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Designing an Efficient and Energy-Saving Automated Hammering Machine for Various Applications

[1]Prof Dinesh H.A., [2]Prof Ramachandra Kulkarni, [3]Dr. Salim Sharieff, [4]Dr. Nadeem Pasha K.

[1]Assistant Professor, [2] Assistant Professor, [3]Professor, [4]Professor
[1] Department of Mechanical Engineering,
[1]HKBKCE, Bangalore, India

Abstract: The Design of Automated Hammering Machine is an innovative approach towards the development of a machine that can automate the process of hammering. The main objective of this project is to design and develop an automated hammering machine that can be used for various industrial applications such as forging, metalworking, and construction. The proposed machine is designed to be simple, efficient, and cost-effective. It is designed to be operated with minimal human intervention, thereby reducing the need for manual labour and increasing productivity.

The automated hammering machine is designed using a combination of mechanical and electrical components. The mechanical system consists of a hammering mechanism that is powered by an electric motor. The hammering mechanism is designed to be adjustable, allowing it to be used for various types of applications. The electrical system consists of a control unit that is responsible for controlling the operation of the machine.

The machine is designed to be portable and easy to use. It can be easily transported to different locations and can be operated by anyone with basic training. The machine is designed to be energy-efficient, consuming minimal power during operation. This makes it a cost-effective solution for various industrial applications.

In conclusion, the Design of Automated Hammering Machine is an innovative approach towards automating the process of hammering. The proposed machine is designed to be simple, efficient, and cost-effective, making it a viable solution for various industrial applications.

IndexTerms **– Automated Hammering Machine, Pully, Shaft, Frame, Arm, DC Motor, Battery**

I. INTRODUCTION

Hammering is an essential process in various industrial applications, including metalworking, construction, and manufacturing. However, traditional hammering methods require significant manual labour and can be time-consuming, expensive, and dangerous for workers. To address these challenges, the Design of an Efficient and Energy-Saving Automated Hammering Machine project aims to develop a machine that can automate the process of hammering.

The proposed automated hammering machine is designed to be efficient, energy-saving, and adjustable for various applications. It is equipped with a combination of mechanical and electrical components, including a hammering mechanism powered by an electric motor and controlled by a control unit. The machine is designed to be portable and easy to use, enabling it to be transported to different locations and utilized in various industrial settings.

This paper presents a detailed overview of the design and development of the automated hammering machine. It includes a discussion of the key mechanical and electrical components of the machine, the control unit responsible for its operation, and the testing and evaluation process used to ensure that the machine meets all performance requirements and safety standards.

The goal of this paper is to provide a comprehensive guide to the Design of an Efficient and Energy-Saving Automated Hammering Machine, which can serve as a reference for future research and development in the field of automated machinery.

II. PROBLEM STATEMENT

Traditional hammering methods require significant manual labour, which can be time-consuming, expensive, and dangerous for workers. This limits the productivity and efficiency of industrial applications such as metalworking, construction, and manufacturing. In addition, the energy consumption of traditional hammering methods is high, which can result in increased costs and environmental impacts.

To address these challenges, the Design of an Efficient and Energy-Saving Automated Hammering Machine project aims to develop a machine that can automate the process of hammering. The machine is designed to be efficient, energy-saving, and adjustable for various applications. It is equipped with a combination of mechanical and electrical components, including a

hammering mechanism powered by an electric motor and controlled by a control unit. The machine is designed to reduce the need for manual labour, increase productivity, and reduce energy consumption.
The problem that the Design of an Efficient and Energy-Saving Automated Hammering Machine project seeks to solve is the inefficiency and high cost of traditional hammering methods. By designing and developing an automated hammering machine that is efficient, energy-saving, and adjustable for various applications, this project aims to improve the productivity and efficiency of industrial applications while reducing costs and environmental impacts.

III. WORKING PRINCIPLE

The automated hammering machine is designed to perform the hammering operation automatically without any human intervention. The machine's working principle involves the use of a hammering mechanism powered by an electric motor and controlled by a control unit.
When the machine is turned on, the electric motor drives the hammering mechanism, which strikes the workpiece repeatedly with a hammer. The control unit is responsible for controlling the operation of the hammering mechanism, which includes the speed and force of the hammer strikes.
The machine's design includes an adjustable mechanism that enables it to be used for various applications. The operator can adjust the speed and force of the hammering mechanism to suit the specific requirements of the workpiece.
The automated hammering machine is designed to be portable, energy-efficient, and safe to operate. It is equipped with safety features such as sensors and emergency stop buttons that ensure the safety of the operator and prevent any accidents.
In summary, the working principle of an automated hammering machine involves the use of a hammering mechanism powered by an electric motor and controlled by a control unit. The machine is designed to be adjustable, portable, energy-efficient, and safe to operate, making it an excellent solution for various industrial applications.

