INDUSTRIAL PAPER AND SOFT SOLID SHREDDER

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Abstract:

A paper shredder is considered to be a mechanical machine that is used to cut paper into either strips or fine particles that portray no information that was written on the paper initially. Government establishments, big business holders, and private personalities use these shredders to abolish private, personal, or otherwise delicate and secret pamphlets. Privacy specialists frequently claim that individuals should shred their bills, tax papers, credit cards, and statements of their bank account, and other kinds of stuff that might be used by robs to commit deceit and theft. In this report, we describe the design and working of a shredder machine that would be able to shred industrial paper and soft solid.

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Acknowledgments

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Chapter 1: Introduction

The shredding machine was designed to solve problems on identity theft, fraud, cost of disposing of paper, and ease of paper recycling by properly shredding sensitive documents. This report includes a complete study of different parts of the shredder machine such as the frame of the shredder, the system of transmission, and the cutting system that are made and designed independently. The first part of the report incorporates the study of the cutting system of the shredder machine for example types of blades, advantages and drawbacks of different kinds of blades. The second part includes the process of design with the comprehensive design of each element of the cutting and transmission system i.e., blade designing and making certain alterations in it and the frame of the machine.

1.1 Project Definition

This report explains a detailed study and designing method of a shredder machine that would be used to shred the industrial paper and soft solid. The report comprises a complete study of various parts of the shredder machine for example the frame of the shredder, the system of transmission, and the cutting system that are made and designed independently.

Categories of paper cutting shredders:

- Strip-cut shredders:

In the strip-cut shredder machine, the revolving blades were used to cut thin strips as long as the unique sheet of paper. These types of strips could be reunited.

- Cross-cut shredders: -

In these types of shredders, there are two opposite revolving drums to cut four-sided, rectangle, or diamond-shaped shreds.

- Particle-cut shredders:

These types of shredder produce minute square or circular fragments.

- Cardboard type shredders:

These types are planned particularly to shred grooved material into either strips or a network of the pallet.

- Pierce-and-tear type shredders:

These shredders are composed of spinning knife-edges that penetrate the paper and then tear it away from each other.

- Grinder type shredders:

They are composed of a rotating shaft with cutting knife-edges that chore the paper until it is small enough to drop from a screen.

- Disintegrators and granulator type shredders:

These are used to constantly cut the paper haphazard until the constituent parts are minor enough to pass through a porous plate.

1.2 Project Objectives

- To study the diverse parts of the shredder machine for example the knife-edges, the frame, the transmission system, etc.
- To plan a shredding machine that will yield less sound and vibrations.
- To design a machine that will shred industrial paper and soft solid.
- To keep the cost of structure as little as possible with no compromise on the final yield.

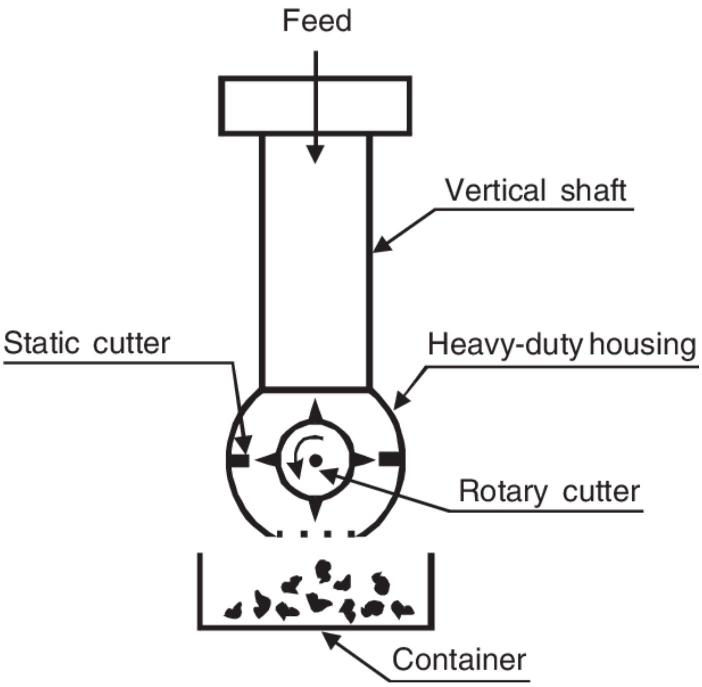
1.3 Project Specifications

- **Specifications:**

The specifications of the machine are:

Vertical Shredder	VS100	VS300	VS600
Motor:	Siemens	Siemens	Siemens
Power:	70 Kw	120 Kw	330 Kw
Voltage:	As per request	As per request	As per request
Dimensions L*W*H	2500*3000*4200 mm	3800*3200*4800 mm	4400*3000*5800 mm
Chamber Height	600 mm	800 mm	900 mm
Rotor Diameter	φ1100 mm	φ1150 mm	φ1150 mm
Equipment Weight	2000 Kg	1500 Kg	1500 Kg
Final Product	20-100mm	30-100mm	30-100mm
Capacity	1200-1500 Kg/Hr	2000-3000 Kg/Hr	3000-4000 Kg/Hr

- **Diagram:**



- **Real-life picture:**

1.4 Applications

Following are the main applications of the shredder we are going to design:

- To terminate the information on the business or important organizational documents.
- To make the fine chips of the solid waste.
- To shred the industrial paper.
- The industrial paper after shredding may be used by recycling process

Chapter 2: Literature Review

2.1 Project background

This paper includes a complete study of different parts of the shredder machine such as the frame of the shredder, the system of transmission, and the cutting system that are made and designed independently. The first part of the report incorporates the study of a cutting system of the shredder machine for example types of blades, advantages and drawbacks of different kinds of blades. The second part includes a process of design with the comprehensive design of each element of the cutting and transmission system i.e., blade designing and making certain alterations in it and the frame of the machine.

