ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 9| Issue: 11| November2023|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2023: 8.224 || ISI Value: 1.188

MODELLING AND FABRICATION OF POWER HAMMER MACHINE

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Article DOI: https://doi.org/10.36713/epra15000
DOI No: 10.36713/epra15000

ABSTRACT

In the industrial and metallurgical sectors, there's a significant amount of activity, with numerous tasks requiring timely completion to optimize company profits. Technological advancements have led to increased market demands for various product components. To address this need, there's been a development of a cost-effective, compact, and user-friendly power hammer machine aimed at easing the forging operations of blacksmiths. This innovative machine targets small-scale industries or workshops seeking more efficient forging solutions that demand less force compared to existing hammer machines. It specifically aids in producing intricate small-scale components. The current project revolves around the modelling, design, and fabrication of this power hammer machine. AutoCAD was utilized for modelling, and design calculations harnessed kinetic principles to determine critical parameters such as motor capacity, hammer impact velocity, torque, kinetic energy, and sudden impact strokes.

KEYWORDS: ***Bearings, Motor, Pullies, Hammer, Anvil, Disc, Spring and Transvers switch.***

1. INTRODUCTION

In today's rapidly advancing world of science and industry, the role of modern machinery has become increasingly vital in our daily lives. Among these advancements, the fabrication power hammer machine, operating in a Drop Shape mode, stands out as a crucial piece of equipment in factories reliant on blacksmithing or casting. These Forging Hammers are pivotal in shaping metals between two Dies, utilizing a Hammer and anvil in the Second Part of the Die. To facilitate this process, a typical Shock-Resistant Lifting Table with adjustable heights precisely positions the product in the lower die, aligning it at the optimal distance to the Hammer Ram before being hammered by the higher die (Pandey et al., 2020). Traditionally, forging was a manual process where metals were heated and hammered by skilled blacksmiths. However, in the current scenario, this process has shifted towards mechanization, employing hammer machine tools. This transition marks a significant shift from manual to automated forging processes, which naturally require a reliable power supply to operate seamlessly. The power hammer, a pivotal machine tool in forging operations, relies on a power source to facilitate its up-and-down motion for shaping various parts or components. Since the 1880s, it has gradually replaced trip hammers and typically consists of several key components: the Ram, Frame, Anvil, Hammer head, Dies, Connecting Rod, and an electric motor serving as its power source. Effectively, the power hammer operates as a machine tool utilizing electric power to drive a motor, thereby enabling the reciprocating motion of the ram (hammer) through a spring-connected mechanism to the connecting rod, utilizing the motor's rotational energy. This work primarily involves the design, modeling and fabrication of tailor made machine for use in University of Technology and Applied Sciences – Salalah campus for the demonstration purpose in the Foundry and Forging Lab. The work was executed as a part of the Second Year Diploma Project.

1.1. Objective

The primary objective of this project is to design, model, and construct an economical and compact power hammer machine requiring minimal power input, emphasizing simplicity in its mechanisms. The aim is to reduce overall machine expenses by employing straightforward mechanisms. The core goal is to develop an automated power hammering apparatus utilizing essential components such as a 2850 RPM motor, bearings, disc iron, pulley, hammer, and anvil. This machine is engineered to streamline and simplify hammering operations. Its functioning involves activating the connecting link, which, upon engaging the spring, lowers the pallet rubber to contact the motor. This action causes the hammer to move up and down, supported by two bearings. The significance of this power hammer machine lies in its exceptional efficiency and the capability to operate continuously for 24 hours, ensuring consistent and reliable performance.

