Study on Development of an Automated Open Die Forging Machine

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***Abstract*— Forging is a prime process of the manufacturing industry. After casting the next process may be considered either machining or forging process. In primary metal forming process, forging provides very good mechanical properties. In all the engineering and diploma colleges, a basic laboratory on forging will be conducted. The objective of this paper is to identify the problems in forging laboratory and developing the forging model which will operate automatically. Before designing the automated forging system, a detailed literature survey has been conducted and identified that the pneumatic force is used for forging but drop forging is one of the simplest and easiest way for forging. In drop forging certain mass of the hammer is dropped from the specified height to get the desired shape for the heated blank.**

Automated forging model which mainly consisting of Frame, Lever, Hammer, Anvil, Cam, Motor and Gear box. The lever is fixed to the frame with the hinge; the hammer is connected to the end of the lever which will be lifted to the desired height with the help of cam. Cam and lever arrangement uses the lever mechanism i.e. Mechanical advantage. The cam is operated by the motor. Here the gear box is used to reduce the speed by 1:50. The cam clamps were used to alter the lift height of the hammer depending on the work piece material to be forged.

Tests were conducted, to check the proper alignment of hammer with the anvil. Simple forging models were prepared both by manual method and by using automatic forging machine. The models prepared were giving satisfactory results. By this machine, with minimum cycle time number of components with accurate dimensions, very good mechanical properties were obtained.

Keywords — Forging, Lever, Cam, Cam clamp, Gear box, Mechanical advantage.

I. INTRODUCTION

Forging is an effective method of producing many useful shapes. The process is generally used to produce discrete parts. Typical forged parts include rivets, bolts, crane hooks, connecting rods, gears, turbine shafts, hand tools, railroads, and a variety of structural components used to manufacture machinery. The forged parts have good strength and toughness; they can be used reliably for highly stressed and critical applications.

A variety of forging processes have been developed that can be used for either producing a single piece or mass produce hundreds of identical parts. Some forging processes are:

- Open – die hammer forging
- Impression – die drop forging
- Press Forging
- Upset Forging
- Swaging
- Roll forging

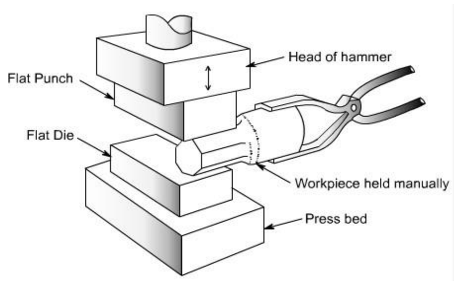


Fig. 1 Open die forging process [NPTEL notes]

A. Open – Die Hammer Forging

It is the simplest forging process, which is quite flexible but not suitable for large-scale production. It is a slow process. The resulting size and shape of the forging are dependent on the skill of the operator.

Open die forging does not confine the flow of metal Fig [1]. The operator obtains the desired shape of forging by manipulating the work material between blows. Use may be made of some specially shaped tools or a simple shaped die between the work piece and the hammer or anvil to assist in shaping the required sections (round, concave, or convex), making holes, or performing cut – off operations. This process is most often used to make linear–final shape of the parts can be obtained further.

Forging is a manufacturing process involving the shaping of metal using localized compressive force. The blows are delivered with the hammer (or) die. Forged metals are generally stronger and more reliable then castings due to the fact that tight grain structure of forging making it mechanically strong. Need of automation for small-scale industry is necessary for better speed and accuracy. In this project main objective is to prepare the design for automatic forging system with the incorporation of motor with speed control. This can improve the forging operation effectively.

Hot forging is the process of deforming metal into a predetermined shape using certain tools and equipment—deformation is accomplished using hot, cold, or even warm forging processes. Ultimately, the manufacturer will look at a number of criteria before choosing which type of forging is best for a particular application.

II. OBJECTIVES

- To prepare the forging model for the forging lab
- To adopt the automatic forging hammer with the help of driving system.
- To prepare the forging components with less number of cycle time.

III. CONCEPT DESIGN AND WORKING PRINCPLE

A. Concept 1:

Conceptual Design is an early phase of the design process, in which the broad outlines of the model is prepared. The basic elements considered are: Frame, lever, hammer, cam, and motor and gear box. Based on the requirements of automatic forging two conceptual drawings were developed in which Fig.2 represents the conceptual drawing where lift of hammer is controlled by the position of the cam, by using mechanical advantage technique.

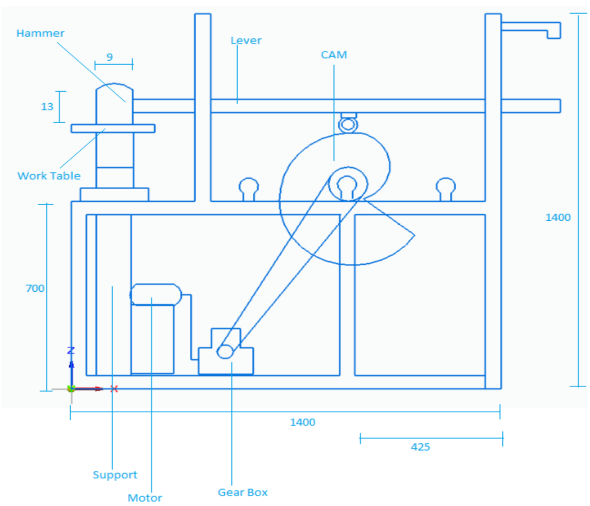


Fig. 2 Concept drawing 1

B. Concept 2:

In the concept drawing 2, same arrangement was used but the change is made on the cam design, cam itself is modified to achive different forging forces depends on what type of the work piece materials to be forged. Fig. 3 shows the concept drawing 2.