2.2 Previous Work

In 2000 Joseph Y. Ko presented a shredder machine with instinctive feeding apparatus which was capable to shred twenty sheets with approximately nine inches width. This machine had three ways to switch for example On, Off, and Auto mode. The blades of the machine were knife rollers which cut the strips of paper but can be seldom organized to have confetti-cuts of the paper need to be shredded. The feeding apparatus had a pair of rollers to guide the paper. The rollers and the knife blades of the shredding machine were driven by a single alternating current motor and a belt and pulley mechanism. In 2000 Frank Chang presented the assembly of blades for a paper shredder that was in a contrasted way. Conventional assembly was composed of extended and short rings. The drawback of the shredder was that even if one part failed, the entire assembly gets released. Instead of composing partition rings, it has consisted of elongated and short plates which were cast with the blade ring. The blades were settled on the rotating shaft to formulate a bladed shaft with the long and short projecting plates of next-to-next blades. This preparation eradicated the use of partition rings, plummeting the cost and increasing the assembly efficiency. Gu-Ming Zeng in the year 2006 presented the knife-edges of the paper shredder that had jagged cutting ends which were shaped by twisting. This could be completed by utilizing two approaches. In the 1st technique, there was a blade body and notched edge intrinsically shaped and pressed from the same fundamental material. With the use of this apparatus, the cost of manufacture was high and even high-level solid material was mandatory for the operation of the machine. On the other hand, in the second technique, there were notched cutting ends particularly condensed to lessen material eating. The problem was that they were also difficult to produce. Three different kinds of blades could be considered according to his approach in the first kind 4 serrated edges regularly spaced with one annular overhang. The second kind of serrated ends with corrugations on the external margin. In the third kind 2 serrated ends with three annular flanges squarely spaced. Ming- Hui Ho. in the year 2003 gave the idea of the paper shredder which was composed of two rotating cutters each of the shredder with several blades. Every blade of the shredder was made of a first cutting blade with numerous first cutting ends and a second cutting blade with numerous cutting ends. The first and the second cutting edges the both were scattered in a non-equiangular way and each of the first cutting edges was a counterpoise to each one of the second cutting blades in the simple language there was only one cutting edge that was connected with the paper was needed to be shredded. When the quantity of shredded paper enlarged then in this case paper shredder was unable to function ordinarily because several cutting edges instantaneously involved with the paper to be shredded, in this way the paper stuck in the shredder and the functioning of the machine was disturbed. This problematic situation was removed out with the use of a rotating cutter with numerous blades with several cutting ends. With this plan which is described here the sound of the shredding was significantly condensed. Willi

Strohmeyer in the days of 1995 provided us with a blade and a stripper assemblage for a paper shredding machine. In this technique in between the blades of every shaft in the cutter region, stripper bars or fingers were provided to avoid the cutting material that got collected everywhere around the blade of the shaft. In this method, the stripper lump was composed of the row of stripper's fingers that were incorporated in the spaces among the blades of the shredder. Mandatory fidelity was achieved since the fingers were involved with the provision ribs of the contradictory housing. Stripper lump was a booster detail part, thus was modest structure and easy to manufacture, and also had little cost.

2.3 Comparative Study

In this technique in between the blades of every shaft in the cutter region, stripper bars or fingers were provided to avoid the cutting material that got collected everywhere around the blade of the shaft. In this method, the stripper lump was composed of the row of stripper's fingers that were incorporated in the spaces among the blades of the shredder. Mandatory fidelity was achieved since the fingers were involved with the provision ribs of the contradictory housing. Stripper lump was a booster detail part, thus was modest structure and easy to manufacture, and also had little cost.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1 Geometrical Constraints

While designing a soft solid shredder machine, some assumptions are considered that are standard for their parts. The sufficient design constraints were taken into account for efficient, economical, and durable manufacturing. Through proper design calculations and formulation of each part, we made a safe design for this shredder machine. The material selection is based on durability, availability, ease of fabrication, and cost were also considered. When we started the plan and design of our project, we faced numerous challenges such as the unavailability of parts like bearings to assist the rotational motion. In the local mechanical market, we found out low-quality bearings which reduced the efficiency and performance of shredder machines. We designed a shredder machine with minimum weight because we can install it easily in any place.

3.1.2 Sustainability

In this shredder machine project, we faced a sustainability problem due to the possibility of deformation and corrosion. Few important steps must be taken to ensure the level of performance and longevity of the machine. These steps include regular repairs and checkups that emptying shredder paper, cleaning, and lubrication to make sure that the parts are running free at their peak performance level.

3.1.3 Environmental

We need to reduce the amount of unrecyclable waste to promote recycling mechanisms regarding the protection of the environment. The paper shredder is an initial step in the paper recycling process, in which paper reduces into small pieces before reaching reprocessing centers. With the help of a paper shredder process, the reprocessing done too easier.

3.1.4 Social

Most private companies, government organizations, and individual persons care about their confidential and private information, which must be present in paper format. The shredder machine destroying secret information and preventing it from falling into unwanted hands. However, such type of system has a social impact because provided a sense of safety and security.

3.1.5 Economic

There numerous factors as machine cost, labor cost, fuel, and transport cost are mainly depending on the paper production cost. The demand for new industrial paper will be reduced, with the help of the recycling and shredding process because production cost automatically decreases correspondingly.

3.1.6 Safety

Privacy and safety information is important reasons for using a paper machine. Shredding of private or confidential documents ensures that there will be no traces left for unwanted eyes to take look at.

3.1.7 Ethical

Now a day, companies, businesses, peoples, and societies with their secret information, with confidence that their data is going to be kept safe. However, we knowns that the business shredder is an important technique of discarding documents without bargaining client's security. The paper shredder technique promises to their customers by confirming that their secret information would not have seeped.

3.2 Engineering Design standards

In this shredder project, each component is followed the engineering design standard. In this heading, we enlisted that each component has been selected for our shredder project. The shredder machine frame compromises feed unit, machine stand, cutting unit, and hopper housing respectively. The selected component includes a shaft, cutting blades, gears, screws, motor, and fans. The bearing standards have been taken according to NSK. The motor standard has been taken according to ISO 9001. The screw standard has been taken according to ANSI Metric.

Table 1 Engineering Design Standards

Shredder Components	**Engineering Standard**	**Details**
Motor	ISO 9001	U5420
Bearing	NSK	Deep groove ball bearing (6300ZZ)
Blades and Shaft	Cutting standard	DINP-4
Screws	ANSI Metric	B 18.6.3, Fed. Spec. FF-S-92, Fed. Spec. QQ-P-416, MS35206-207, NASM35206

3.2.1 Shaft

In this shredder project, the cylindrical shaft is made with mild steel material. The shaft is stepped down on both sides with the help of a lathe machine.

