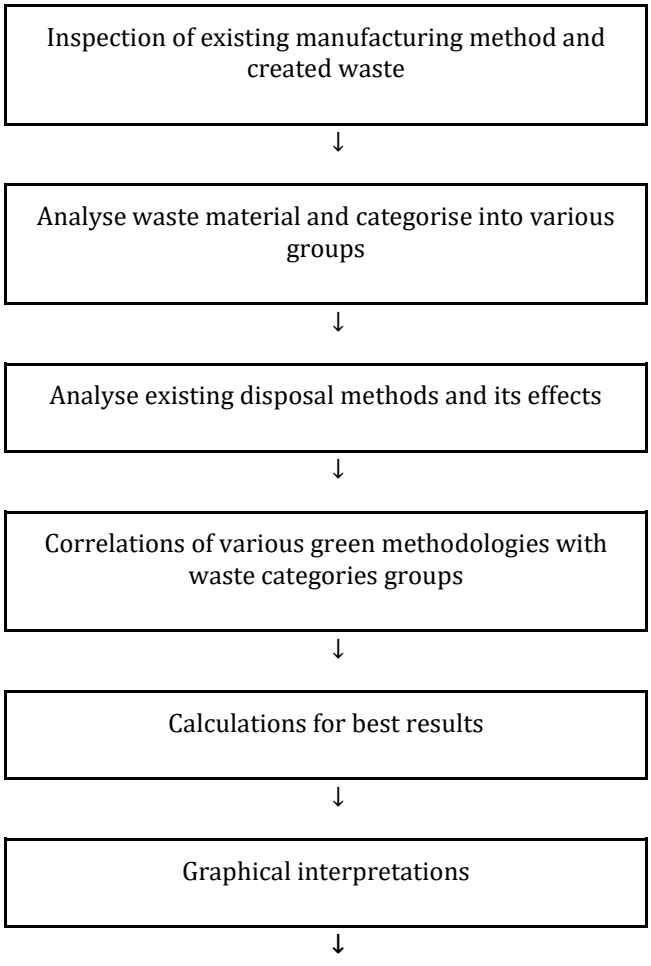
Prior to this project work Solid waste created by the company is manually collected in a bin and handover to MSW van. Doing this increases the burden on MSW in terms of handling and transportation. It also generates zero profit to the company. This project study extensively finds out the solid waste generation and applying 3R (Reduce, Reuse, Recycle) out of this Reducing of waste is the main concern of this study

6. AIM AND OBJECTIVE

- To study the various waste generated during die cutting processes at the Protolab
- To analysis of the waste produced in 1st objective
- To identified the impact of waste-on-waste management and environment
- To implement the green practices

7. RESEARCH METHODOLOGY

The following methodology adopted for experimentation



8. METHODOLOGY USED TO REDUCE WASTE

8.15-s

5S is a tool for workplace organization, with 5 phases that each start with the letter "S": Sort, Straighten, Shine, Standardize and Sustain. These 5 phases are also implemented in this specific order.

Manufacturing industries play a tug-of-war between the public and private sectors, each demanding the fastest, cheapest, and highest-quality products – with the lowest environmental impact. The EPA reports 5-S systems offer several environmental benefits Regular cleaning decreases the accumulation of cuttings, shavings, dirt and other substances that can contaminate production processes and result in defects. A reduction in defects will lead to considerable environmental benefits because energy and materials are no longer wasted in producing and disposing of defective products.

A 5-S implementation can also significantly reduce the square footage needed for operations by organizing and disposing of unused equipment and supplies. Less storage space means less energy needed to heat and light the space.

This work is implemented first and Last 'S' i e Sort and Sustain. The raw material as well as waste material is sorted according to weight and volume The results are shown in tables and graphs

8.2 TQM (Total quality management)

Total quality management (TQM) is a term that originated in the 1950s. The term 'total' means the entire organization—all teams, departments and functions—is involved in quality management. The 'system' refers to the managerial and technological methods to achieve quality requirements and business objectives throughout an entire organization. Although it may go by various names, Juran believes 'enterprise excellence' to be a more appropriate name for TQM.