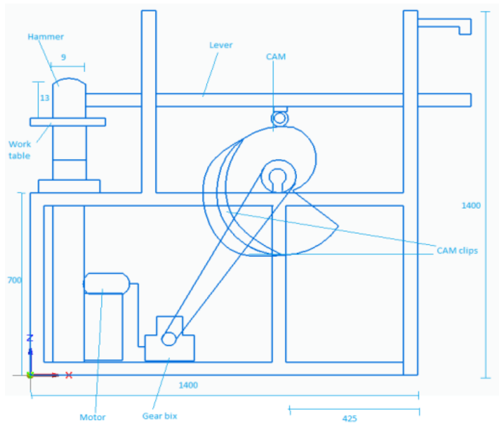


Fig. 2 Concept drawing 2

C. Workig Principle :

The forging model is mainly prepared to reduce the human efforts during manual forging process and also to achieve the accurate shape with less number of forging cycles. It works by lifting the forging hammer to some height and it is dropped from that height. The lift height and weight of the hammer decides the forging force.

In the new developed forging model, there is a provision for changing the height of forging by cam and cam clamps arrangement. The Cam is rotated by the motor and the speed of the cam is reduced by using the gear box. The gear ratio used here is 1:50. Because of the high impact force by the hammer can produce the required forging force on the pre heated component. By thus the accurate and desired shape of component can be achieved.

IV. MODELLING AND FORCE CALCULATION

A. Modelling

By considering the complexity and ease of work, Conceptual drawing 2 is best and accordingly to that the 3D model is developed. The 3D draft is developed by using the Sold edge ST 4 software. The Fig. 3 represents the 3D View of automatic forging model.

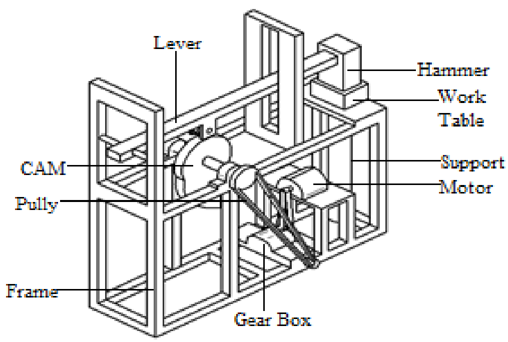


Fig. 3 3D View of automatic forging model

B. Force calculation

i) Mass of the hammer:

The hammer is designed based on the minimum weight required for forging. For manual forging the hammer used in all engineering laboratory weighs around 3 to 4 kgs. Therefore the approximate hammer is designed as shown in the figure.

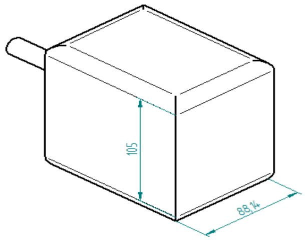


Fig. 4: hammer with dimension

- Length and thickness of the hammer head= 105 mm
- Width of the hammer head = 88 mm
- Volume of the hammer = L * T * W

  V = 105 * 105 * 88

  V = 970200 mm^3

- Density = 7.85 $gram/cm^3$
- Mass = (970200 *10^{-3}) * 7.85 gram / cm^3
- Mass = 761607 grams
- <u>Mass = 7.616 kg</u>

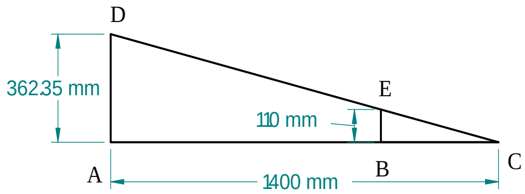
ii) Impact force:

The impact force from the hammer is calciulated by considering the height of the forging hammer and the velosity of the hammer. The Table 1 shows the maximum height of the hammer lifted and the impact force for each case. It was foud that the MS metal piece reduces its strength as the temperature increases. And during forging the recommended temperature would be around recrystalization temperature of 700 to 900^o C.

Table 1 : Maximum lift for the hammer and the impact force

Sl no	Maximaum cam radius (mm)	Maximum lift for the hammer (mm)	Imapct Velocity (m/s)	Imapct force (N)
1	110	362.32	1.469	82
2	120	395.29	1.534	90
3	195	642.35	1.955	145

The maximum lift of the hammer is calculated using the graphical method. Fig. 5 shows the triangal for the hammer and lever at the maximum height. In this model two cam clamps were used and three different lift of hammer are predicted. For ductail material the cam without the clamps can be used for forging process.



AD = Height of the hammer lifted

BE = Cam height

Fig. 5: hammer with dimension

B. RESULTS AND DISCUSSION

The model was prepared and fabricated according to the design. The fig. 6 shows the final model. It was noticed that by using automatic forging system, good surface and accurate shaped components are prepared compare to the manual forging process.

Fig. 6: Final Model

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