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FORFING DIE DESIGN FOR CLOSED DIE HOT DROP FORGING

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***Abstract** — Forging is a controlled plastic deformation process in which the work material is compressed between two dies using either impact or gradual pressure to form the part. Forging operation carried out usually at an elevated temperature. It is used to change not only the shape but also the properties of the metal because it refines the grain size and therefore improves its structure. Forging is a cost-effective way to produce net-shape or near-net-shape components. Forged parts are used in high performance, high strength and high reliability applications where tension, stress, load and the human safety are critical considerations. Hence, the dies required for forging process must have a sufficient amount of strength to resist the impacts applied on it. This is where the design factor for dies comes into play as a vital role in the forming process of a metal. The better designed die will give best possible forged components. There are various parameters affecting the design of a die as there no specific design for any forged product. They are made according to the component to be forged. However, there is no specific set of methods for forging die design. Through the present study an attempt has been made to understand & define a specific set of methodology for die design through a case study of automobile driveline component, "companion flange". A die was made out of design provided and was found to be forging components satisfactorily out of it*

Keyword- *Forging strength*

I. INTRODUCTION

Forging process may be defined as a metal working process by which metals or alloys are plastically deformed to the desired shapes by application of compressive forces with the help of a pair of dies. One die is stationary and another die has a linear motion. Forging process can be carried out both in hot & cold states of metal, but unless otherwise mentioned the forging process is considered to be "hot forging" process.

Forging is one of the oldest known metal working processes. Traditionally, forging was performed by a smith using hammer and anvil. The smithy or forge has evolved over centuries to become a facility with engineered processes, production equipment, tooling, raw materials and products to meet the demands of modern industry. In modern times, industrial forging is done either with presses or with hammers powered by compressed air, electricity, hydraulics or steam. These hammers may have reciprocating weights in thousands of pound. Smaller power hammers, 500 lb's (230 kg) or less reciprocating weight. Open die forgings are less costly than closed die forgings & so it is used where number of components to be forged is too small to justify the cost of impression dies, or where the sizes are too large and too irregular to be contained in the usual impression dies. Open die forging can be used for simple shapes only such as: Bars, slabs or billets with rectangular, circular, hexagonal or octagonal cross sections, welder rings, and many other components of simple shape s .on the other hand for more complex & accurate parts and with increased production rates, impression dies are preferred. In open die forging the weight range of forging goes upto few tonnes, whereas in impression die forging, the weight range is limited upto few hundred Newton's due to limitation of die size. In open die forging, the forging are made usually on hydraulic presses designed for forging ingots, whereas impression die forgings are made on hammers or presses. Open die forgings are required for heavy equipment and machinery such as for steel plants, power generation, shipping & defense, whereas impression die forgings are generally used in automobile sector. In open die forging, the simplicity of tooling is gained at the expense of the complexity of process control, whereas in impression die forging, the process is simplified to a sequence of simple compression strokes at the expense of a complex die shape.

II.LITRETUTRE REVIEW

The broad objective of this chapter is to provide requisite background information relating to the proposed study from literature. The identified areas of the survey include: The closed die hot forging process is most suitable for generating complex shaped work parts with reasonable profile accuracy. The process is quite complex from the analysis point of view as there exist several parameters, that can influence the process. These parameters in broader terms can be classified into two categories: design and process parameters. The design parameters include the preform shape design and die design. The preform shape design is primarily dependent upon the number of stages involved. The die design includes parameters such as flash thickness, flash width, draft angle, corner and fillet radius, input billet geometry etc

The hot forging process under closed die condition was studied in terms of flash formation by Tomov. A number of expressions proposed by earlier researchers for flash land calculation were compared using both analytical and numerical approaches. The best expression among the comparative work was identified so that it can be used as a first step for die design.

A Study of Process Parameters towards Improving Efficiency of Closed Die Hot Forging Process was studied by ChandanSamal. A number of process parameters were studied and proper methodology was given for analysis of forging process and its parameters, also a study on die design was also made through FEA method. As a sample case, a real life automotive driveline component, a flange yoke, is taken for investigation. A simulation-driven approach using a commercial package (DEFORM), based on finite element method, was adopted. Trials were conducted using an industrial press, data generated were validated against those predicted. The correlation was found to be satisfactory.

The importance of corner radius and friction in the closed die forging process were highlighted by Ab-Kadir based on an exhaustive FE study. By conducting an iterative study on a bolt head forging, the effect of corner radius on die filling was compared. It was found that increased die radius in forging is favourable. Similar comparative study on friction showed that, the forging load and consequently dies wear increases with increase in frictional value.

A novel approach for optimizing the forging process and reduce the required force to forge the final product by Harshil Parikh, Bhavin Mehta, Jay Gunasekera. A complex 3- dimensional part was been utilized for preform shape design. Simulation results predicted that the complex 3D part could be forged in one step, using at least a 900 ton capacity press or higher. The task was to design a preform and two die sets to manufacture the part using the existing press. Solid Edge was used to model the dies while MSC. SuperForgewas used to simulate the forging process. Several different preforms were designed and analyzed to obtain the final product in two stages with a maximum load of less than 750 tons. Force requirement for the same part can be reduced by selecting appropriate preform shape. SuperForge is found to be very helpful in simulating and analyzing forging process and selection of appropriate preform shape. In HCDF (Hot Closed Die Forging) – State of Art & Future Development published by B. Tomov an approach has been made for the future developments in HCDF regarding process planning & process management by including forging die design as a key aspect in the process planning & allowing it to be the major part of future development and concluded that HCDF technology is on threshold of new period of development as a lot of efforts are put in connection between economical and technical aspects of forging process.

