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College of Engineering

Department of Mechanical Engineering

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Senior Design Project Report

Design of Automated Hammering Machine

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

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Abstract

This project aims at designing and fabricating an automated hammering machine that can perform hammering operations without the involvement of any human operator. This project is selected because no such machines are available in these industries. The introduction of an automated hammering machine in the industries will help the industries in prospering and it will make the operations safe and easy. Moreover, the project will have a greater impact on the metal industries. The machine will be capable of performing fast and accurate hammering operations with the help of a 16V battery. Mild steel is used for fabricating the machine. A large pulley and a shaft are connected with the help of a connecting rod. The spinning shaft will provide lateral motion to the rod. A mid-swinging arrangement is used for attaching the hammer and the connecting rod. A suitable bed will be developed for holding the workpiece. Solidworks is used for designing the machine.

The main objective of the project is to develop an automated hammering machine with the help of a pulley, shaft, connecting rod, hammer, and 16V battery to provide ease for the hammering operations. Future work may involve the development of a body case for the machine.

Acknowledgments

We, the students of the mechanical engineering college (Fall 2020 - 2021), would like to present our thanks and deep appreciation to the Dean of the College and faculty members and supervisors of the graduation project. (Design and Fabrication of Automated Portable Hammering Machine) to give us this opportunity to gain the knowledge and skills to design and implement this project. We also promise to be the best representatives of the college in the field of workers.

We wish you all success

List of Acronyms (Symbols) used in the report:

Symbol	Definition
V	Volt
Kg	Kilogram
Mm	millimeter
M	Meter
RPM	Revolutions per Minute
A	Ampere
W	Watt
T	Torque
P	Power
Nm	Newton-meter
N	Newton, Number of Cycles
FBD	Free Body Diagram
Sec	Second
D	Diameter
J	Polar Moment of Inertia, Joules

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Chapter 1: Introduction

1.1 Project Definition

This project is intended to design and manufacture a simple rotor test rig, where rotor faults can be inserted and tested. The test rig is to be fitted with vibration sensors to enable collecting data and use it to monitor the health of machines. The project is very important to the industry as through understanding the characteristics of failure, time and money will be saved. This is also very important from the safety perspective as this will lead to a safe operating environment for rotary machines.

1.2 Project Objectives

The main objectives of this project are:

1. To design an automated hammering machine that can give automated blows.
2. To replace the use of manual hammering for heavy-duty operations.
3. To fabricate an automated hammering machine that can help workers in hammering processes.
4. To increase the efficiency and accuracy of the hammering operations.

1.3 Project Specifications

Figure 1: Photo of the real system

The most reliable design of automatic hammering machine is described below along with their specification in order to show the different existing approaches to the small and portable automatic hammering concept.

These data could be useful when performing the initial sizing in the design stage of the automatic hammering machine project. Following are 13 designs for initial data collection:

Total weight	24 kg
Hammer weight	5 kg
Hammer length	790 mm
Hammer stroke height	350 mm
Width	300 mm
Length	600 mm
Height	700 mm
Battery	16 V
Motor	0 – 450 RPM, I = 1,5 A, V= 16 V Max, P = 24 W, T= 7.6 NM
Diameter of big pulley	200 mm
Diameter of small pulley	100 mm
Diameter of bearing	16 mm
Length of link rod	490 mm

Table 1: The system measurements

➢ Marketing features

Locally:

- Increase profits
- increase production
- reduce cost
- increase safety
- realise manpower

Globally and internationally:

- Raise the economy
- accuracy in international manufacturing
- increase in the international industrialization
- fast completion in global manufacturing

➢ Engineering standards:

ASTM A36 Welding Standards:

- If the metal is thicker than 1/4 - 6 mm, preheat to 150F
- E7018 stick electrode, an 0.035 or 0.045 E70S-3-6 MIG wire, or for all position welds an E71T-1 electrode wire
- Ensure mill scale in weld area is removed and the plate is always at a temperature >60F
- keep single pass fillet welds < 1/4 - < 6mm
- For multi-pass welds, use inter-pass temp control
- hardness and grain size checked

Design Constraints Engineering Standards:

- quality features of hand hammers
- characteristics and verification
- Applies to hammers used under normal working
- Best practices established by experts in the industry
- Comply with laws that specify design and testing criteria
- Reduce product liability risk
- Budget for certification testing

1.4 Applications

- Use in a production line
- Can be used indoor to drive nails, fit parts, forge metal, and break apart objects
- Use in workshops

Chapter 2: Literature Review

2.1 Project background

With the evolution of technology and the advancements made in the industry, automation has become an important resource for industrial operations. Hammering is a very common process in the industries of mechanical engineering. Most of the industries that involve the fabrication and machining of metal components use hammering. Moreover, hammering is extensively used in the wood industry. This project aims at designing and fabricating an automated hammering machine that can perform hammering operations efficiently. Moreover, the hammering operation is manually performed that results in different types of injuries to the operators. Adding more to it, the efficiency and accuracy required in hammering operations are not achieved through manual hammering operations. Therefore, this project is selected that aims at designing and fabricating an automated hammering machine. An image elaborating the automated hammering machine is given below:

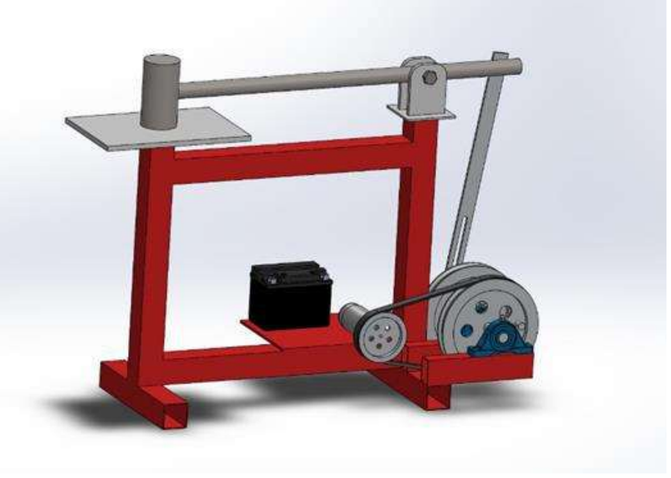

Figure 2 Automated Hammering Machine

It is a simple device but it will be helpful in many operations. The industry now requires accuracy and there are very small limitations of allowed tolerances. An important aspect of this project is the improvement of the operations and the safety of the operators. For instance, consider the hammering operation being done on a large metal piece. If this device will be used, there will be small risks of injuries for the operators but manual operations can bring a lot of harm. Moreover, this device will help in gaining the required level of accuracy. If this automated hammering machine is developed on a commercial basis and it is provided to different industries, it can bring a lot of revolution in the industries.

2.2 Previous Work

First of all, I would like to discuss the work of Julen Agirre. He designed and fabricated a monitoring machine for the testing machine of hammer forging. It is quite relevant to our project. In this work, the authors have worked on developing an automated forging machine. Forging is a similar process to hammering and an almost similar machine was designed and fabricated in the work. Figure 2 shows the machine designed by them.

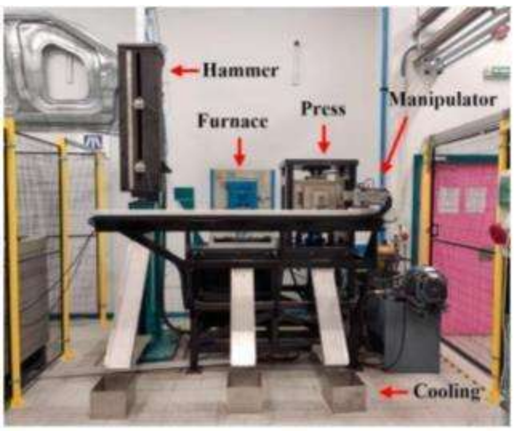

Figure 3 Automated Forging Machine

This machine has a furnace for heating the metal, then cooling equipment for cooling the metal after the completion of the operations and a press that is used for hammering. From this literature, we have gained an idea about the required components for the automated hammering machine.

