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COMPUTER AIDED CLOSED DIE DESIGN AND MANUFACTURING FOR OPEN END WRENCH

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ABSTRACT

Tool and Die design and its manufacturing were developing at a very rapid pace. Delivering quality tools at right time is a challenging task for manufacturing organizations. A typical case study of computer aided closed die design and manufacturing for open end wrench and corresponding trimming fixture design steps are explained. The purpose of this paper is to formulate a standard procedure computer aided closed die design and manufacturing for open end wrench.

Hot work die steels are commonly used for hot forging dies subjected to temperatures ranging from 1100 to 1200 °C. These materials contain chromium base steels contain chromium and tungsten. Alloying elements which have hardening characteristics and resistance to abrasion and softening, such as H11 or H13, H14 are used for the critical die works. Moreover, the trimming die or bottom die can be used from D2 tool steel that has a high strength alloy hard face applied to the cutting edge. Forging die design procedures were sequentially used to produce computer aided closed die design and manufacturing tools. This includes the creation of final forged product model, Blocker model, Bender and Flattener model before extracting the die profile. Trimming fixture will trim and give finished part. Basically all this procedure can be standardized and utilized for various product varieties. The results of the research are shown as 3D model views and 2D drawings. The 3D model creative are finisher model, blocker model, wrench assembly layout, top and bottom die and trim fixture are the result of this work.

Keywords: Dies, Manufacturing Wrench, Trim fixture.
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1. INTRODUCTION

Closed-Die Forging is the shaping of hot metal completely within the walls or cavities of two dies that come together to enclose the work piece on all sides. The impression for the forging can be entirely in the forging stock, generally round or square bar, is cut to length to provide the volume of metal needed to fill the die cavities, in addition to an allowance for flash and sometimes for a projection for holding the forging. The flash allowance is, in effect, a relief valve for the extreme pressure produced in closed dies. Flash also acts as a brake to slow the outward flow of metal in order to permit complete filling of the desired configuration [2].

With the use of closed dies, complex shapes and heavy reductions can be made in hot metal within closer dimensional tolerances than are usually feasible with open dies. Open dies are primarily used for the forging of simple shapes or for making forgings that are too large to be contained in closed dies. Closed die forgings are usually designed to require minimal subsequent machining. Closed die forging is adaptable to low-volume or high-volume production. In addition to producing final, or nearly final, metal shapes, closed-die forging allows control of grain flow direction, and it often improves mechanical properties in the longitudinal direction of the work piece. Closed die forging Size: The capability forgings produced in closed dies can range from a few once to several ton or kilogram. The maximum size that can be produced is limited only by the available handling and forging equipment. Forgings weighing as much as 25,400kg have been successfully forged in closed dies, although more than 70% of the closed-die forgings produced weigh 0.9 kg.

The Shape of closed die forging: Complex nonsymmetrical shapes that require a minimum number of operations for completion can be produced by closed die forging. In addition, the process can be used in combination with other processes to produce parts having greater complexity or closer tolerances than are possible by forging alone. Cold coining and the assembly of two or more closed die forgings by welding are examples of other processes that can extend the useful range of closed-die forging [3].

2. LITERATURE REVIEW

Closed die forging describes a process in which the work piece is compressed between two or more dies which have cavities designed to form the material to a particular geometry. The material may be partially or completely constrained, or may be relatively unconstrained. The dies may be designed such that as they close, a thin section remains unclosed. Controlled metal flow through this section can improve the filling of the impression. This thin section is referred to as flash. [5]

Design for closed-die forging of a bevel gear used for a component of automobile transmission was made using three-dimensional finite element simulations. The Process variables of the closed-die forging of the bevel gear were selected to be the pressing type, punch location, and billet diameter. Based on finite element simulation results, appropriate process design without causing under-filling and folding defect was determined. In addition, with design of a die set including die insert and stress ring, cold forging of the bevel gear was experimented to estimate effectiveness of the designed process, the design process for the closed die forging of the bevel gear for the 3D finite element analysis.[13]

The forging die have emphasized in their work to assess the applicability of different failure concepts for a closed cold forging die. The critical, process-dependent load is quantified and localized by using a finite element method. Based on the resulting stress strain distributions, the damage parameters have been calculated yielding different estimates of tool life that are compared with practically experienced data. The selection of the die materials is a very significant decision in the production of precise components by forging. Appropriate selection of die materials is imperative to get acceptable die life at reasonable cost. Die wear is mostly influenced by the hardness of the die material and other material properties such as toughness and ductility. Selection of proper die materials is very important for reducing the production costs and setting narrow tolerance of the forged part. In hot forging, mainly hot work die steels are used due to their ability to retain their hardness at elevated temperatures with sufficient strength and toughness to withstand the stresses that are imposed during forging. There have also been some successful applications of other materials such as ceramics, carbides and super alloys although their application is limited due to design and cost of manufacturing. [6]