2. LITERATURE REVIEW

Dynamic testing of materials, as investigated by (Agirre et al., 2020), proves necessary for modeling high-speed forming processes like hammer forging and blanking, and also for studying crash/impact behavior in structures. In their review, (Pandey et al., 2020) explored the utilization of various machines and equipment across industries, such as forging, hammering, and cutting operations. (Manaye et al., 2019) focused on designing and constructing a modified hammer milling machine to meet the increasing demand for cassava flour in bakery industries, addressing the limitations of existing mills. The work presented by (Emovon et al., 2021) introduced a fuzzy MOORA technique for the design and fabrication of an automated hammering machine. (Ocak et al., 2018) emphasized the importance of predicting the net breaking rate of an impact hammer and determining daily advance rates for scheduling and estimating project costs in mining, civil engineering, and tunneling projects. (Ojomo & Fawohunre, 2020) developed a hammer mill with a double sieving device for grinding grains and agricultural products, using locally available materials. (Akash Santosh Pawar, 2021) focused on the manufacturing, design, and analysis of a hammer mill machine and its rotor assembly with a capacity of 200 kg/hr. (Ezurike et al., 2018) designed, constructed, and evaluated the performance of a flat screen hammer mill machine, achieving 92.9% efficiency when tested with dried maize. (Musa & Glory, 2020) developed a compact single-acting hammer mill machine using locally sourced materials. (Abhijeet Dhulekar et al., 2018) designed and fabricated an automatic hammering machine, considering factors like maximum torque, impact velocity, torque force, and shear failure in bolt joints. (Dominguez, 2021) developed a financially feasible hammer mill for small-scale corn milling operations, also focusing on separating fine corn grits from coarse ones for diverse animal feed utilization. (Sivasubramanian et al., 2018) created a foot-pedal-operated blacksmithy hammer, providing a traditional yet functional tool. (Bhoyar & Umredkar, 2020) presented an inclusive review discussing various forging processes, marking a technological revolution in forging and its applications. (Praveena, 2019) explored the development of an Automated Open Die Forging Machine, demonstrating superior surface quality and accurate component shaping compared to manual forging. (Akmal Bin, 2021) designed and fabricated an automated hammering machine, eliminating the need for human intervention in hammering operations. (Jay Govind Yadav et al., 2019) also designed and fabricated an automatic hammering machine, calculating key factors such as maximum torque, impact velocity, torque force, and shear failure in bolt joints. (Saberi et al., 2021) delved into investigating mechanical vibrations in hammer forging processes. Their theoretical analysis demonstrated an approximate 4% increase in forging efficiency with an initial anvil velocity of 0.2 m/s, aligning well with experimental results."

3. METHODOLOGY

The project is to consolidate various forging operations into a single machine. This includes tasks like blanking, piercing, coin making, nail insertion, embossing, and metal hammering. To achieve this, a straightforward hammer machine was designed and fabricated to encompass all these diverse operations. The design concept was studied in terms of the motor's capacity relative to the hammer's needs. Similarly, the machine's compressive strength was evaluated using different materials. The most dependable design for the automatic hammering machine is elaborated below, accompanied by its specifications, showcasing various approaches to the compact and portable automatic hammering concept. These details serve as valuable insights during the initial sizing phase of the automatic hammering machine's design process. The comprehensive flowchart of the proposed project is depicted in Figure 1 below.

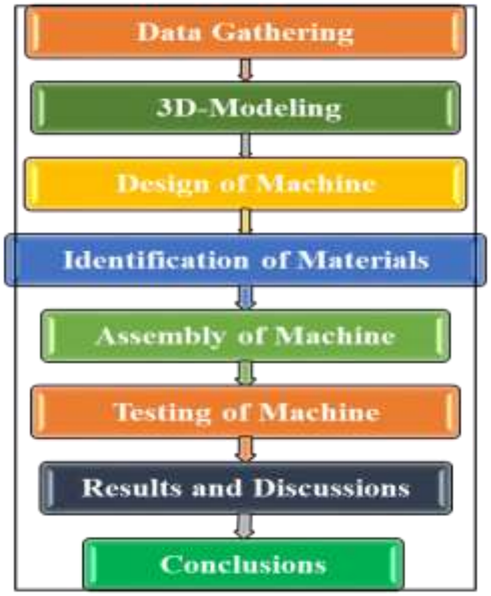

Figure 1: Flow Chart of Proposed Work

4. RESULTS AND DISCUSSIONS

4.1 Modelling

The modeling process was executed using AutoCAD 2020, ensuring precision in design and structure. Machine specifications were meticulously incorporated based on the project's demands. Various perspectives of the machine, including front, top, and side views, were captured in figures 2, 3, and 4. These comprehensive views aid in better comprehension during the fabrication phase, facilitating a clearer understanding of the machine's construction and assembly.