For the second work, the work done by A.A. Dyakonov will be discussed. In this work, the author has worked on developing an automated processing machine for testing the vibrations of the components. It is a mega form of our project. This project also involves an automated hammering machine but a separate automated hammering machine is not developed yet. In this work, the authors have also developed a software module for controlling the vibrational press. This software module is a new innovation and it will be very helpful if we integrate a software module in our project for the calculated hammering strokes per minute. Moreover, the authors have used Matlab for analysing the results. Some of the new results obtained by the authors are shown in figure 3.

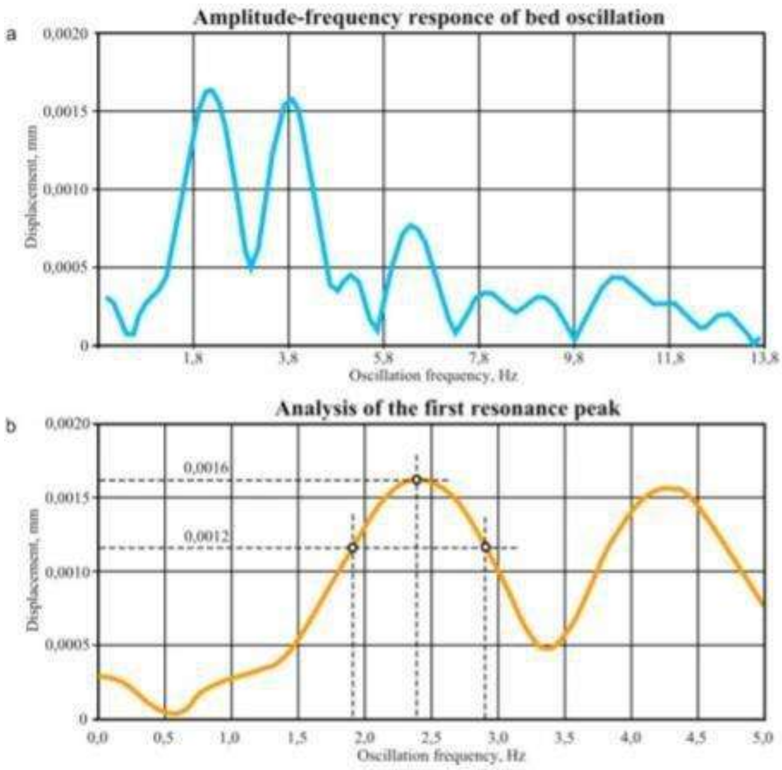

Figure 4 Results obtained by the authors

2.3 Comparative Study

It is an industrial project in which the influence of impact force, stroke length, and impact angle are studied on the hammering machine. In this project, a hammering machine is not developed and a pressing machine is used for the study purposes. Our project is a lot different from this project and our project has a lot of new innovations. Our project will bring a lot of ease to the industry. We have a targeted approach to developing a hammering machine. This project has focused on the residual stresses and MHP of the strokes. Therefore, this project is a lot different than our project. In the following image 4, the results obtained in this project are elaborated.

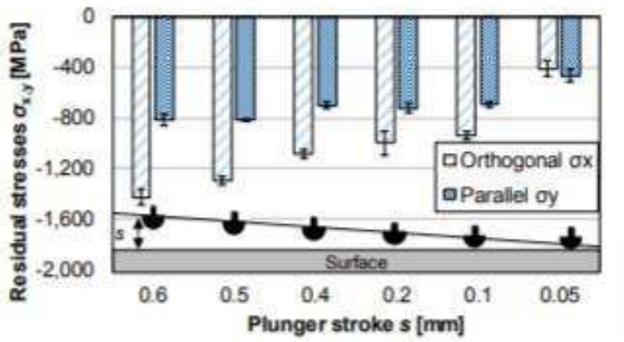

Figure 5 Residual Stresses against Plunger Stroke

The project also involves the comparative study of different materials and the impact of hammering on those materials. Our focus will be on developing an automated hammering machine that can produce the required impact on each and every material. We will design our machine according to the requirements of the material.

For the next chosen project, it has been accomplished by Jan Roman Honninge. In this project, an inter-pass rolling machine is developed that is capable of rolling materials under cold temperature. It is a completely different machine but this machine and our machine can be categorized into the same type. Both of the machines are providing ease to the workers in the industries. Moreover, they have used the same software 'Solidworks' for designing the machine and the same is the case with us. However, our project has differences from their project. Their project is not capable of working under different situations while our project can work under all the given temperatures. Their project is only made for operations under cold temperature while our machine can perform hammering on hot temperature metals as well as cold temperature metals. All we need is to change the plunger according to the given requirements of the material and the object. The comparison of different materials in their machine are shown in figure 6.

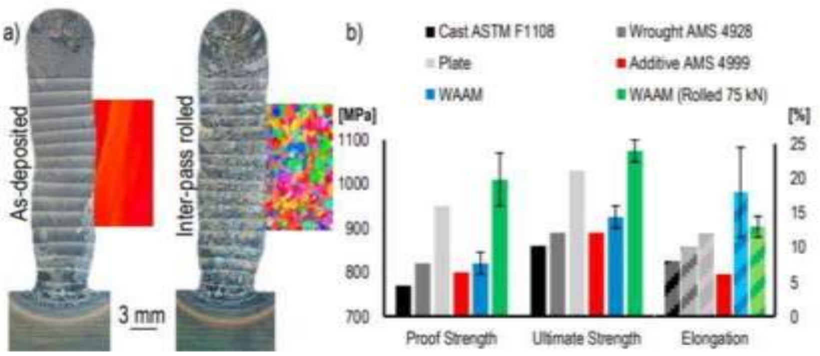

Figure 6 Comparison of Materials for the Machine

The third project that we are comparing with our project is the analysis of the surface defects on different industrial hammering tools. This project is an extended branch of our project. In this project, the authors have performed an analysis of the surface of the materials that are being stroked by the hammers. This project will help us in understanding the force of stroke and the length of the plunger for the given material. However, this project does not involve any design and fabrication of the hammer and it has performed analysis on the manual hammering operations. The calculations of the stress for sample material and the microscopic view of the defects are shown in figure 7.

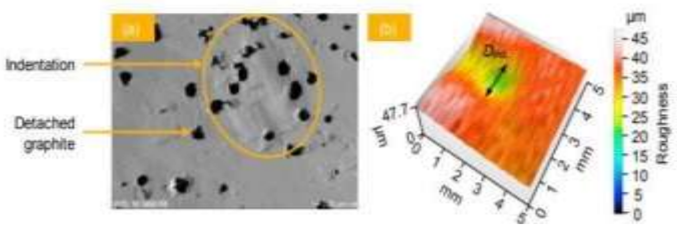

Figure 7 Microscopic Image of the Defects and Stress Analysis

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

Here is the architecture diagram of the Portable Automated Hammering Machine.

Figure 8 Architectural Design

Selection of Operation system:

The first step was the choice of the right system for the automated Hammering machine. At this stage, I have two options

1) Automatic Pneumatic Hammering Machine
2) Automatic Electric Hammering Machine

Automatic Pneumatic Hammering Machine:

Pneumatic Hammering Machine uses a compressor which is connected to that of the hammer which is input for the whole system. It consists of a pneumatic cylinder, a metal strips that are attached on the rare side of the hammer. Hammer will be mounted on that of the frame with the assistance of a bolt such that the pneumatic cylinder will actuate the hammer will swing and finally hammering will start.