RESEARCH GAP

In recent past to find out best suitable materials for die blocks. There are various grades of materials available for die and are widely used from them the most prominent material is carbon steel of varying percentages of other alloying elements such as Mn, Si, Cr, Mo, V, Ni, W, and are used according to the material to be forged. But the best suitable material at the same time which is cost effective irrespective of material to be forged can produce forged components efficiently and die life can be increased.

Also lately there has been a declination in the research for further development about methods for designing and manufacturing of dies. There have been only standards set up by various organizations and authors of various publications. And all the methods do not comply with each every component to be forged. Hence, in this report a full fledged methodology required for designing and manufacturing of die for forging is given for which a component of automobile driveline assembly 'companion flange' is taken as a case study.

III. DIE DESIGN FOR CLOSED DIE FORGING

This chapter includes the proper methodology given for designing the die & manufacturing of die for the required automobile driveline component, "companion flange".

Forged Component: - Companion Flange

Customer: - Hamid Malik Engineering Works.

The calculations & steps for designing of die for the automobile driveline component, "companion flange" are as given below:

1. Determination of Stock/Billet Size for the Experiment:

As the first step, the machine drawing of the component was prepared with the help of dimensions taken up by the model of final forged product
provided by the customer. It is then converted to into the forging model by introducing simplification of features and adding up allowances. The next step is to decide the input billet size for the processing. Referring to the data generated from model, we can find the followings:

i. Net weight of the finished component = volume of the finished component (from model) x density (steel)
Volume of forging = 244275 mm3

Density of material = 7.86×10-6 kg/mm3
Therefore, the net weight of component is 1.92 kg

ii. Net weight of the forging component = volume of the forged component (from model) x density (steel)
Volume of forging = 406616 mm3
So the net weight of the component is 3.196 kg

iii. Estimated flash loss
= (15 to 20) % of the net forging weight based on complexity of geometry
= 0.64 kg (considering the upper limit)

iv. Required input billet weight
= Net weight of the forging + Flash loss
= 3.84kg

v. Approximate yield of production
= (Net weight of the forging/ Billet input weight) x 100
= 83 %

In general, square, rectangular shaped billets are preferred over round; for forging such complex shapes. The flat side of such billets ensures proper seating in the cavity, and less attention on operating required.
Considering round billet with radius of 45mm dimension
Cross-sectional area = 1594 mm2
Length of billet required = (Required weight/density of material) /Cross sectional area
= 306 mm. (Approx.)
So, the derived input billet dimensions are (SQ 45 x L 306) mm.

2. Determination Flash Land Dimensions:

As the flash must be thin to aid the die filling and to produce close tolerances, also it acts as a safety valve for excess metal. The flash land dimensions are determined by the empirical formula given below and the tolerances for the same are taken from standard chart provided by the BIS (Bureau of Indian Standards) in IS: 3469-1975.
Flash thickness = h & calculated as

$h = \{0.015\times\sqrt{A}\}$ mm
Where,
A = projected area of forging in mm2

... $h = (0.015\times\sqrt{5141})$
$= 1.075$ mm

&, Width of flash i.e. Flash Land is calculated as,
Flash Land = 3×h to 5×h.
Where h = Flash thickness.
... Flash land = 4×1.075
= 4.3 mm

1. Design of die: the design for the die are made with the help of dimensions of the forging part to be manufactured as it becomes easy to calculate various parameters of the profile of forging die rather than applying trial

and error. Hence, the forging part is drawn by applying the forging tolerances. After the design of the forging part is finalized the dimensions of that part are taken as reverse geometry is done for the die profile. The die is given the tolerances by 1-1.6 mm per face of forging for the shrinkage as well as to provide space to allow the flow of metal uniformly through the die cavity.

IV.CONCLUSION

Since there has been no further development in the recent past about the proper methodology and manufacturing as well as processing techniques and ways of designing of die for closed die forging. As the growing variety of complexity of shapes or parts to be manufactured has increased there was an instant need to provide a set of standards and methodology to overcome this problem. Hence, an attempt was made to provide a set of specified standards used practically in forging industries for designing & manufacturing of dies.

In the mean while time we all learned various aspects to be considered which are to be utilized while designing a die for closed die forging. We also came to know about how to approach to new and different types of challenges faced by a die designer while designing a die or for that matter any object. Further we also learnt how to interpret, measure, analyze, utilize, and to apply the various parameters of any type of design. We were also enlightened about how to interpret data from various design data handbooks & how to calculate forging tolerances from Indian Standards (i.e. IS:3469-1975). The provided methodology was used for designing a die for "automobile driveline component-companion flange" and was found to be working satisfactory. By the end the project we as students were showered by a great practical & running industrial application based knowledge, we also understood the culture, discipline, rules & norms and the environment within a industry. We also understood the importance of a teamwork functioning together to achieve the aim and objective of the industry. We were indeed overwhelmed by the response given to us by both management as well as the workers while the whole tenure of the project.

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