- Length = 600 mm
- Diameter = 35 mm
- Stepped diameter = 25 mm

3.2.2 Cutting Blades

In this industrial shredder project, there are 56 blades in each shaft and 112 cutting blades in both shafts respectively. The cutting blades are made with mild steel material. These cutting blades are further divided into two parts as the movable blade and fixed blade. These blades are designed to cut industrial paper with dimensions equal to or less than 160mm^2. These industrial papers are easier to recycle because we compared their relative size with high-security standards.

3.2.3 Screws

Two types of screws have been used in this shredder design project.

Screw’s type 1:

- Length: 13.0 mm
- Head Height: 1.5 mm
- Head Dimeter: 4.0 mm
- Driver style: Phillips

Screw’s type 2:

- Length: 9.0 mm
- Head Height: 2.0 mm
- Head Dimeter: 6.0 mm
- Driver style: Phillips

3.2.4 Motor

The specifications of the motor are enlisted below:

- Motor speed: 6690RPM
- Motor power: 0.588kW
- Shaft teeth: helical type
- Shaft length: 14.0 mm
- Diameter: 45.0 mm
- Length: 96.0 mm
- Armature length: 26.0 mm
- Armature width: 54.0 mm

3.2.5 Gears

In industrial paper and soft solid shredder projects, the four types of gear have been used as motor gear, first gear, second gear, and third gear. In this shredder project we used helical gears due to the following reasons:

- Helical gears can handle high RPM coming from an electric motor.
- Helical gears are used for noiseless power transmission purposes because their teeth are inclined to the axis of the shaft.

Motor Gear:

The motor gear is a double type gear whose side A directly connected to motor gear and side B is connected to gear one respectively.

<u>Side A</u>

- Type: Helical Gear
- Root diameter: 28 mm

- Tooth depth: 2 mm
- Thickness: 11 mm
- Teeth count 37 teeth.
- Tip diameter: 32 mm

Side B

- Type: Spur gear.
- Tooth depth: 3 mm
- Teeth count 7 teeth.
- Thickness: :10 mm
- Root diameter: 9 mm
- Tip diameter: 15 mm

First Gear:

The first gear is a double type gear whose side A connected to side B of the first gear and side B is directly connected to side A of the second gear.

Side A

- Type: Spur gear
- Tooth depth: 3 mm
- Teeth count 28 teeth.
- Thickness: 7.5 mm
- Root diameter: 38 mm.
- Tip diameter: 45 mm

Side B

- Type: Spur gear.
- Teeth count 6 teeth.

- Tooth depth: 3 mm
- Thickness: 15 mm
- Root diameter: 6.5 mm.
- Tip diameter: 13 mm

Second Gear:

The second gear is also a double-type gear that is directly attached to the first shaft.

<u>Side A</u>

Side A is connected to shaft B of the first gear, which was responsible for motion.

- Type: Spur gear.
- Teeth count 41 teeth.
- Tooth depth: 3 mm
- Thickness: 4 mm
- Root diameter: 57 mm.
- Tip diameter: 63 mm

<u>Side B</u>

Side B is directly connected to the third gear.

- Type: Spur gear
- Tooth depth: 4 mm
- Teeth count 9 teeth.
- Thickness: 6 mm
- Root diameter: 15.5 mm.
- Tip diameter: 23.5 mm

Third Gear:

The third gear is responsible for the motion of the second gear shaft, which was directly connected to side B of the second gear.

- Type: Spur gear.
- Tooth depth: 4 mm
- Teeth count 9 teeth.
- Thickness: 6 mm
- Root diameter: 15.5 mm.
- Tip diameter: 23.5 mm

3.3 Theory and Theoretical Calculations

3.3.1 Gears Rotational Speed

The motor shaft is directly connected to the first gear (N_1), and first gear is further connected with the second gear (N_2), and the second gear is again connected to the third gear (N_3). The speed of industrial paper shredder is found out by using a third gear (N_3), which was directly connected to the driven shaft. The industrial paper shredder speed is found out by using the following relation:

$$\boldsymbol{Industrial\ Paper\ Speed = Motor\ Speed} \times \frac{\boldsymbol{Product\ of\ Transmission\ Teeth}}{\boldsymbol{Product\ of\ Receiving\ Teeth}} \qquad \textbf{(3.1)}$$

3.3.2 Design of Shaft

The material selection for the shaft is AISI 304 standard stainless steel. The standard stainless steel is widely used because of its simplicity and less cost. The torsional moment of the shaft is given as:

$$\boldsymbol{M_t = \frac{\pi}{16}\tau d^3} \qquad \textbf{(3.2)}$$

3.3.3 Torque on Shaft

The torque on the shaft is depending on the speed of the industrial paper shredder and motor power respectively. The torque on the shaft is found out by using the following relation:

$$\boldsymbol{P = \frac{2\pi NT}{60}} \qquad \textbf{(3.3)}$$

By rearranging;

$$T = \frac{P \times 60}{2\pi N} \quad \textbf{(3.4)}$$

3.3.4 Cutting Force of Industrial Paper

The cutting force for industrial paper occurred when the blade force is larger than the tear force of industrial paper. In this industrial shredder project, there are 56 blades in each shaft and 112 cutting blades in both shafts respectively. Each blade required 0.27N force to cut industrial-size paper. The total cutting force for this industrial paper shredder is found out as:

$$F_{cutting} = 0.27 \times C \quad \textbf{(3.5)}$$

Where C represents the total number of blades in a paper shredder.

3.4.5 Number of Papers in Each Cut

The industrial paper cutting force is found out by using the following relation:

$$F = 2\pi \times n \times p \quad \textbf{(3.6)}$$

Where “n” represents the number of papers in each cut and “p” is the pressure force to cut industrial paper that was equal to 0.789 N/m^2.

3.4.6 Results

N_{motor} = 6690 RPM

Motor Power = P = 0.588 kW = 588W

Cutting force for each blade = 0.27N

Total number of blades in industrial paper shredder = 112

Pressure force = p = 0.789 N/m^2

Step (1):

We have the motor speed and the product of transmission and receiving teeth. We used equation (3.1) to find out the speed of industrial paper shredder.

$$Output\ paper\ speed\ (N_3) = 6690 \times \frac{(37 \times 9)}{(7 \times 28 \times 6 \times 41)}$$

$$N_3 = 40.303\ RPM$$

Speed of industrial paper shredder = speed of third gear = N_3 = 40.303 RPM

Step (2):

Now, we used equation (3.4) to find torque on the shaft.

$$T = \frac{588 \times 60}{2 \times 3.14 \times 40.303}$$

$$T = 139.39\ N.m$$

Torque on the shaft = T = 139.39 N.m.