Automatic Electric Hammering Machine:

The electrical hammering machine uses electric input power from the battery, which then powers the Dc motor. Dc motor then drives a gear train, which then drives the hammer automatically.

I make the choice of Automatic Electric System for the project.

Design Constraints:

Sustainability Constraints:

Sustainable design demands the reduction of negative impacts of design on environment, health ,and on the comfort of the building occupants, and improving the performance of the building.

Principles of Sustainable design:

1) Optimize the site potential.
2) To minimize the energy consumption of non-renewables.
3) To use the product which is friendly to the environment.
4) Not water waste.
5) To increase maintenance and operational practices.

- Design of the Automated Hammering Machine considered almost all the sustainability constraints as
- We made it from scrap material, which uses the waste material
- Shifting from manual to automatic always increase the efficiency and it helps human for doing his job easily.

But on the other hand, it had some drawbacks

- Like it uses the energy which is non-renewable
- It makes much noise which causes human discomfort,

Geometric Constraints:

Geometric constraints help in controlling the relationships of objects with respect to each other. We use dimensional constraints for the control distance, radius, angle, and length values of objects. With constraints you can: include formulas and equations within dimensional constraints.

- We follow the geometric constraints while modeling on the cad Here are the geometries of the model along with dimensions.

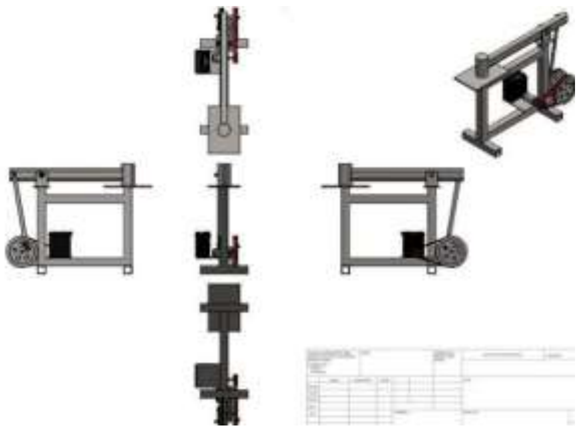

Figure 9 Automatic Hammering Machine

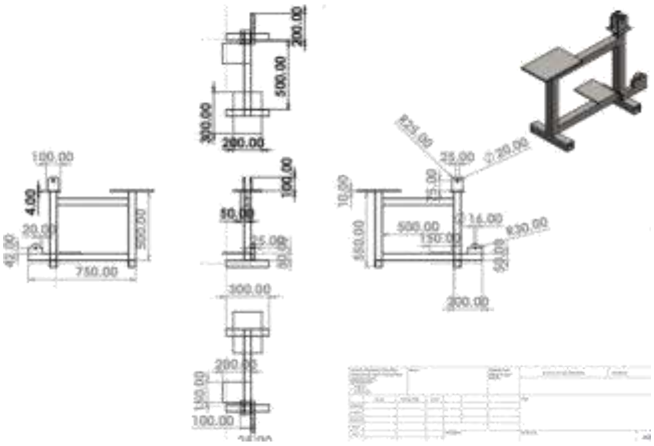

Figure 10 Frame

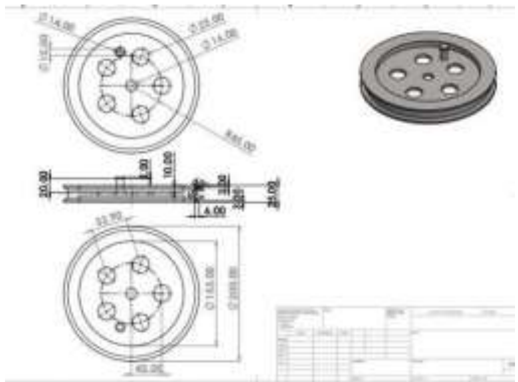

Figure 11 1st Pulley

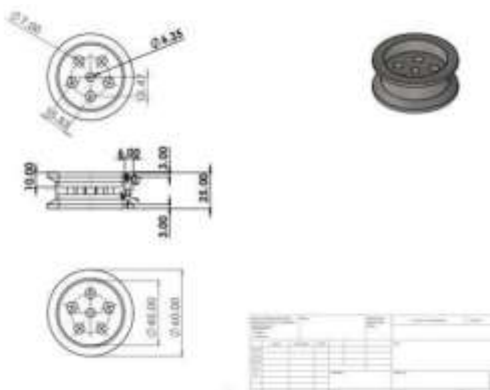

Figure 12 2nd Pulley

Figure 13 Shaft

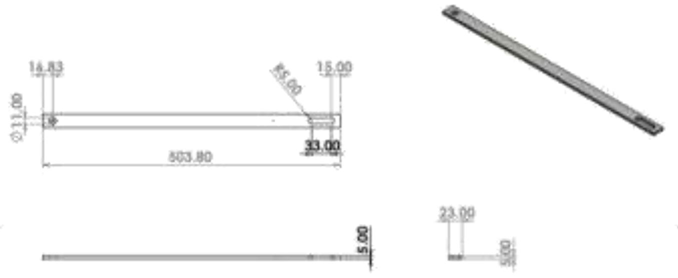

Figure 14 Arm

Economic Constraints:

Primary considerations for the economic constraints are the cost of the making product, what will be its price the pricing of a product.

- The product is design according to the Economic Constrain because it uses scrap (waste material), which decreases the manufacturing cost of this project.

Environmental Constraints:

- This project has plus and negative points for environmental constraints. Having no Air pollution is the plus point for the project but noise pollution is a negative point for this because it causes no pollution and hence causes humans.

Health and Safety Constraints:

The purpose of this constrain is that product should be for the betterment of the human being. It should be designed such that its daily use doesn't cause any health issues for humans. And it should be safe for use.

- As far as our product is a concern, it has some negative impacts too. Like it causes noise pollution and daily use of this can affect the hearing power of humans. First, engineering is about the application of knowledge for the betterment of humanity

Manufacturability Constraints:

It is concerned with the designing of a product so that it can be manufactured.
It includes that parts can be made easily assembly of the parts should be easy and finally, it should ha an acceptable cost.

- Using the scrap part make our project cost effective. Its pars are easy to fabricate and assembly was simple, so we consider the Manufacturability constrains.

Social Constraints:

It concerned with the product design such that it should meet the human needs and address social issues

- Our product is designed to meet human needs, it provides an ease to humans.

Ethical Constraints:

It is basic concerned it to insured the design of the product so that it doesn't heart the feeling of others, you should be aware of code and conducts which provide us the standards of the proper behavior while interactions with others. This should not be muddled with what we feel is correct, our religious beliefs are perfect, what the law states, or what are the socially accepted norms of behavior.

- Our product doesn't have any ethical conflict.

Primary is the comparison between different hammer designs
The secondary is a comparison between Hammers in general and other sources of illumination'
Yes mean the product is up to the mark
No means there is some conflict with these constraints

	Primary	Secondary
Economic	Yes	No
Environmental	Yes	No
Health and Safety	No	yes
Manufacturability	Yes	Yes
Sustainability	Yes	No
Social	Yes	No
Ethical	Yes	yes

Table 2 Constraints Table

3.2 Engineering Standards and Codes

Standards and Codes

Standards, codes, and specifications are extremely important and are often essential - technical documents in engineering and that of the related technical fields.

STANDARDS:

A standard is basically an established norm. It is basically a formal document which creates uniform engineering and technical criteria, process, methods, and practices. These formal documents are prepared by the professional group which are believed to be good and have proper engineering practices and which contain mandatory requirements.