Fig -10: TQM Phases [34]

The continuous improvement leads to energy saving as well as meeting the current trends of customers. It's ultimately beneficial for the company's growth. This work is also implemented. Strategic and systematic approach to minimize the waste and focusing on accurate drawing of printing 2 D sheet and precision machining.

9. EXPERIMENTATION

9.1 Initial Step

In the start of this work, first of all various types of the waste are observed and categorized into different categories, broadly separated as metal and non metals. Their weight and volume are measured by conventional measuring methods.

Table -3 Initial data collection

Month	Week	Solid Waste (Kg)			Volume (m^3)
		Metal	Non-Metal	Total	
Feb-21	Week_1	4.3	2.2	6.5	1.9
	Week_2	4.4	2.2	6.6	1.8
	Week_3	4.3	2.2	6.5	1.9
	Week_4	4.4	2.3	6.7	2.25
	Total of the Month			26.3	7.85

9.2 Second step observations

This step is in continuation with the previous step and also collects the waste in the same manner. Unfortunately, the die cutting machine no.2 was committed to sudden maintenance for 3 days. Hence waste generation is quite less than previous stage.

The observations are listed below

Table -4: Observed data

Month	Week	Solid Waste (Kg)			Volume (m^3)
		Metal	Non-Metal	Total	
March -21	Week_1	4.3	2.2	6.5	1.9
	Week_2	4.4	2.1	6.5	1.8
	Week_3	4.3	2.2	6.5	1.9
	Week_4	4.1	2.0	6.1	1.6
	Total of the Month			25.6	7.32

9.3 Application of Precise machining process

In this phase the focus is made on precise machining. The workers are instructed and observed for precise machining of the cuts provided during die penetration are critically handled. The observed waste is compared with the non precise waste. It was found that the waste is reduced quite less.

The observations are listed below

Table -5: Precision experiment

Month	Week	Solid Waste (Kg)			Volume (m^3)
		Metal	Non-Metal	Total	
June-21	Week_1	4.1	2.2	6.3	1.9
	Week_2	4.0	2.2	6.2	1.8

	Week_3	4.0	2.2	6.2	1.9
	Week_4	4.0	2.3	6.2	1.8
	Total of the Month			~25	7.4

9.4 Implementation of Accurate drawing

In this phase along with precise machining the focus is made on accurate drawing. The sheets for printed circuit board as well as digital Graphics User interface (GUI) are instructed to optimize in material point of view. Then optimized sheets are precisely machined. The quantity of waste is reduced by a considerable the observations are listed below:

Table -6: Accurate drawing result

Month	Week	Solid Waste (Kg)			Volume (m^3)
		Metal	Non-Metal	Total	
July-21	Week_1	3.9	2.2	6.1	1.7
	Week_2	3.8	2.1	5.9	1.7
	Week_3	3.9	2.0	5.9	1.6
	Week_4	3.8	2.0	5.8	1.6
	Total of the Month			23.7	6.6

9.5 Best from Waste

In this step a sample of generated waste is used to investigate for reuse and to identify for energy potential. The generated waste has considerable metal type material which can be recycled and reused. Most of the waste metal alloy like stainless steel, aluzinc, aluminum was handed over to the municipal waste collection center. Nonmetal waste has complex compositions hence more investigation techniques are required. It has a great future scope.