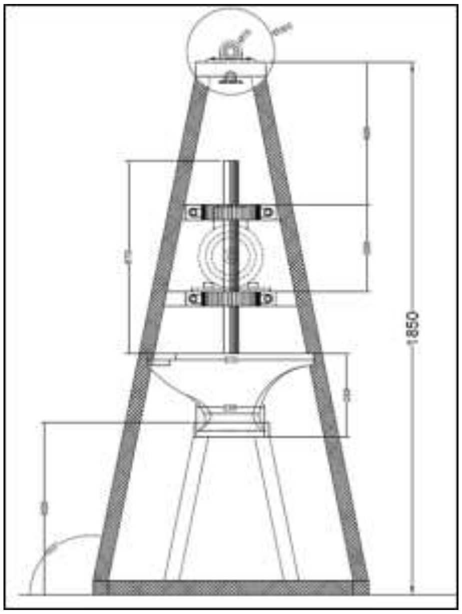

Figure 2: AutoCAD Model Front View

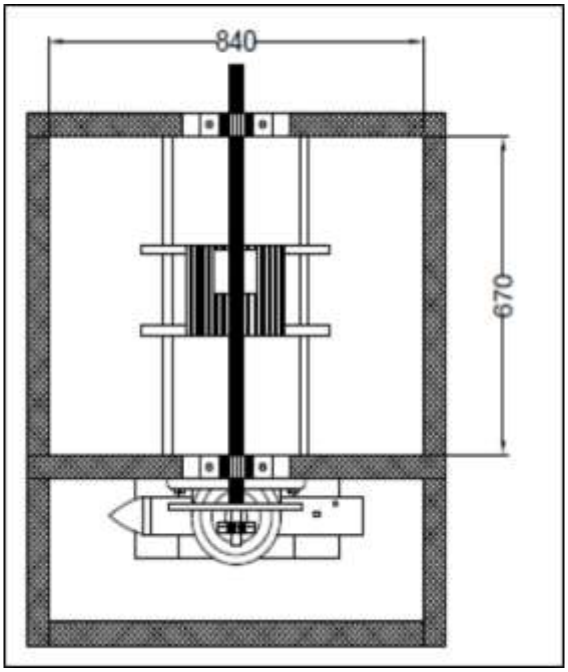

Figure 3: AutoCAD Model Top View

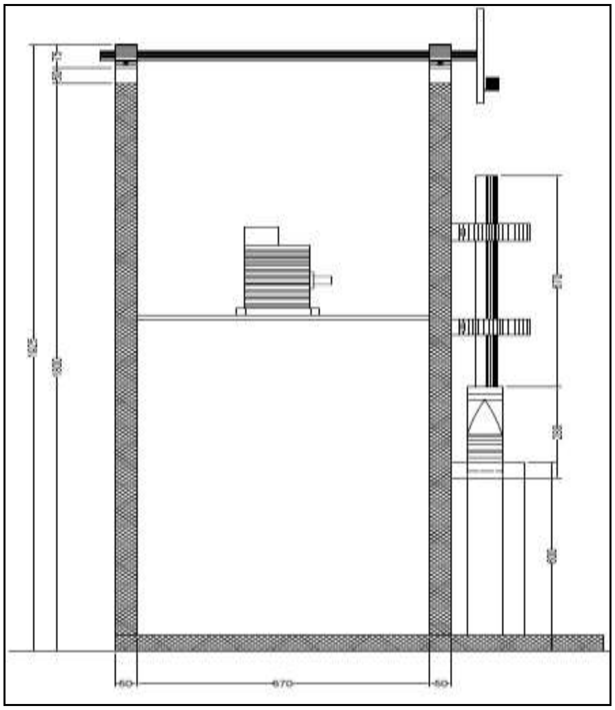

Figure 4: AutoCAD Model side View

4.2 Design Calculations

Design calculations were conducted to ascertain the machine's capacity, a crucial aspect in determining its performance across diverse metals and materials used in forging operations. This comprehensive analysis aimed to gauge the machine's efficacy and suitability for various forging tasks, accounting for the distinct properties and characteristics of different metals and materials involved in the process.

Power Transmitted by Motor

$P = V \times I$ -------------(1)

$V = 230$ - Voltage

$I = 13.5$ - Current

$P = 230*13.5 = 3105$ W

Torque by the motor

$P = 2\pi NT/60$ -------------(2)

$T = P \times 60/2\pi N$

$T = 3105*60/2*3.14*2850 = 11.56$ N – m

Impact velocity of Hammer = Change in momentum of the hammer with time

By applying the impulse momentum principle, we can find the impact velocity of hammer

$I = m \times (V_2 - V_1)$ ------------ (3)

I – Impulse Momentum (Where $I = F \times t$)

V_1 – Initial velocity of the hammer

V_2 – Final velocity of the hammer

$F \times t = m \times V_2$

V or $V_2 = \frac{F\ x\ t}{m}$ ------------(4)

$V = 19.62$ m/s

Kinetic Energy $= \frac{1}{2} m v^2$ -------------(5)