CODES:

A code is the set of specifications and Rules for design, installation, inspection, and fabrication methods prepared so that it can be adopted by legal jurisdiction. Codes can be approved by local, state, or federal governments and can carry the force of law. The purpose of the codes is public protection by setting up a minimum acceptable level of safety for buildings, processes, and Products.

Standards:

1) This International Standard defines the quality features of hand hammers which are judged to be satisfactory as far as the hammer head and the assembly are concerned.
2) It defines the characteristics and verification methods for hammer heads and for their assembly.
3) It applies to hammers used under normal working conditions, i.e. only used to strike items having a maximum hardness of 46 HRC.
4) NOTE Striking items of a greater hardness are liable to cause chipping, this necessitates choosing with properties different from those defined in this International Standard.
5) This International Standard does not apply to steel hammer heads with a head mass of less than 100 g.

- Identify design constraints from best practices established by experts in the industry
- Comply with laws that specify design and testing criteria
- Reduce your product liability risk by not complying with best practices and/or laws

3.3 Theory and Theoretical Calculations

Theory

Hammer:

A **hammer** is basically a tool which is consisting of the weighted "head" which is fixed on a long handle that is swung to give the impact to a small area of the object.

It can be used to put the nail into the wood piece. It is also used to crush the rock as well as to sharp the metal.

Hammers have a wide range of driving and breaking applications.

In a modern hammer, their head is made of steel that has been treated by the heat for the purpose of a harness. The handles of the hammers are mostly made of wood and plastic.

Figure 15 Hammer

Automated Hammering Machine:

An automated hammering machine is a device, which works automatically with the help of an automated system, which drives by the motor, output rotary motion, which them transfer to the pulley, and then finally, automated the motion of the hammer. Input to the motor may be a battery source.

Figure 16 Assembly

Mechanism: The slider-crank mechanism is used in this project as a design Mechanism for this project.

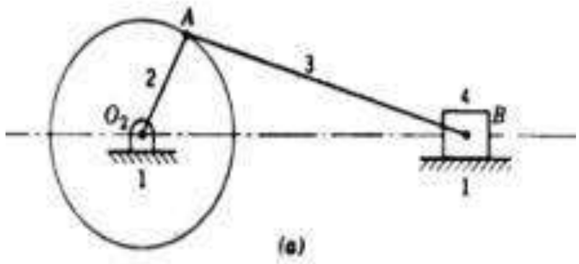

Figure 17 Slider Crank Mechanism

Slider-crank mechanism:

A slider-crank mechanism is used to convert the **rotary motion** into **linear motion**. For we need to connect a slider and crank with that of the rod.

Here we have the output of the DC motor in the form of rotary motion, and we use a connecting rod with a slider crank, which then convert the rotary motion of the motor from the gear train from the motion of the hammer.

Calculations

Calculations for the Automated Hammering Machine are the following:

- Weight Total =24 kg
- Weight of hammer = 5 kg
- Length of hammer =790 mm
- Hammer stroke height = 350 mm.

Classification of The Motor:

motor rating,

Data:

N = 0-450 RPM

I=1.5A

V=16V

Motor power transmission:

$P=V\times I=16\times 1.5$

$P=24W$

Torque by the motor:

Max. Torque (Nm) = 57

The torque by 30 rpm:

$$P = \frac{2\pi NT}{60}$$

$$24 = \frac{2\pi x 30 x T}{60}$$

T = 7.6 N.m

Hammer’s Calculations:

Force:

F= m.a m= 5 kg

= 5x9.81 a= 9.81 m/s^2

=49 N

Torque:

T =F.d d = 0.8 m

= 49x0.8 F= 49 N

T = 40N.m

Velocity:

V = h.T T= 2 sec

= 0.23x2 h= 0.23

V = 0.5m/s

The moment:

M= F.d F= 49 N

= 49x 0.5 d= 0.5 m

= 24.5 N.m

Potential Energy:

PE= mgh m= 5 Kg

= 5x9.81x0.23 g= 9.81 m/s^2

= 11.28 J = 0.23 m

Kinetic Energy:

$KE = (½)m.v^2$ m =5 Kg

$= (½)(5)(0.5)^2$ v= 0.5 m/s

$= 0.625$ J

Impact Force:

$W = KE = Fd = (½)mv^2$ m= 5 kg

$\Rightarrow F = [(½)mv^2]/d$ d= 0.23 m

$= [(½)5x0.5^2]/0.23m$ v= 0.5 m/s

=2.7N

3.4 Product Subsystems and selection of Components

Selection of Components:

Components of the system are the following:

Supporting Frame:

Here is the basic structure of the supporting frame for the Installation of the Motor, Pully, Shaf, and Arm of the hammer. The material used for the manufacturing of the frame is I section Cast Iron Rod because it is strong, cheap easily cut, readily available, and easy to form.

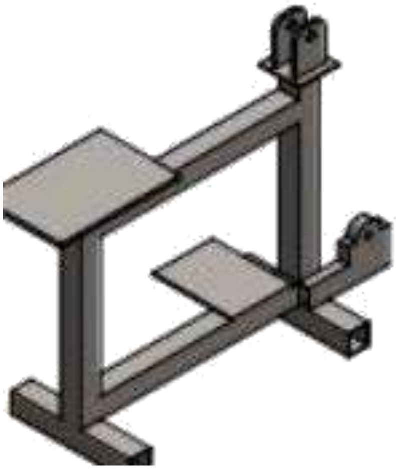

Figure 18 Supporting Frame

.**Pulley one:**

Pulley is used to transfer energy and motion, the pulley used in the project was selected according to the size ratio of the motor. Its function is to transfer motion and energy to the 2^{nd} pulley from the Dc motor. Material is Cast iron.

Figure 19 Pulley One

Shaft:

The shaft is used to connect the 1st pulley with 2nd pulley. Its material is Mild Steel.

Figure 20 Shaft

2nd Pulley:

Here we have the 2nd pulley which takes input from the 1st pullet with the help of the shaft and is attached with the slider crank. It is mounted on the lower rare side of the main structure and is parallel to the main structure on its left side. Material is Cast Iron

Figure 21 2nd Pulley

Arm:

Here we have the arm of the system, its orientation is perpendicular to the axis of rotation of the shaft. Its material is mild steel.

Figure 22 Arm

Dc Motor:

16v DC motor is being used in this project which is input power for the pulley.

Figure 23 DC Motor

16 v Battery:

For input power, to the Motor, we use the 16 v Battery.

Figure 24 16 Volt Battery

Other components include

- Bearings
- Joints & Screws
- Couplings
- Sprockets
- Toggle Switch

3.5 Manufacturing and assembly (Implementation)

1) The first step was the Cad Model
2) Make a structural analysis of the Design
3) After analysis, go to the workshop and start working on the fabrication of the Model.
4) Mount the Motor 1^{st} and 2^{nd} PULLEY on the frame of the Hammering Machine
5) Make them connected, i.e make a connection between 1^{st} pulley and Dc Motor with the help of a belt.
6) Now connect the 1^{st} pulley with 2^{nd} pulley with the help of the Shaft 7) Now attach the Slider Crank Mechanism

8) Connect the arm with the handle of the hammer.

9) Now attach the input battery power to the motor

10) The motor will get the input (electric) and then convert it to the rotary motion, then the energy in the form of rotary motion will transfer to the slider motion. finally, the automated to and from motion of the hammer.

Thus, we have an Electrical Automated Hammering Machine.