The observations are listed below:

Table -7: data collection for convert into useful work

Month	Week	Solid Waste (Kg)			Volume (m^3)
		Metal	Non-Metal	Total	
Aug-21	Week_1	3.8	2.0	5.8	1.6
	Week_2	3.8	2.0	5.8	1.6
	Week_3	3.7	2.0	5.7	1.5
	Week_4	3.7	2.0	5.7	1.5
	Total of the Month			23	6.2
Sept-21	Week_1	3.5	1.4	4.9	1.3
	Week_2	3.4	1.5	4.9	1.3
	Week_3	3.3	1.4	4.7	1.2
	Week_4	3.3	1.4	4.7	1.2
	Total of the Month			19.2	6.0

10. EFFECTS OF RESEARCH

10.1 Manufacturing Cost Effect

		values are in INR
parameter (per week)	Before Study (Lakh)	After study (Lakh)
Raw material	2.5	2.48
Man-Machine	1.3	1.3
cutting fluid	0.03	0.028
electricity	0.015	0.015
tool used	0.05	0.05

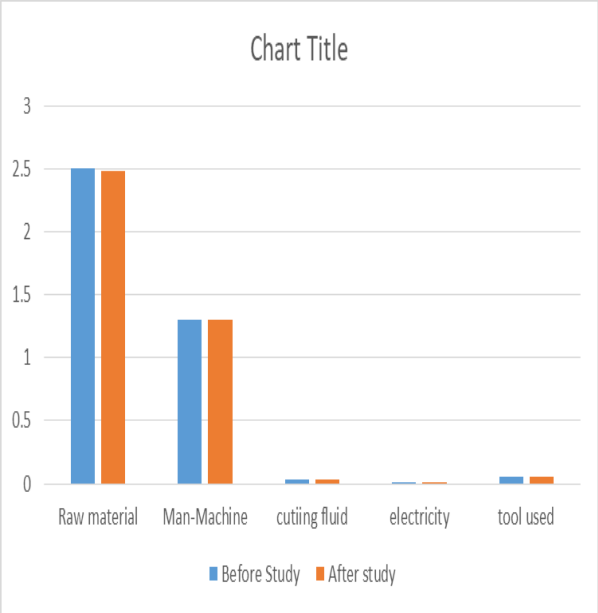


Chart -1 Manufacturing Cost Effects

10.2. Waste Handling Cost Effects

parameter (per week)	Before Study (Lakh)	After study (Lakh)
metal waste	0.05	0.047
Non Metal waste	0.002	0.0015
liquid waste	0.0015	0.001
waste collection	0.002	0.0018
waste transportation	0.005	0.0048

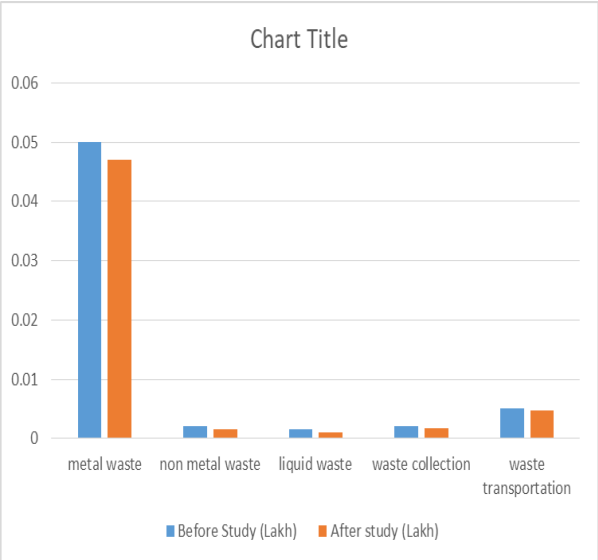


Chart -2 Waste Handling Cost Effects

10.3 Energy extraction

The studded waste has solid as well as liquid waste. Further solid waste is also categorized into metal and non metal waste. Therefore, there are great opportunities to reuse this waste and produce the useful effect or extract the best from waste.

In present study the metal waste is sent to reuse after waste separation, where it is reprocessed and converted into reusable form.

The non metal waste is processed for plastic toy industries and liquid waste are processed for further analysis like COD and BOD calculations.