Objectives of project:

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.

Design Specifications:

Total weight	24 Kg
Hammer weight	5 Kg
Hammer length	790 mm
Hammer stroke heigh	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

IV. METHODOLOGY

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

Figure: Architectural Design

Selection of Operation System: The first step was choosing the right system for the automated hammering machine.
At this stage two options.
1) Automatic Pneumatic Hammering Machine
2) Automatic Electric Hammering Machine

Automatic Pneumatic Hammering Machine: A pneumatic hammering machine uses a compressor that is connected to that of the hammer, which is the input for the whole system. It consists of a pneumatic cylinder and metal strips that are attached to the rare side of the hammer. The hammer will be mounted on the frame with the assistance of a bolt such that the pneumatic cylinder will actuate the hammer, it 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. A DC motor then drives a gear train, which then drives the hammer automatically. I made the choice of an automatic electric system for the project. Design Constraints: Sustainability Constraints: Sustainable design demands the reduction of negative impacts of design on the environment, health, and comfort of the building occupants, as well as improving the performance of the building. Principles of Sustainable Design:
1) Optimise the site's potential.
2) To minimise the energy consumption of non-renewables.
3) To use a product that is friendly to the environment.
4) Not water waste.
5) To increase maintenance and operational practises.

- The design of the automated hammering machine considered almost all the sustainability constraints.
- We made it from scrap material, which uses waste material.
- Shifting from manual to automatic always increases efficiency, and it helps humans do their jobs easily.

But on the other hand, it had some drawbacks.

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

Geometric Constraints:
Geometric constraints help control the relationships of objects with respect to each other. We use dimensional constraints to control the 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 modelling on the Cad. Here are the geometries of the model along with their dimensions.

Figure: Automatic Hammering Machine

Product Subsystems and selection of Components

The 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 the 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.

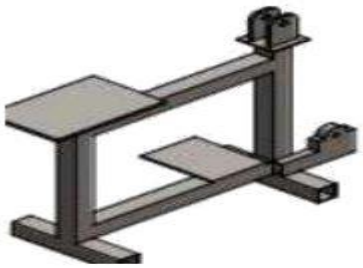

Figure: Supporting Frame

Pully One:
A 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 2nd pulley from the DC motor. The material is cast iron

Figure: Pully One

Shaft:
The shaft is used to connect the first pulley with the second pulley. Its material is mild steel.

Figure: Shaft

2nd Pulley and Arm

Here we have the second pulley made of cast iron, which takes input from the first pulley with the help of the shaft. and is attached to the slider crank. It is mounted on the lower left side of the main structure and is parallel to the main structure on its left side and arm made of mild steel and its orientation is perpendicular to the axis of of rotation of the shaft. Its material is mild steel.

Figure: 2nd Pulley

Figure: Arm

Dc Motor and 16 v Battery:

A 16-volt DC motor is being used in this project, which is the input power for the pulley and For input power to the motor, we use the 16-volt battery.

Figure: DC Motor

Figure: 16 v Battery

V. System Testing and Analysis

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 made an experimental setup for the automatic hammering machine. Which is described below: We make use of manual and automatic impact hammering and compare them in terms of repeatability, adjustment of force, efforts, and time required, etc. Here is the experimental setup shown in the figure below for automatic hammering.

Figure: Experimental Setup of Automatic Hammering Machine

VI. RESULTS

It is observed that when the distance between the target and the hammer head is large enough, obtain a single hit for every trial. The figure below is obtained from the measurement and describes the phenomenon of a single hit.

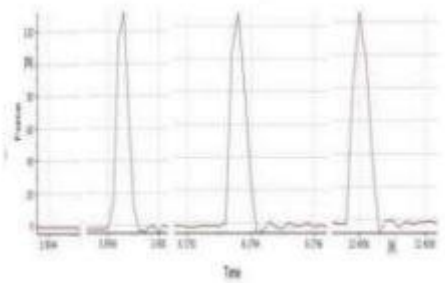

Figure: Single hits (Time Vs Force)

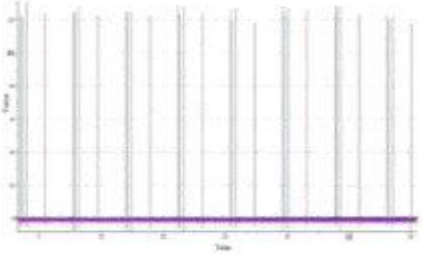

Figure: Repeatability of the force

The automatic hammering machine is capable of displaying a repeated process due to its sturdy construction and the predetermined motion of the hammer head. The point of stimulation is consistent for each observation, resulting in a constant force magnitude across all measurements.