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

After making a practical model, experimental testing for the purpose of analysis and its performance is also very important. So, we make an experimental setup for the automatic hammering machine. Which is describes below;

We make use of the manual and automatic impact hammering and compare them in sense of repeatability, adjustment of force, efforts and time required, etc. here is the experimental setup shown in the figure below for automatic hammering.

Figure 25 Automatic Hammering Machine

We perform an experiment related to the impact force and gathered the results.

Figure 26 Experimental Setup

4.2 Results, Analysis and Discussion

It is observed that when the distance between the target and hammer head is large enough we obtain a single hit for every trial.

The figure below is obtained from the measurement and describes the phenomenon of a single hit.

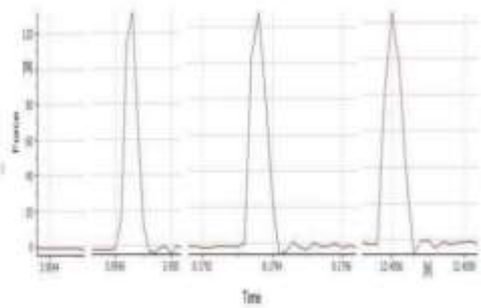

Figure 27 Single hits obtained from the experiment (Time Vs Force)

It was noticed that the automatic hammering machine was showing the repeatable process. It is due to the strong structure of t automated hammering machine and the predefined motion of the hammer head. It can be also seen that the point of excitation is also the same for every measurement. From the figure, it can be seen that we got consistent force magnitude from the different measurements. There is some variability in the applied force which is due to the phenomenon of friction in the system. (1)

A comparison between manual and automatic hammering also showed that impact force from the automatic hammering is more repeatable than manual hammering. Due to the high repeatability which is obtained from automated hammering machine cost, time and manual effort will be decreased. It can be seen from the figure below:

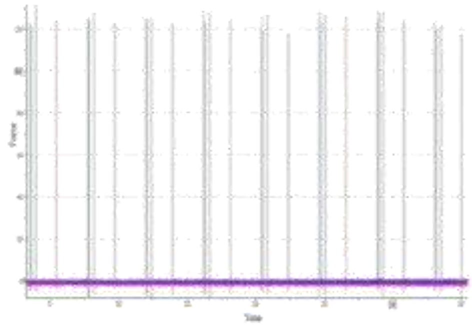

Figure 28 Repeatability of the force

An important aspect of the automatic hammering machine is that the force can be adjusted by changing the dimensions of the cam follower, the angle between the joints in the driver cam group, and the distance between the target and that of the hammer head. The force adjustment aspect of the automatic hammering machine maintains repeatability. Force adjustment and repeatability of the adjusted force obtained from the different measurements can be seen in Figure below:

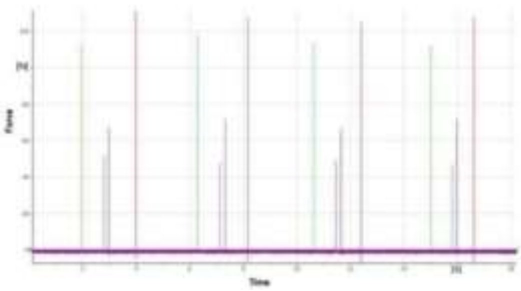

Figure 29 Force adjustment and repeatability of the adjusted force

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From the experimental results, it can be concluded that:

- The automatic hammering process increases the repeatability of the process, reduce manual effort and time.
- Automatic hammering ensures a single hit in every trial.
- It also got the aspect of adjustable force
- Automatic hammering is an operator-independent process.

These are some reasons why the simulation of the automatic hammering is more reliable than that of the data which is obtained from the manual impact testing.

Then, we observe the quality of the automatic hammering as compare to the manual hammering process. For this, ten hits were made on the same structure with both automatic and manual hammers.

First of all, input and output signals were used to obtain the FFTs. Then, the FFTs of the data were averaged and then averaged data was used to compute the required frequency response functions.

The figure shows the FRF from the manual measurements:

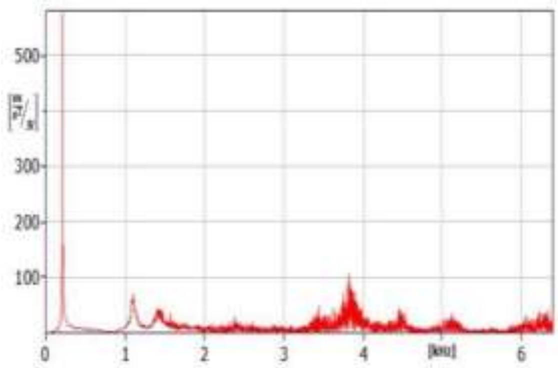


Figure 30 FRF obtained from the manual hammering

The figure below shows FRF obtained from automatic hammering:

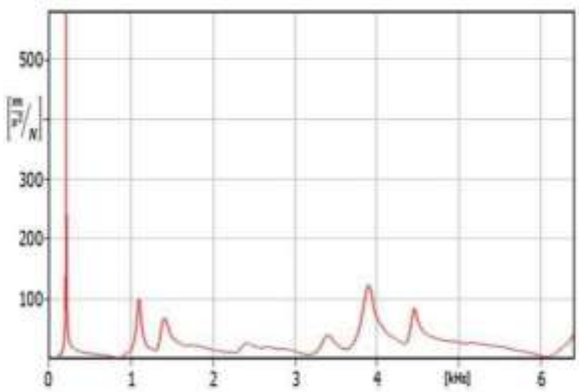


Figure 31 FRF obtained from the automatic hammering

All the aspects were not excited by using manual hammering measurements. As a result, the frequency response function deteriorates between the 1k Hz – 7k Hz frequency range. For getting a smoother frequency response function, we can use a filter. The frequency response from the automatic hammering gave a fairly good and relatively smooth. In conclusion, automatic hammering measurements are more reliable.

Summary and Conclusion:

Experimental results showed that an automatic hammering machine can replace manual hammering due to the following reasons:

- It has excellent repeatability of force
- Its ability to reduce the time and manual efforts required for the process.
- Using automatic hammering eliminates double hits and a single hit was obtained from every measurement.
- The operator-independent process can be achieved using automatic hammering.
- No highly skilled operator is required for operating an automatic hammering machine; hence reduce the cost of the process.
- This device was designed for a low impact and therefore is suitable for only small structures.
- The maximum force which can be obtained using an automatic hammering machine is limited.