2.1. FORGING ANALYSIS

The design, control, and optimization of forming process requires [1] analytical knowledge regarding metal flow, stresses and heat transfer as well as technological information related to lubrication, heating and cooling techniques, material handling, die design and manufacturing, and forming equipment.[11]

Table 3.1 Strain rate, $\dot{\varepsilon}$ =f(r and initial height ho of the blank)

Machine	**Ram impact velocity v in m/s, $(\varepsilon = v/h_o)$,(s^{-1})**													
	h_o, mm	5	10	20	30	40	50	100	150	200	250	300	400	500
Hammer	5.6	1120	560	280	185	140	112	56	37.3	28	22.4	18.6	14	11.2
	6	1200	600	300	200	150	120	60	40	30	24	20	15	12
	12	2400	1200	600	400	300	240	120	80	60	48	40	30	24
Screw press	1.0	200	100	50	33.3	25	20	10	6.7	5	4	3.3	2.5	2
Hydraulic presses	0.25	50	25	12.5	8.5	6.2	5	2.5	1.7	1.25	1	0.83	0.6	0.5
Crank press, where $\alpha=30^0$	0.6	120	60	30	20	15	12	6	4	3	2.4	2	1.5	1.2

In hot forging of metals at temperatures above the recrystalization temperature, the influence of strain on flow stress is insignificant, and the influence of strain-rate (i.e. rate of deformation) becomes increasingly important, whereas opposite for at room temperature (i.e, in cold forging).The effect of strain-rate on flow stress is negligible, and the effect of strain on flow stress (i.e. strain hardening) is most important. The degree of dependence of flow stress on temperature varies considerably among different materials.To be useful in metal forming and dies, the flow stress of metals must be determined experimentally for the strain, strain-rate, and temperature conditions that exist in metal forming process.

The methods most commonly used for obtaining flow stress data are tensile, uniform compression, and torsion tests.

$$\bar{\sigma} = C\dot{\varepsilon}^{m} \qquad 3.1$$

Where:

$\bar{\sigma}$ =flow stress, (N/ mm^2)

c= strength coefficient, (N/ mm^2)

m=strain rate sensitivity exponent

$\dot{\varepsilon}$=strain rate

A general range of values form is up to 0.05 for cold working, 0.05 to 0.4 for hot working, and 0.3 to 0.85 for super-plastic materials.

The development of remeshing methods and the advances in computational technology have made the industrial application of FE simulation practical. Commercial FE simulation software is gaining wide acceptance in the forging industry and is fast becoming an integral part of the forging design and development process.

The metal flow, friction at the tool/material interface, the heat generation and transfer during plastic flow, and the relationships between microstructure/properties and process conditions are difficult to predict and analyze. Therefore, in most of the time products are made by trial and error to reach to the final correct product shape, which is a costly process as materials are wasted in the process as well as it takes considerable time of the expert involved in the operation. With the applications of finite elemental method some of the problems of analysis could be reduced significantly [27].

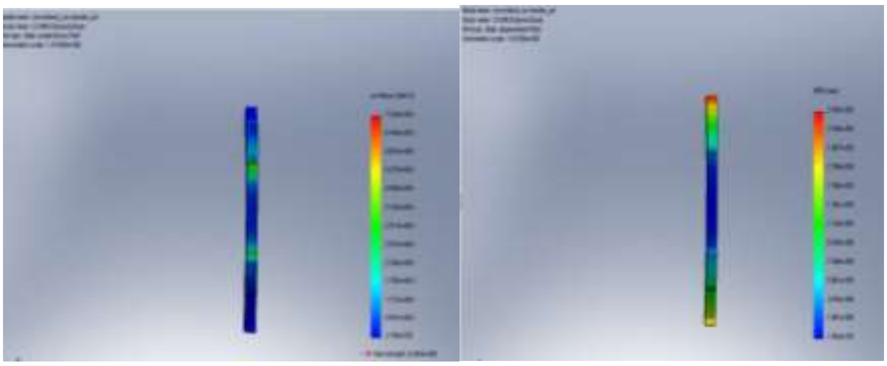

Figure 3 1 a) Flattener stress analysis and b) static displacement

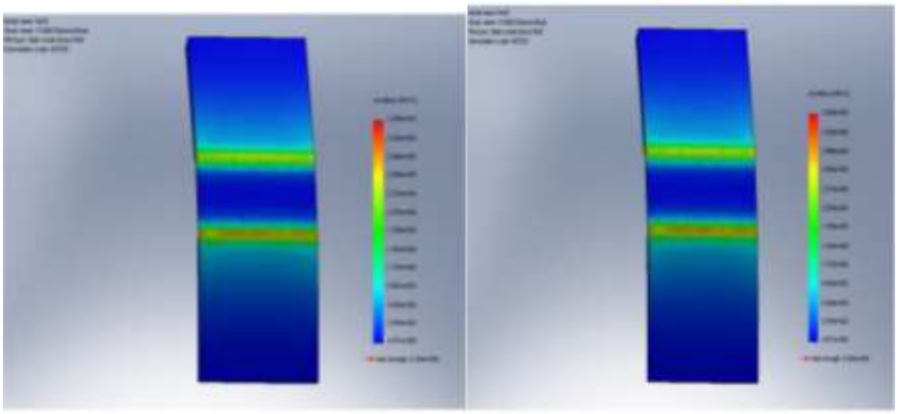

Figure 3.2 a) Bottom die stress analysis and b) static displacement

In general the above finite element result of the analysis all along the stress on the limit stress distribute design die forging is no premature failure.