$= \frac{1}{2} * 15 * (19.62)^2$

$= 2.88 \times 10^3$ Joules

Impact Force (F)
Impact Force can be expressed from impulse momentum theorem.
Impact Force (F) x t = $mv_2 - mv_1$ ---------------(6)
Where,
Initial velocity $V_1 = 0$ m/s.
Final Velocity = 19.62 m/s
Mass of Impact (m) = 15 kg.
T = time taken for one rotation of the disc (2 sec)

$$F = \frac{15 \times 19.62}{2}$$

F =147.15 N

Compressive strength (or) The stress developed in the specimen is given by:

$$\sigma = \frac{F}{A}\left[1 + \sqrt{1 + \frac{2AEh}{Fl}}\right], \ \frac{N}{mm^2} \text{ ------------------(7)}$$

Where,
F – Impact force (N)
A – Cross sectional area of the hammer
($\pi * r2 = 1963.5 \text{ mm}^2$)
E – Young's modulus of material (Mild Steel) = 210×10^3 MPa)
h - Hammer strike height (h = 110 mm)
l – length/ thickness of the specimen (25 mm)
σ = 372.5 MPa

4.3 Fabrication Work

At the outset, an AutoCAD model was created to guide the selection of components for the power hammer machine. Initially, mild steel square tube channels were chosen and precisely cut to meet the required dimensions. The entire machine frame was constructed using these tubular channels, ensuring robustness and stability. A suitable motor was carefully selected to power the machine, positioned within a specially designed frame at the machine's core. Connecting the motor pulley to a larger pulley atop the machine via a V-belt, a shaft was utilized to drive a disc made of mild steel, boasting a diameter of 106 mm. Constructing a trapezoidal frame using mild steel square channels, a spring of appropriate specifications was securely fixed within this framework. One end of the spring was linked to the disc, while the other was connected to the hammer. Positioned beneath the hammer, an anvil was strategically placed to receive the impact during operations. For operation initiation, a pedal mechanism was integrated at the machine's base, facilitating the initiation of power supply to the motor. The resulting manual pedal-operated power hammer machine is now fully equipped to perform a range of operations. A detailed breakdown of the machine's components and their specifications is presented in Table 1 below. A final assembly of power hammer machine is illustrated in figure 5

Table1: Selected Components and its Specifications used in the Project.

S.NO.	Components	Specifications
1.	Total Wight of machine	175.3 Kg
2.	Hammer Wight	15 Kg
3.	Anvil	52 Kg
4.	Hammer strike height	110 (mm)
5.	Hammer (Diameter)	50 (mm)
6.	Pulleys (Diameter)	67 & 60 (mm)
7.	Bearings (Diameter)	50, 30 & 24 mm
8.	Length of link rod	628 mm
9.	Motor details	50(Hz), 15A, 230 (V), 2850RPM
10.	Disc iron (Diameter)	106 (mm)
11.	Disc (Thickness)	25 (mm)
12.	Bearing (Thickness)	10 (mm)
13.	Hammer (Length)	607 (mm)
14.	Hammer (Diameter)	50 mm

Figure 5: Power Hammer Machine

5. CONCLUSIONS

- The automated hammering machine demonstrated consistent performance across various forging operations, showcasing its repeatability and reliability. The structured design and predefined motion patterns of the hammer head contributed significantly to its consistent output.
- The project's emphasis on kinetic principles allowed for a thorough evaluation of the machine's capabilities. Calculations determining the motor's lifting capacity and hammer impact force provided crucial insights into the machine's performance potential.
- The compressive strength values obtained for various materials further validated the power hammer machine's suitability and versatility for forging operations. These values offered a comprehensive understanding of the machine's capabilities across different materials.
- The implementation of an adjustable force feature in the automated hammering process emerged as a significant advantage, offering adaptability and flexibility for diverse forging requirements.
- The observed repeatability and efficiency of the automated process indicate the potential for broader industrial applications.
- Future enhancements could focus on refining the adjustable force mechanism for greater precision and control in forging operations.
- Consideration of real-time feedback systems might further enhance the machine's adaptability to varying materials and forging requirements.
- The results demonstrate the successful design and implementation of an automated power hammer machine, showcasing its potential to revolutionize traditional forging processes through increased efficiency, repeatability, and reduced manual intervention.

ACKNOWLEDGMENT

This paper represents the culmination of the academic efforts undertaken during the 2022-23 academic year, specifically in Semester 1, as part of the second-year diploma project at the University of Technology and Applied Sciences –Salalah. The authors would like to extend their sincere gratitude to the university for its invaluable support, which played a pivotal role in facilitating the successful execution of this project by the students.

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