Chapter 5: Project Management

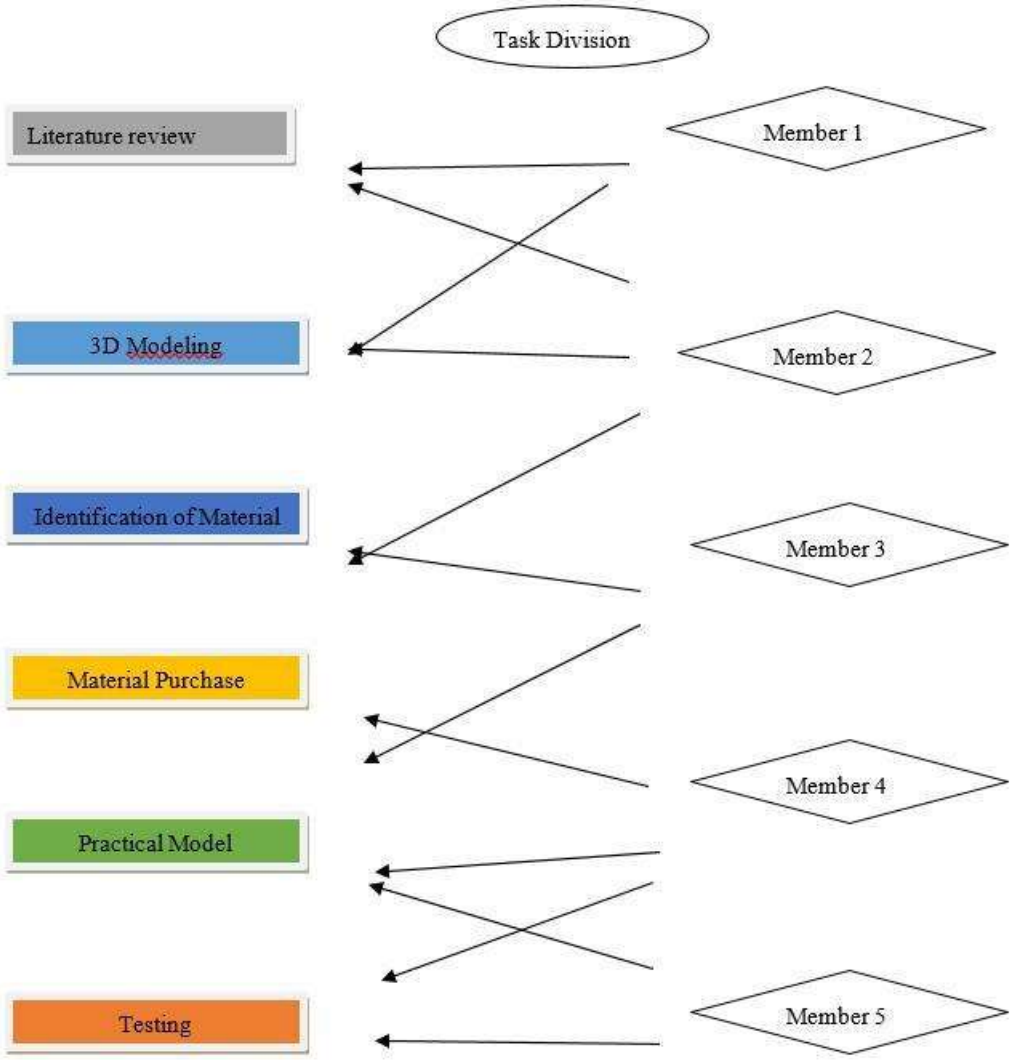
5.1 Project Plan

Break Down of Tasks:

We have divided the task into 8 tasks

- Literature review
- 3D Modeling
- Identification of the material
- Material purchase
- Making a practical model
- Performing test
- Concluding the project
- Report writing

Map tasks to team members.



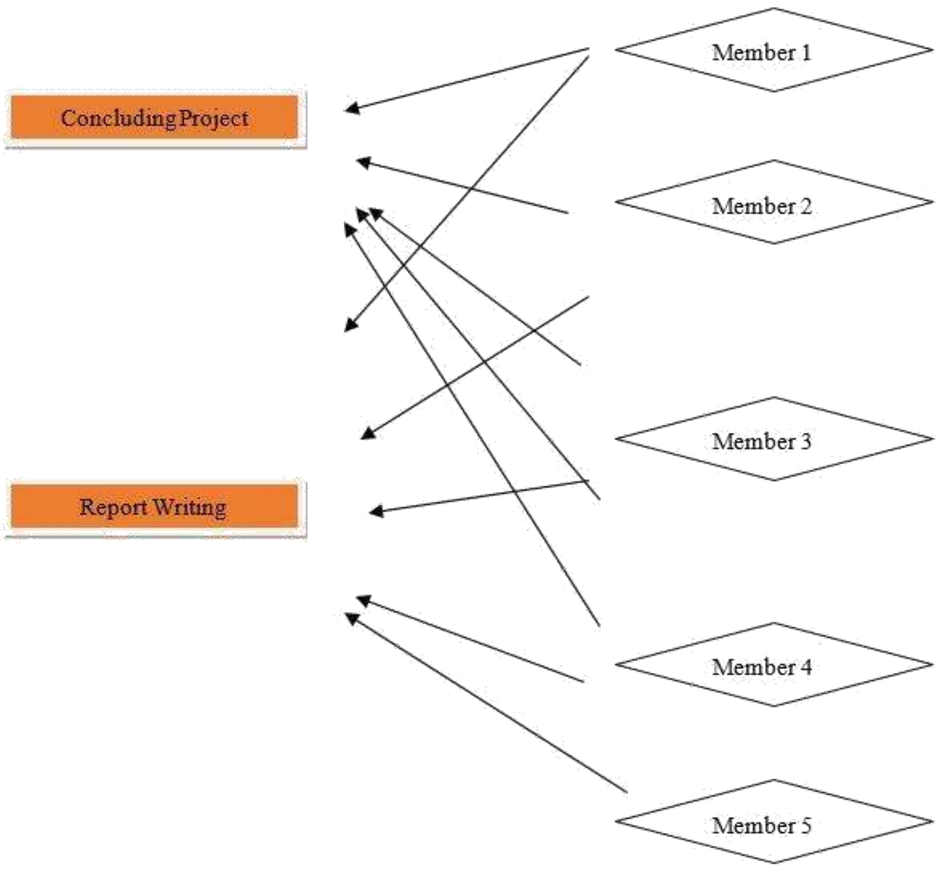


Figure 32 Task Division Chart

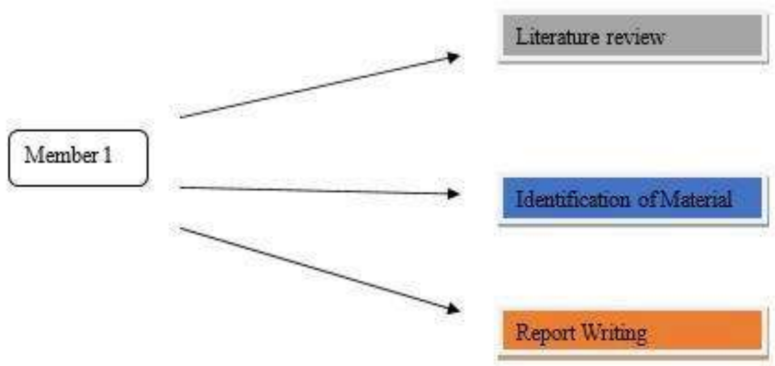
Time duration table of each task:

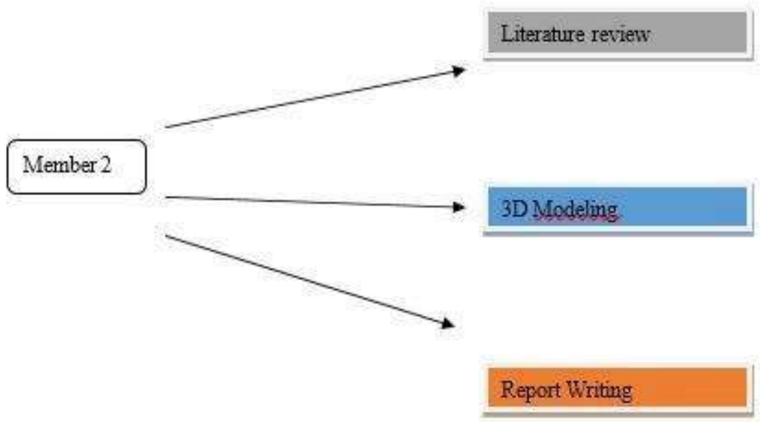
Task	August	September	October	November	December
Task 1	Literature review				
Task 2		Modeling			
Task 3		Material Identification			
Task 4			Material Purchase		
Task 5				Practical Model	
Task 6					Testing
Task 7	Report Writi ng				

Table 3 Time Duration Table

5.2 Contribution of Team Members

The following describes the contribution of members towards this project:





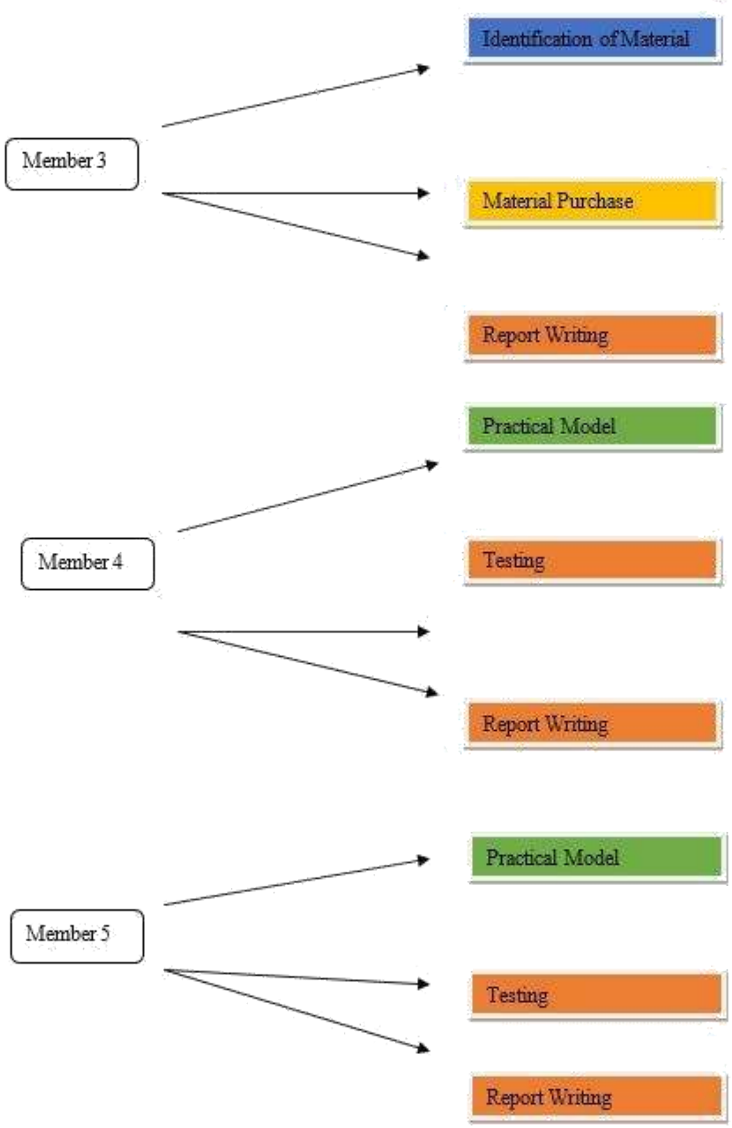


Figure 33 Members Contribution Chart

5.3 Project Execution Monitoring

Project Execution performs the following activities:

- First of all team members had a meeting and we select the course project.
- We had the Literature review
- Then, we make a meeting with the advisor for the project approval.
- After the project is approved by the advisor, we search for the right methodology for the completion of the project.
- Literature review for selection of appropriate methodology
- We went for three methodologies (Analytical Calculations, 3D modeling, and Practical Model)
- Then, we divide the project into the sub-tasks
- Each task was assigned to each group member
- Search for Suitable Methodology for making practical model
- Meeting with the advisor and get an approval of the methodology
- We search for the right material regarding availability in the market and the cost of the components.
- Purchase of the selected material
- Working on practical model according to the 3D CAD model
- Meeting with the advisor and define the testing criteria
- Analysis and testing of the portable automatic hammering machine
- Report writing of the whole project.

Finally, we conclude the project.

5.4 Challenges and Decision Making

Challenges Faced:

- **COVID-19**

Covid-19 was the major hurdle in our project. Due to lockdown and unavailability of the components, it was the biggest challenge to gather all the equipment required for the project. Moreover, the imposed lockdown restricted us from meeting our supervisors that made it more difficult for us to perform all the design and manufacturing in his absence.

- **Problems with team members not cooperating/meeting.**

Overall the project was best in terms of learning as well as in terms of teamwork. Every member of the group gave his 100% towards the completion of the project. Everybody cooperates and helps each other starting from the cad model to concluding the project. Tasks were divided and each group member performs them quite well.

- **Problems or delays in procuring required parts/components/tools.**

Overall the project followed its timeline very well but the delay in the project was due to the tooling issues. Tools required for the project were quite expensive, so we decide to do these tooling in some workshop which has the required toll-like shaft or handle of the hammer used the lathing machine and so. Delay in the project was also due to the late delivery of some components like motors and so.

- **Problems with equipment or components not working or malfunctioning.**

The problem in the project was due to the delay of the tooling of the gear arm and shaft for the portable hammering machine. We take help from the internet and came to know the right machine for their tooling. And then we went to the workshop for machining of the described components. Designing of the whole machine was also the problem which we solve by getting help from journal articles

Decision Making:

Every engineering project makes us learn about decision making regarding the selection of the material, methodology, and design constraints. These are critical and need strong decision making using your engineering knowledge. The overall project gives opportunities for making appropriate decisions. Some of them are the following:

- Choice of the project for this course
- Choice of the team members for the project
- Choice of the appropriate methodology
- Choice of the appropriate parts for each member in the project taking in mind their expertise.
- Best suitable material section

All team members gave take part in deciding all these factors and making a decision regarding the completion of the project. Where all of us didn't have any idea, we took help from books, journals articles and so.

5.5 Project Bill of Materials and Budget

The Bill of Materials for this project is the following, which indicates the expected cost of the project.

	Unit	Unit price	Total quantity	Total price	Total cost	Grand total
DC Motor	No.	55$		55$		
16V battery	No.	20$	1	20$		
Square tube 50x50x2 Mild steel	Meter	20$	3	60$		
Toggle switch	No.	5$		5$		
Belt	No.	8$	1	8$		
Pulleys	No.	25$	3	75$		
1"x1" mild steel channel	m^2	21$	1	21$		
Nut bolts	No.	1$	4	4$		
25mm bearing housing	No.	27$	2	54$		
MS sheet	No.	14$	1	14$		
MS rod	No.	7$	1	7$		
Bush (M.S and gunmetal)	No.	2$	1	2$		
Total components cost					**325$**	
Lathe machining cost	Job	30$	1	30$		
Welding	Job	40$	1	40$		
Total Machining cost					**70$**	
						395$ = 1482 SAR

Table 4 Bill of Material of Project

Overall, the budget was estimated to be 300$ but in the end, it cost us 395$. The reason is first of all when making purchasing components were more expensive than we were expecting to be. So we make a purchase of 325$ for the first time. then we have to pay 70$ for machining, which makes the total to 395$.

Chapter 6: Project Analysis

6.1 Life-long Learning

Life-long learning from the project:

- It makes us aware of the tools like lath machine usage, paper cutting machine and so. We make use of these machines and get great information regarding manufacturing engineering processes.
- Understanding of the 3D modeling software like CAD, Solids works, etc.
- We learn the steps to create a practical prototype from the 3d model.
- We learn about different tooling techniques
- We use engineering knowledge in the practical application
- It makes us learn the material selection criteria
- We lean time management from this project, it was a key to handle upcoming projects timely and accurately
- It makes me learn how to manage a team in teamwork to get a productive output
- It makes us learn to convert a manual system into an automatic machine, so we also get an idea of the automatic machines.