Step (3):

The total cutting force for industrial paper shredder is found out by using equation (3.5)

$$F_{cutting} = 0.27 \times C$$

$$F_{cutting} = 0.27 \times 112$$

$$F_{cutting} = 30.24\ N$$

Total cutting force for industrial paper shredder = 30.24 N

Step (4):

In order to cut industrial paper, we need to fulfill the following condition as ($F_{paper} < F_{cutting\ total}$).

$$F_{paper} < 30.24$$

$$Maximum\ number\ of\ industrial\ paper = F_{paper} = 6 \times 2 \times 3.1415 \times 0.789$$

$$F_{paper} = 29.729 < 30.24\ N$$

The paper shredder can be shred up to six industrial papers in each cut.

3.4.7 Summary of the Calculations

We repeated the same procedure steps of the calculations when the shredder force is equal to 0.789 N/m^2.

Table 2 Summary of Results

Shredder Features	Results
Industrial paper speed (N_3)	40.303 RPM
Torque on the shaft (T)	139.39 Nm
The total cutting force of the shredder	30.24 N
Single cutting force	0.27 N
Number of industrial paper in each cut	6 industrial papers

3.4 Product Subsystems and selection of Components

The figure shows the exploded view of the industrial shredder project. The various parts of the shredder project including cutting blades, gears, two bases, motor, screws, and shaft. Each blade has the capacity to cut six industrial papers during each cut. Each blade contains its inner cavity that allows the shaft to slide through cutting blades. The blade also contains small teeth in its inner race because to prevent rotation without intension. Both shaft and cutting blade is made with standard AISI 304 steel. This material is a very popular choice because of its availability and low cost as well. The two bases are designed to hold gears, a motor, and two shafts. In this industrial shredder project, the gears are used for speed reduction application and transfer power from one shaft to another shaft.

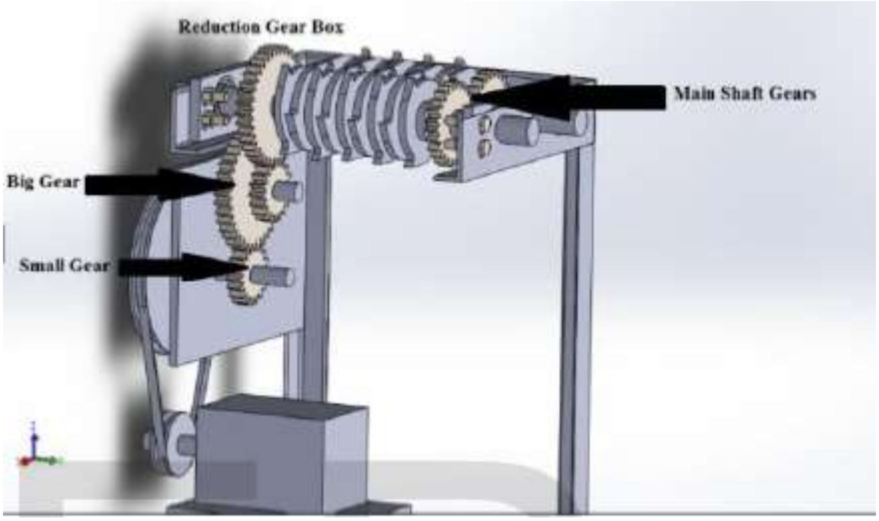


Figure 1 Transmission system of paper shredder machine

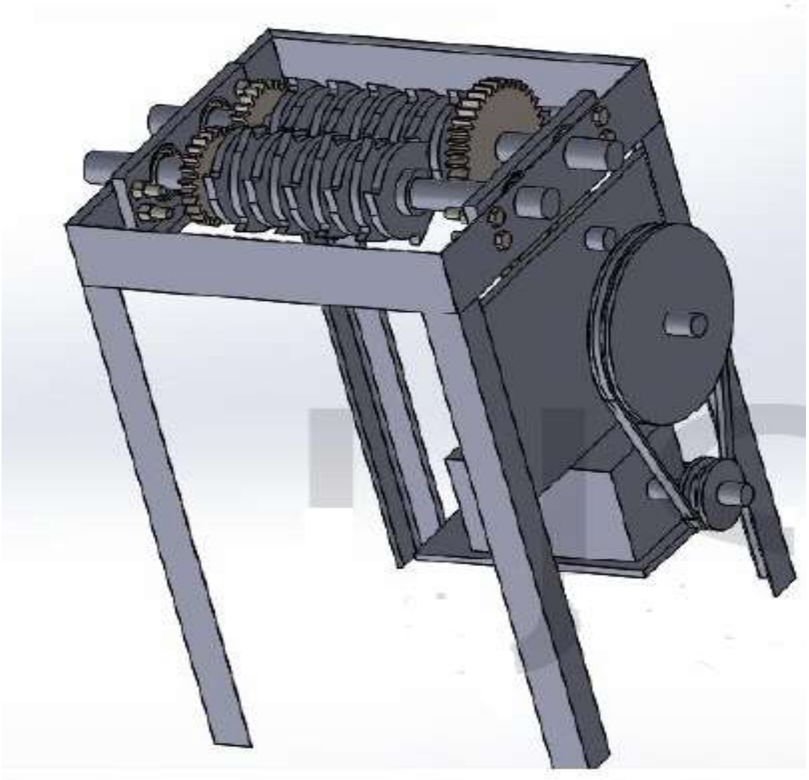


Figure 2 Isometric view of paper shredder machine

3.5 Manufacturing and Assembly

Both shaft and cutting blade is made with standard AISI 304 steel. This material is a very popular choice because of its availability and low cost as well. The motor gear and first gear are made with plastic to minimize vibration and noise. The outer casing of the paper shredder machine was made with aluminum because it is a reliable and lightweight widely used material. This industrial paper shredder process starts with a 0.588 kW DC electric motor, which produces rotary motion through motor gear. In this paper shredder machine, the compound gear system was chosen over the pulley system due to more efficiency. The compound gear train was provided various gear ratios and less speed which is what is needed here. The different pairs of shafts are used to enhance cutting force and security as well as provide a smaller cut. The main shredder shaft is held cutting blades, which are responsible for the shredding process. For the shredding process, the cutting blades are made with stronger materials like stainless steel.