11. RESULTS

11.1. Results are summaries in tabular form

Table -8: Results

Month	Week	Solid Waste (Kg)			Vol. (m^3)	Method used
		Metal	Non-Metal	Total		
Feb.-21	Week_1	4.3	2.2	6.5	1.9	Nil (Start of project Work)
	Week_2	4.4	2.2	6.6	1.8	
	Week_3	4.3	2.2	6.5	1.9	
	Week_4	4.4	2.3	6.7	2.25	
	Total of the Month			26.3	7.85	Initial Observations
March-21	Week_1	4.3	2.2	6.5	1.9	machine failure (3days)
	Week_2	4.4	2.1	6.5	1.8	
	Week_3	4.3	2.2	6.5	1.9	
	Week	4.1	2.0	6.1	1.6	

	_4					
	Total of the Month			25.6	7.32	
June-21	Week _1	4.1	2.2	6.3	1.9	Precise Machining
	Week 2	4.0	2.2	6.2	1.8	
	Week _3	4.0	2.2	6.2	1.9	
	Week _4	4.0	2.3	6.2	1.8	
	Total of the Month			~25	7.4	
July-21	Week _1	3.9	2.2	6.1	1.7	Precise Machining + Accurate Drawing
	Week _2	3.8	2.1	5.9	1.7	
	Week _3	3.9	2.0	5.9	1.6	
	Week _4	3.8	2.0	5.8	1.6	
	Total of the Month			23.7	6.6	
Aug.-21	Week _1	3.8	2.0	5.8	1.6	Precise Machining + Accurate Drawing + utilizing for Project W
	Week _2	3.8	2.0	5.8	1.6	
	Week _3	3.7	2.0	5.7	1.5	
	Week _4	3.7	2.0	5.7	1.5	
	Total of the Month			23	6.2	
Sept.-21	Week _1	3.5	1.4	4.9	1.3	Precise Machining + Accurate Drawing + utilizing for Project W
	Week _2	3.4	1.5	4.9	1.3	
	Week _3	3.3	1.4	4.7	1.2	
	Week _4	3.3	1.4	4.7	1.2	
	Total of the Month			19.2	6.0	

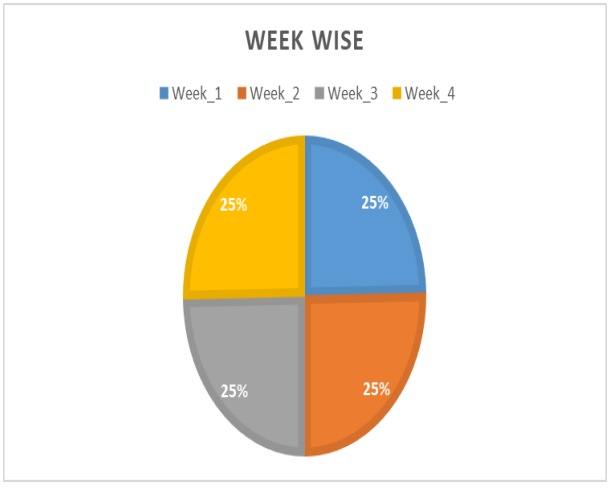


Chart -3 Graphical Representation of Work

12. CONCLUSION

This work is exclusively focused on waste observations and its effect on the environment by implementing green technology, like TQM, 5S etc. based on the observations the waste generated have various categories. This work broadly

classified the waste into metal and non metals (paper, plastic, polymers etc.). The result shows that precise machining reduces the waste in a few kilograms but precise machining in association with accurate drawing with skilled workers reduced the waste by a considerable amount.

The waste generated has good enough potential energy which can be converted to more utilized form, but it requires complex research. The liquid waste includes printing ink, machining oil and wastewater which is further treated for COD and BOD.

The result shows that the volume of waste generated is also reduced by imparting green technologies. It would ultimately reduce the storage, handling and transport of the MSW management system.

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