For productive, useful information, and completion of the project, we got help from the internet (scientific topics, journal papers research topics). We also get help from the books related to this topic. Also, some seniors and electronics department fellows help us in learning all the above

6.2 Impact of Engineering Solutions

Automatic machine has many engineering impacts, the impacts of the automatic hammering machine are described below:

- Automatic hammering is an instant process, we can make use of it for instant use
- Efficiency is increased using an automatic hammering machine
- Automatic hammering is a fast process
- Multi Operations can be done by using an automatic hammering machine • Automatic hammering machine makes use of accurate repetition and impact.
- Automatic hammering is a time-saving process.
- The automatic hammering had a low tooling cost
- Maintenance of the automatic hammering machine is easy.
- It is easy for us (Myaszk n.d.)

6.3 Contemporary Issues Addressed

Automatic portable hammering machine has addressed the following issues:

- It has addressed the issue of manpower. Being an automatic machine I will not make use of the manpower.
- It has solved the safety issues for labor. Using manual hammering has safety concerns.
- It makes use of modern technology for the conversion of the 3D CAD Model to the practical model.
- Automatic hammering has addressed the issue of manual hammering.
- Being an automatic machine, a portable automatic hammering machine can be placed anywhere for usage.
- A portable hammering machine has a low initial cost.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

- In this project, an automatic hammering machine is designed and manufactured.
- All the components of the machine were designed on SolidWorks and a prototype was manufactured.
- The materials were selected for each component on the basis of the engineering standards.
- This machine is a unique machine and no other automatic hammering machine of this design exists.
- This machine can be controlled and operated for the required number of strokes per minute.
- Previously designed automatic hammering machines did not involve variable strokes.
- The project was full of challenges because of COVID-19 and the unavailability of the important components.
- The experience of designing an automatic hammering machine and then fabricating it was fascinating.
- From this project, we have learned the selection of materials for different components and we learned about different machining processes that can be used for manufacturing a specific component.
- The project taught us regarding economic constraints that how can we manage a project under a given budget.
- Moreover, if this product is manufactured on a commercial basis, it can be proved as a useful product for the industry.

7.2 Future Recommendations

- The automatic hammering machine designed in this project can be improved from many perspectives.
- The first perspective is the design of the stroke of the hammer. It can be further improved and made lightweight.
- The strength of the hammer should be improved so that it can be used for proper hammering operations in the industry.
- Moreover, the time lag between two strokes of the hammer can be reduced so that time can be saved during hammering operations.
- Adding more to it, the aesthetics of the machine can be enhanced.

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[4] J. R. Honninge, "Improvement of Microstructure and Mechanical Properties in Wire + Arc Additively Manufactured Ti-6Al-4V with Machine Hammer Peening," 2017.

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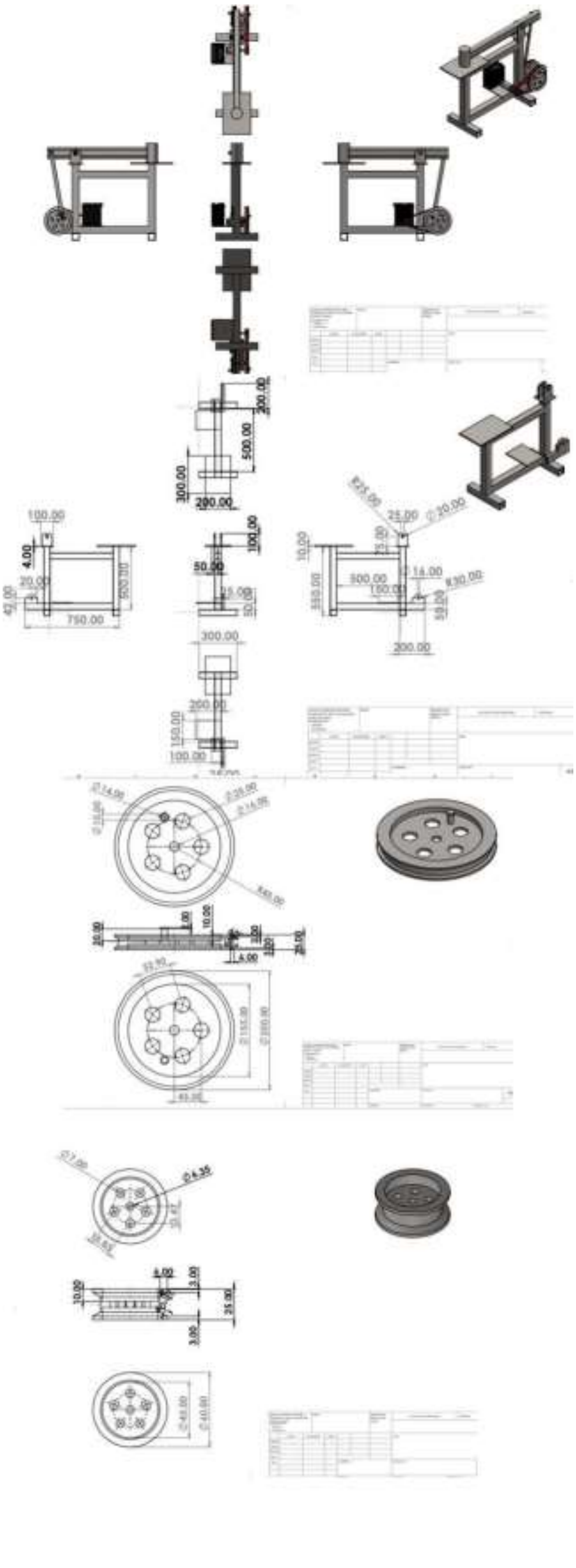
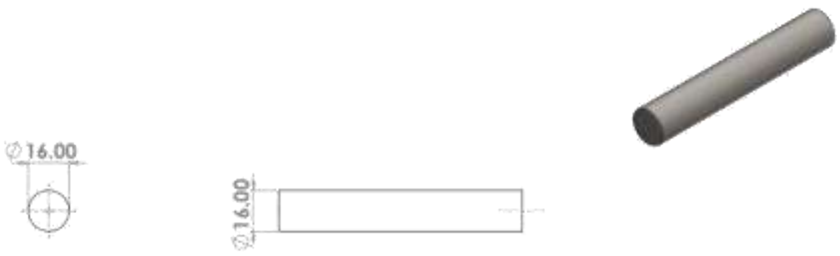
Appendix A: CAD drawings and Bill of Materials





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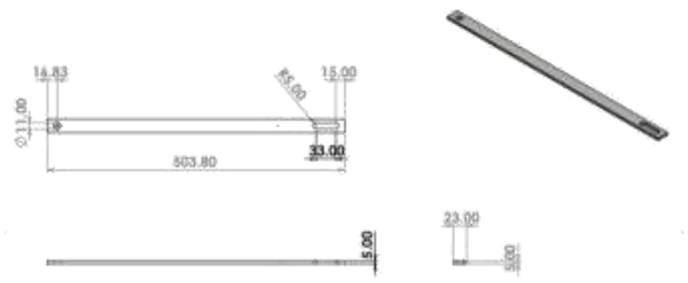

Appendix B: Engineering standards (Local and International)

ASTM A36 Welding Standards:

- If the metal is thicker than 1/4 - 6 mm, preheat to 150F
- E7018 stick electrode, an 0.035 or 0.045 E70S-3-6 MIG wire, or for all position welds an E71T-1 electrode wire
- Ensure mill scale in weld area is removed and the plate is always at a temperature >60F
- keep single pass fillet welds < 1/4 - < 6mm
- For multi-pass welds, use inter-pass temp control
- hardness and grain size checked

Design Constraints Engineering Standards:

- quality features of hand hammers
- characteristics and verification
- Applies to hammers used under normal working
- Best practices established by experts in the industry
- Comply with laws that specify design and testing criteria
- Reduce product liability risk
- Budget for certification testing