While there may be some variation in the applied force due to the systemic phenomena of friction, the impact power from the automatic hammering machine is still more repeatable than human hammering. This leads to a reduction in manual labour and time, thanks to the machine's excellent repeatability.

Another important feature of the automatic hammering machine is the ability to adjust the force 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 the hammer head. This adjustable force aspect of the machine maintains its repeatability.

The repeatability of the adjusted force can be seen in the figure below. Overall, the automatic hammering machine is a reliable and efficient tool for various applications, offering increased repeatability, reduced manual effort and time, and adjustable force.

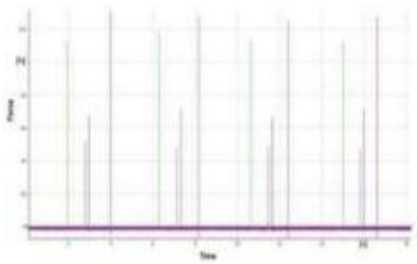

Figure: Force adjustment and repeatability of the adjusted force

Based on the experimental results, it can be concluded that the automated hammering process has several advantages over manual hammering. These include increased repeatability, reduced manual effort and time, operator-independence, and adjustable force.

Additionally, the results of the automatic hammering process are more reliable than those obtained from manual impact testing, making it a more accurate and consistent method for measuring the impact response of a structure.

To compare the quality of the automatic hammering process to the manual hammering process, ten hits were made on the same structure using both methods. The input and output signals were used to obtain the FFTs, which were then averaged to compute the required frequency response functions.

The figure shows the FRF obtained from the manual measurements, which can be compared to the FRF obtained from the automated hammering process. Overall, the results demonstrate that the automated hammering machine is a reliable and efficient method for hammering and measuring the impact response of various structures.

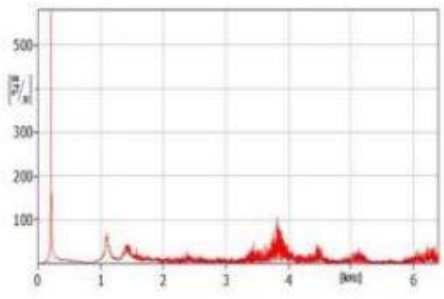

Figure: RF obtained from the manual hammering

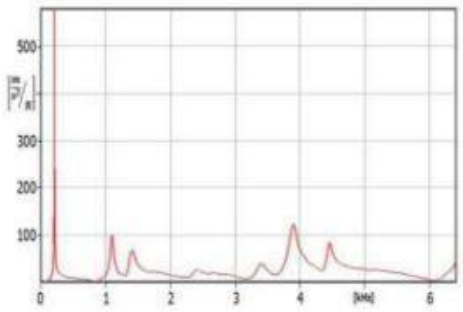

Figure: FRF obtained from the automatic hammering

One limitation of manual hammering measurements is that they do not excite all aspects of the structure. As a result, the frequency response function may deteriorate in the 1k Hz – 7k Hz frequency range. To obtain a smoother frequency response function, a filter can be used.

In contrast, the frequency response function obtained from the automatic hammering machine is relatively smooth and provides more reliable measurements. Overall, the automated hammering machine offers significant advantages over manual hammering measurements, including increased repeatability, adjustable force, and more accurate frequency response measurements.

In summary, the experimental results demonstrate that an automated hammering machine is a viable alternative to manual hammering. The machine offers several advantages, including excellent repeatability of force, reduced time and manual effort, elimination of double hits, operator independence, and reduced labour costs. However, the machine's design limits its application to small structures, and its maximum force is also limited. Overall, the automated hammering machine offers significant benefits and is an effective tool for a variety of applications.

VI Conclusions and Future Recommendations

The project of designing and manufacturing an automatic hammering machine was successfully completed. The machine was designed using SolidWorks and a unique prototype was manufactured by selecting appropriate materials for each component based on engineering standards. This machine is capable of variable strokes per minute and is a unique design as compared to previously designed automatic hammering machines. The project faced challenges due to the COVID-19 situation and unavailability of important components. However, the experience of designing and fabricating the machine was fascinating and the team learned about material selection, machining processes, and project management under a given budget. This automatic hammering machine can be a useful product for the industry if manufactured on a commercial basis. Overall, this project was a success and achieved its objectives of designing and manufacturing an efficient and energy-saving automated hammering machine for various applications.

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