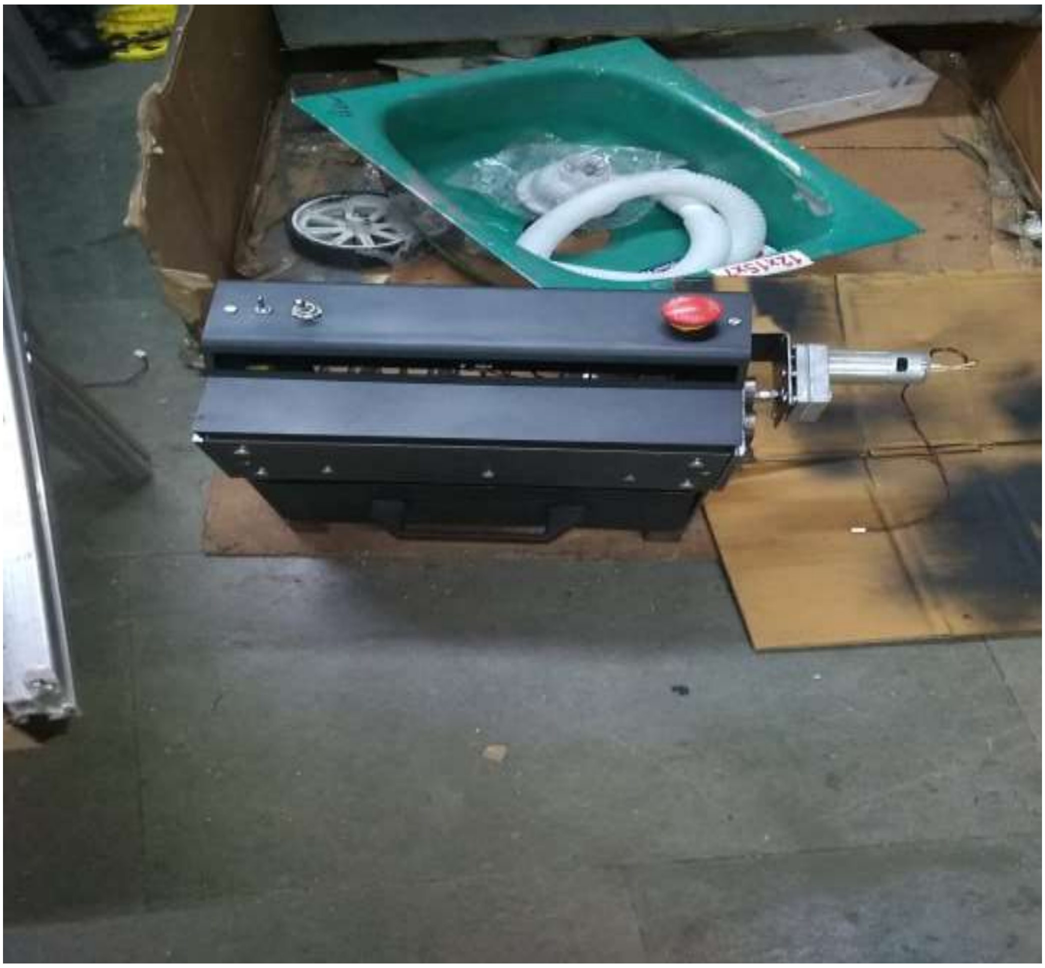


Figure 3 Final Prototype of Paper Shredder Machine

Figure 4 Assembly of Shredder Machine

3.6 3D CAD DESIGN

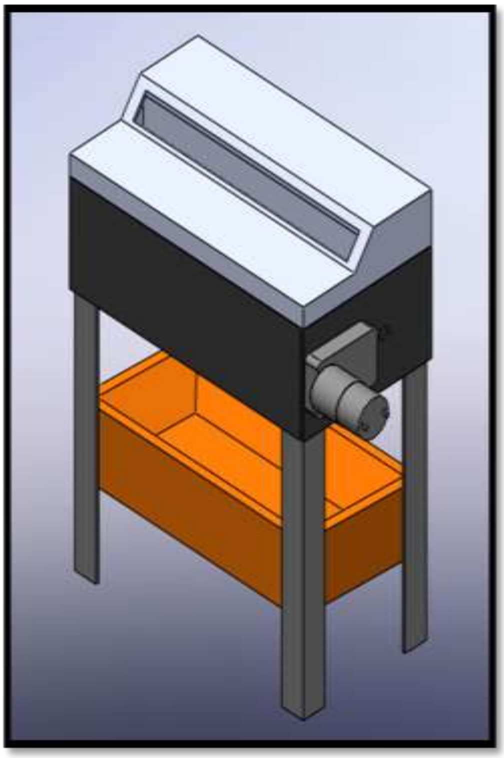


Fig 4 - 3D view of Paper Shredding Machine

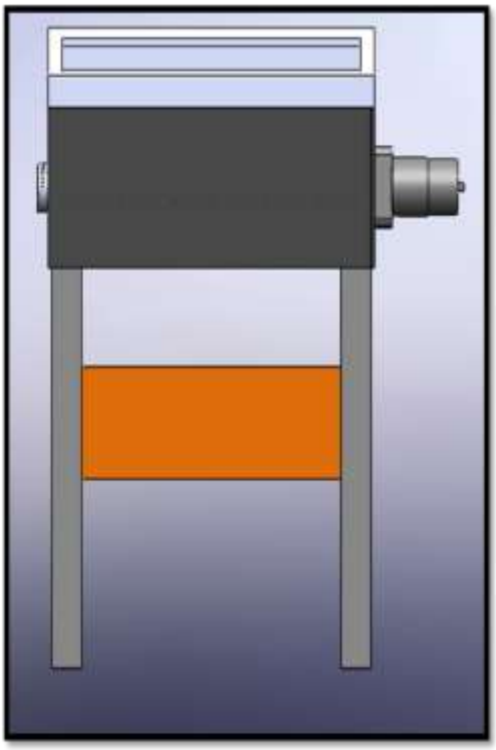


Fig 5 - Front view of Paper Shredding Machine

3.7 Economic Evaluation of projects

The economic evaluation of a project is considered the most important phase of any report because it explains the viability of a project. When a company plans to launch a news service or a new product in the market the most important thing which is considered by the deciding body of that organization is a financial analysis of a project which includes the 10-year or more than 10-year plan about the working procedures and profits expected from that product. This financial analysis helps the company to include both the equipment and construction cost as a part of the capital cost that will be required as a non-recurring cost needed to be paid by the investors of the organization. The operating cost included in the economic evaluation has consisted of energy cost, electricity cost, labor cost, insurance cost, and the cost of taxes. All these operating costs are the recurring costs that need to be paid continuously by the company till the end of the total tenure linked with that project.