2.2. Top and bottom closed die

Dies for closed-die forging on presses are often designed to forge the part in one blow, and some sort of ejection mechanism is often incorporated into the die. Dies may contain impressions for several parts. Hammer forgings are usually made using several blows in successive die impressions. A typical die used for hammer forging is shown in Fig. 3.1. Such dies usually contain several different types of impressions, each serving a specific function. These are discussed below.

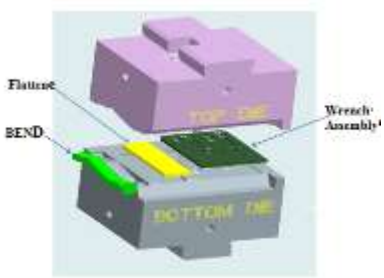

Figure 3.2.1 Complete Forging Die Assembly

Top and Bottom die design requires details like location, clamping system from the forging machine on which it is mounted. The clamping and location sizes from forging machine are used in the die features. This data is available from standard machine suppliers.

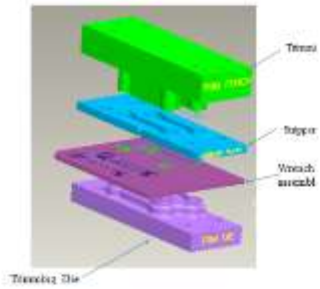

Figure 3.2.2 Trimmer fixture assemblies for trimming

3. RESULT AND DISCUSION

In this thesis work, a compressive study on forging process was done. The inputs from review of literature regarding forging process, closed die design, die materials, die life, analysis etc. were half full for standardizing the forging die design process.

All of the results of the research are shown as 3D model views and 2D drawings. The 3D model creative are finisher model, blocker model, wrench assembly layout, top and bottom die and trim fixture are the result of this work. This work included a case study on double ended wrench products. All the steps needed for forging die design are extensively studied, analyzed and documented. That is:

A Finisher is the first part to be modeled considering appropriate flash land.

Blocker is a volumetrically increased model to take care of the geometrical deformation during the forging process.

Top and bottom closed die impression will determine the process sequence and produce bender model, flattener, blocker and finally finished product (finisher).

The last stage of Forged product manufacturing process is trimming. Trimming fixture assembly will consist of Trimming punch and die and Stripper plate.

The capabilities of pro engineering software were demonstrated in the whole process of die design and also in die manufacturing and CNC code generation.

Pro/Engineer is a feature based parametric solid modeling system with many extended design and manufacturing applications. As a comprehensive CAD/CAE/CAM system, covering many aspects of mechanical design, analysis and manufacturing, Pro/Engineer represents the leading edge of CAD/CAE/CAM program. Pro/Engineering software is a gather of programs that are used to design, analyzes, and manufacture a size of products. This thesis will make use of the manufacturing part whereas the sketch part has the capability to create the 3D solids, and engineering drawings.

Pro/Engineer Wildfire 2.0 has advanced features in the manipulating volume surface and solid. The Pro/Manufacturing can be used to generate CNC tool paths for machining the surface and toper form NC Check to verify the machined surface. The other out puts are reduction of process time, raw material, and cost which was wasted during the conventional process

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Thesis work presents a framework and the implementation details of an integrated system that has been developed for computer aided closed die design and manufacturing for open end wrench factory specializing in precision punches and dies. A CAD/CAM based system has been implemented on manufacturing of a CNC machine using the pro engineering programming.

The standardized procedure stated here can be applied for any new product modification done with respect to hand tool forging die design. By standardizing the Die design process explained above and utilizing the modeling and modification capability of available 3D packages industries can remain competitive in delivering products to customers with minimum time. The information provided in this case study may be used for initiating the tooling activity for industrial growth of developing countries.

4.2. Recommendation

To strength computer aided closed die design and manufacturing for open end wrench factory, research innovative ideals, resources and committed management is necessary. Based on the research findings and conclusions the researcher forwarded the following recommendation for the future improvement.

- The issue of simulation of die filling and die design deformation is also one possibility for future research using any higher general purpose CAD/CAM package.
- The post-trial error manual manufacturing system of forging die design production should be improved by using complex geometric design system.
- To generate production of forging die design components to integrate the CNC machine process should be considered.
- Detail cost breakdown and analysis should be considered to obtained available cost information of each forging die design components to facilitate production
- Further fine tuning a better design procedure if possible can be suggested by feature researchers.

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