After this, the revenue generated by the company each year with the help of different products is incorporated. The revenue section includes the total income that is generated by the company with the help of its products. If the company has incorporated more than one product then the sum of incomes generated by all those products will be equal to the revenue generated by the company in that particular year. After the calculation of revenue, the next end most important procedure for the economic evaluation of any project or product is to calculate the profit generated by that company with the help of the aforementioned products as it can be one product or several products. The profit generated by the company is calculated by subtracting the annual cost, both capital and operating cost, from the revenue generated by that company.

The economic evaluation for our product is performed and shown in the chart below. the costs involved in the project are used with the following values:

Capital cost

- equipment cost = 500
- construction cost = 100

Operating cost

- energy cost = 200
- electricity cost = 120

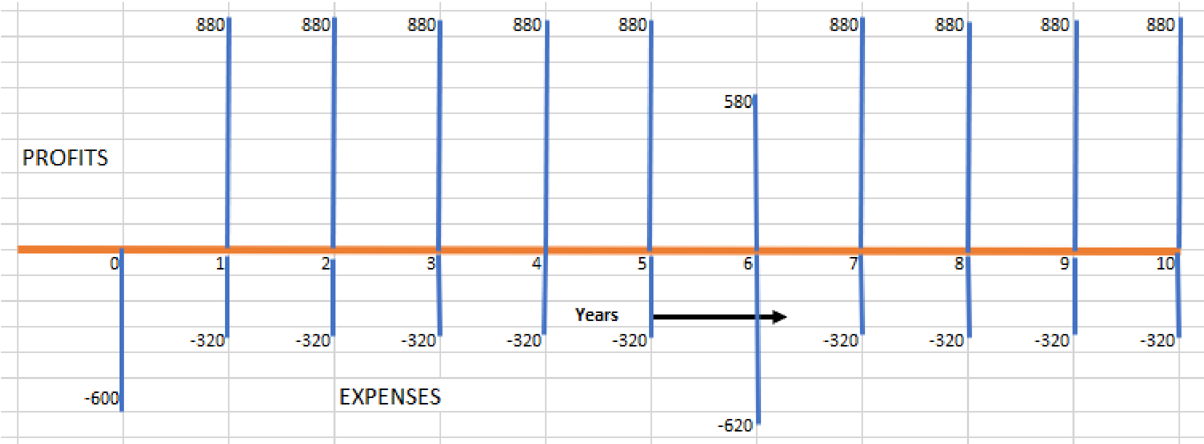
The annual revenue is expected to be equal to 1200 USD.

The complete chart incorporating the costs, revenue generated, and the profits are shown below:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs (USD)											
Equiprment	500	0	0	0	0	0	250	0	0	0	0
Construction	100	0	0	0	0	0	50	0	0	0	0
Total	600						300				
Operating Cost (USD)											
Energy	0	200	200	200	200	200	200	200	200	200	200
Electrcitiy	0	120	120	120	120	120	120	120	120	120	120
Labour	0	0	0	0	0	0	0	0	0	0	0
Insurance	0	0	0	0	0	0	0	0	0	0	0
Taxes	0	0	0	0	0	0	0	0	0	0	0
Total	0	320	320	320	320	320	320	320	320	320	320
Revenues (USD)											
Product 1	0	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Product 2											
Product 3											
Total	600	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Profits (USD)	-600	880	880	880	880	880	580	880	880	880	880

The operating cost for 0^{th} year is not included because the project started it is working from the start of year one after the completion of its construction and design. Therefore, the 0^{th} year incorporates only the capital cost which is a nonrecurring one. After that, capital cost will not be included in the further years because the product is designed and completed only once at the start of a project. in the 6^{th} year, the capital cost is once again mentioned but quite less as compared to the first one is showing the maintenance cost that is required to be paid by the investors for effective working and efficient process flow of the product. Because in our case, we have only one product that needs to be considered, therefore the revenue generated by that product is mentioned. Then, the values for profit are calculated by subtracting the costs paid by the company and the revenues generated in response to that.

The cash flow generated in this regard with the help of applicating the values calculated for our product, the shredder machine, is shown below:



The blue line shown above cash flow shows the total revenues generated by the product which is equal to 1200 USD. The orange line separates the profits from expenses as the profits are shown above the orange line at the end of each year-end expenses are shown by the lines below the axis at the end of each year.

Chapter 4: System Testing & analysis

4.1 Sounds and vibration test results [9][10]

The analysis for the sound and vibration on the as-built model is as follows

Part	Natural Frequency (Hz)	Test Frequency (Hz)
Shaft	Approx. 315	80
Electric Motor	Approx. 260	65
Cutting blades	Approx. 246	62

The above vibration analysis results indicate that the machine is and will operate within the safe region and might not break down before its service time.

4.2 Decision matrix [10][11]

The design criteria are being influenced by the following decision matrix. The matrix assigns the weightage of the criteria and appropriate score as far as the present project is concerned. The sum of all weights is 100% and the Score is from 1-10 where 1 is the least and 10 is the most.

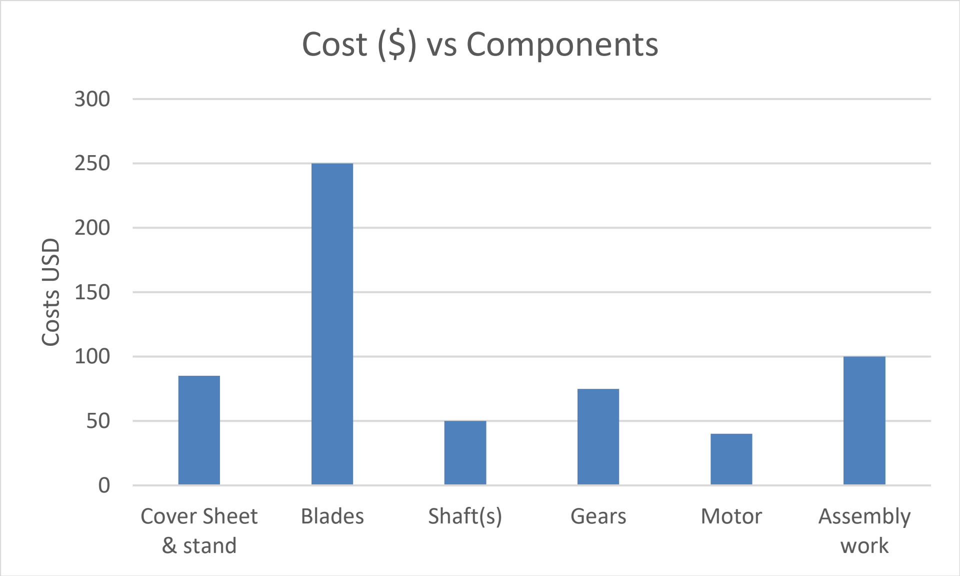
Criteria	Weightage (%)	Score (1-10)

Reliability	15	8
Cost effective	10	6
Ease of operation	10	9
Speed	15	6
Stability	20	8.5
Portability	10	5
Noise	15	8.5
Size of collecting bin	5	9

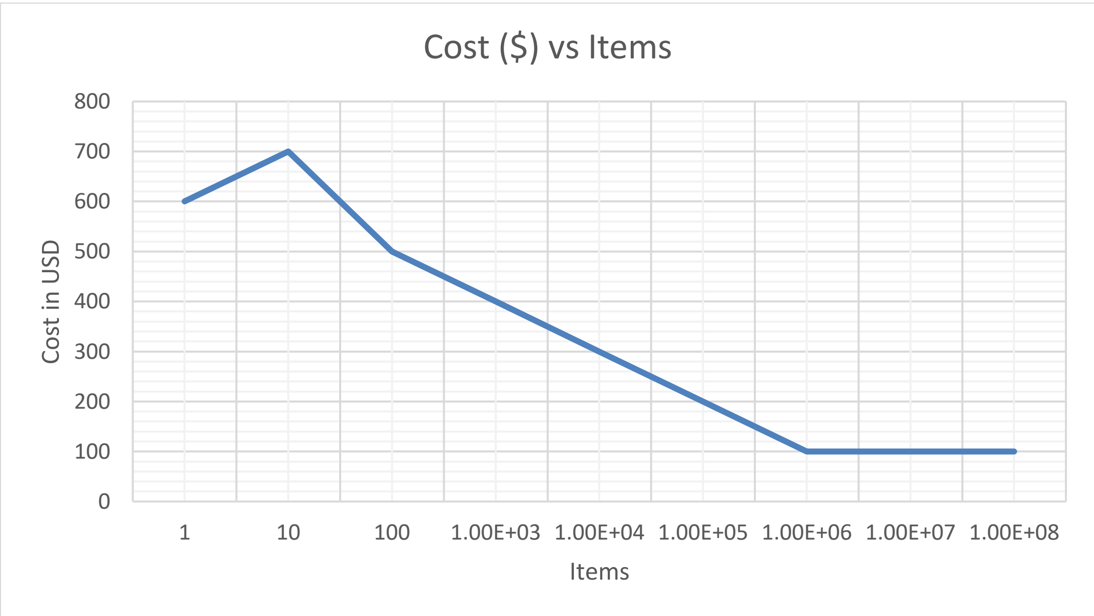
4.3 Cost analysis

The following table gives the cost of different parts and the associated graph

Part / Service	Cost ($)
Cover Sheet & stand	85
Blades	250
Shaft(s)	50
Gears	75
Motor	40
Assembly work	100



From the above graph, it could be observed that the blades have a lion-share of the total costs followed by the assembly work. But overall work is being done cheaply (around 600 USD). Besides, the current project is only a proof of concept and the costs might come down as economies of scale assume the position with large-scale industrial manufacturing. It is assumed that the cost of the final product with scaling of the economy could be seen in the following diagram.



Chapter 5: Project Management

5.1 Project planning & Monitoring

Project planning in the context of the present project is done with the help of the project planning module of MS Excel. The project scope is defined in the beginning. Thereafter the tasks are distributed among team members taking into account their skills and interests. The project management plan could be seen from the following Gantt chart. It is from this Gantt chart project deliverables are monitored closely.

5.2 Team members contribution

The team members met every other day to discuss the progress and brainstorm ideas for efficient and effective project management. The discussions could range from theoretical analysis to economic considerations. The contribution of each member could be found from the Gantt chart in the above section and also as a brief table below. Note that the numbers are subjective and by no means the perfect representation of member's contributions.

Member	Contribution (%)
Ibrahim almaki	19
Abduallah alkhaldi	19
Louai alawaad	23
Dhafer Alshehri	19
Abdulaziz almulhim	18

Paper shredder Project Schedule

Project Start Date	2/25/2021 (Thursday)	Display Week	1
Project Lead	Dhafer Alshehri		

Week 1 — 22 Feb 2021 | Week 2 — 1 Mar 2021 | Week 3 — 8 Mar 2021 | Week 4 — 15 Mar 2021 | Week 5 — 22 Mar 2021

WBS	TASK	Task LEAD	LEAD Contribution	START	END	DAYS	% DONE	WORK DAYS
1	**Introduction**				-			-
1.1	Project Definition	Ibrahim almaki	3%	Thu 2/25/21	Fri 2/26/21	2	100%	2
1.2	Project Objectives	Ibrahim almaki	5%	Fri 2/26/21	Tue 3/02/21	5	100%	3
1.3	Project Specifications	Abduallah alkhaldi	5%	Sat 2/27/21	Wed 3/03/21	5	100%	3
2	**Literature review**				-			-
2.1	Project background	Abduallah alkhaldi	3%	Sun 2/28/21	Tue 3/02/21	3	100%	2
2.2	Previous Work	Abduallah alkhaldi	10%	Mon 3/01/21	Mon 3/08/21	8	100%	6
2.3	Comparative Study	Louai alawaad	6%	Tue 3/02/21	Sat 3/06/21	5	100%	4
3	**System Design**				-			-
3.1	Design Constraints and Design Methodology	Dhafer Alshehri	6%	Mon 3/08/21	Thu 3/11/21	4	100%	4
3.2	Engineering Design standards	Dhafer Alshehri	5%	Tue 3/09/21	Thu 3/11/21	3	100%	3
3.3	Theory and Theoretical Calculations	Dhafer Alshehri	5%	Wed 3/10/21	Fri 3/12/21	3	100%	3
3.4	Product Subsystems and selection of Components	Ibrahim almaki	6%	Thu 3/11/21	Tue 3/16/21	6	100%	4
3.5	Manufacturing and Assembly	Ibrahim almaki	2%	Fri 3/12/21	Sun 3/14/21	3	100%	1
3.6	3D CAD DESIGN	Abdulaziz almulhim	16%	Sat 3/13/21	Sat 3/27/21	15	100%	10
3.7	Economic Evaluation of projects	Ibrahim almaki	3%	Sun 3/14/21	Tue 3/16/21	3	100%	2

Paper shredder Project Schedule

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Project Start Date	2/25/2021 (Thursday)	Display Week	1
Project Lead	Dhafer Alshehri		

Week 1 — 22 Feb 2021 | Week 2 — 1 Mar 2021 | Week 3 — 8 Mar 2021 | Week 4 — 15 Mar 2021 | Week 5 — 22 Mar 2021

WBS	TASK	Task LEAD	LEAD Contribution	START	END	DAYS	% DONE	WORK DAYS
4	**System Testing & analysis**				-			-
4.1	Sounds and vibration test results	Louai alawaad	6%	Mon 3/15/21	Thu 3/18/21	4	100 %	4
4.2	Decision matrix	Louai alawaad	5%	Tue 3/16/21	Thu 3/18/21	3	100 %	3
4.3	Cost analysis	Louai alawaad	5%	Wed 3/17/21	Fri 3/19/21	3	100 %	3
5	**Project Management**				-			-
5.1	Project planning & Monitoring		-	Thu 2/25/21	Sat 3/27/21	-	100 %	22
5.2	Team members contribution		-	Thu 2/25/21	Sat 3/27/21	-	100 %	22
5.3	Project Challenges		-	Thu 2/25/21	Sat 3/27/21	-	100 %	22
6	**Project Analysis**				-			-
6.1	Long term learning	Dhafer Alshehri	2%	Tue 3/23/21	Tue 3/23/21	1	100 %	1
6.2	Impact of Engineering Solutions	Dhafer Alshehri	2%	Wed 3/24/21	Wed 3/24/21	1	100 %	1
6.3	Contemporary Issues Addressed	Ibrahim almaki	2%	Thu 3/25/21	Thu 3/25/21	1	100 %	1
7	**Project Analysis**				-			-
7.1	Conclusions	Abduallah alkhaldi	2%	Fri 3/26/21	Fri 3/26/21	1	100 %	1
7.2	Future Recommendations	Abdulaziz almulhim	2%	Sat 3/27/21	Mon 3/29/21	3	100 %	1

Total working days 62

5.3 Project Challenges

5.3.1 Design challenges overview

One of the biggest challenges the project has is product specification standards. Although a lot of standards exist for shredded paper, no universal standard exists for components for a paper shredder. In addition to that, papers come with different standards in which they are eligible to be recycled. Also, the same level of shredded paper could be accomplished with different blade designs, materials, and types. Choosing a proper design based on the constraints is a huge task.

5.3.2 Fabrication challenges overview

The obvious design challenge is communication in the present pandemic i.e., COVID-19. Although the internet helps a lot to have online video meetings, some situations require one-on meetings. These are accomplished by adhering to proper pandemic protocols.

The fabrication of the as-built model requires a safe place to assemble, place workshop tools and fabricate using a variety of techniques such as pressing, welding, drilling, etc. Added to those safety requirements are the restrictions imposed due to the pandemic COVID-19. Team members chose one vaccinated person to do all the work related to purchases and rentals while other members maintained the proper safety protocols. Online purchases are made whenever possible.

Chapter 6: Project Analysis

6.1 Long term learning

The current project is a combination of theory and practice in that it asks for

1. Design
2. Analysis
3. Fabricate
4. Test

All with a single goal of application i.e., ‘Paper shredder’.

The concepts learned had vast implications on the team member's understanding of the vast difference between the proper understanding of a theory and its practical implementation. E.g., team members understood proper time and work management during this project, while enhancing their technical and people skills. This learning goes a long way in understanding complex projects in the future.

6.2 Impact of Engineering Solutions

The solutions proposed in this project have a small yet focused impact on the team and society at large as it shows how the engineering could be done with the help of CAD and practical testing and analysis. As far as the impact of the project is considered, proper ‘Paper Shredder’ which could shred paper and soft materials alike have a huge potential. As explained elsewhere in the project, paper although a thing of the past is widely used to control knowledge dissemination. It becomes of obvious importance that the papers which carry official secrets and/or of secret in nature should be shredded without a chance of reconstruction. Similarly, soft paper-like materials, e.g., credit cards, etc. also needed to be destroyed while maintaining the feasibility to be recycled.

6.3 Contemporary Issues Addressed

The Kingdom of Saudi Arabia similar to other emerging economies utilizes paper-based information transmission. The recycling of paper requires a lot of energy if the paper is not shredded. Additionally, not all information is needed to be known to everyone. By proposing a neat solution like a custom paper shredder, employees carrying information could be encouraged to destroy the secrets as soon as their purpose is accomplished. It also helps to inculcate a feeling of cleanliness in employees and encourage them to keep their environment clean.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

The current project is one small step in the right direction of conservation of the environment and preservation of important information. The project started with well-defined objectives and then specifications are estimated using theoretical knowledge and expertise. A brief literature review comparing previous work in the same direction is being presented. A comprehensive design involving theoretical calculations and CAD design is being performed. The fabrication of ‘Paper Shredder’ is followed by basic testing and analysis. An overview of project management and project analysis finishes this project.

7.2 Future Recommendations

There is a scope to improve the current project by integrating dynamic analysis and Computer-Aided Manufacturing. Also, the material for the project could be improved by proper research in metallurgy and material sciences. Finally, the fabrication could have been done with Computer-Aided Manufacturing to maintain proper tolerances and dimensions.

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