Design of Hot Forging Die for Rear Axle Torque Plate

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Abstract— As the torque plate is an automobile component, it is subjected to the dynamic loading. Forgings have the high strength & offer great resistance to impact & fatigue loading. It is better to use hot forging method to manufacture the torque plate as forging provides greater impact and fatigue strength. In this project, the author has tried to design hot forging die for automobile Rear Axle Torque Plate. Designing includes design of flash gutter, die material selection and development of die block solid model. FEA analysis is carried out for validating the die design.

Key words: Hot Forging, Die Design, Warm Forging

I. INTRODUCTION

Forging is a manufacturing process involving shaping of metal using localized compressive forces without removing the metal. A metal such as steel can be shaped in a cold state but the application of heat lowers the yield point & makes permanent deformation easier. Hot forging refers to the process in which the metal deforms plastically at recrystallization temperature. Hot forging is a plastic deformation of metal at a temperature and strain rate such that recrystallization occurs simultaneously with deformation, thus avoiding strain hardening. Torque plate is non axis-symmetric component. The complexity of its shape make difficult to design a die. So, the design of hot die for rear axle torque plate is taken as project.

The rear axle torque plate is an automobile component. Generally, most of the automobile components are made up of carbon steel 35C8, and torque plate is also made up of 35C8. There are various types of allowances which are added to the basic dimensions of the component. Shrinkage allowances are added because component shrinks or contracts while cooling. Machining allowances are added because machining is required for better finish after forging. Drafting allowances are added for easy removal of the component from the die after the process is over. For the design of the die it is most essential to design the flash gutter, so that it will be economical. Die material is selected for generation of CAD model of the die. The selection of this die material is based on the observation of hardness, Rockwell C property of the raw material 35C8 and different die materials like hot die steel H11, H13 and H21. Hardness of raw material is 13 BHN and 52.2 BHN for die material H11. Here we simply observed that the hardness of raw material is very less than the die material. But if we consider the H21 & H13, it is not economical. The forging of the rear axle torque plate is to be carried out in three stages and then develop the die block solid model. FEA analysis is carried out for validating the die design.

Fig. 1: 3D Drawing of Part

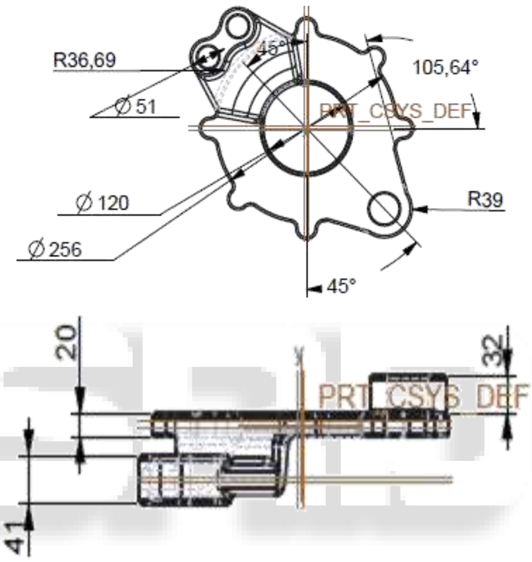

Fig. 2: 2D Drawing of Part

II. DESIGN STEP (METHODOLOGY)

Following are steps in which the whole design work is carried out for the Rear Axle Torque Plate.

A. Calculation of Different Forging Allowances & CAD Model of the Torque Plate

Forging Allowances:

- Shrinkage allowances:
- Shrinkage allowances=1.5% of the dimensions.
- Drafting allowances:
- α=Drafting angle for outside faces =5˚
- β=Drafting angel for inside faces =7˚
- Machining allowances =4 mm

The calculation given below shows how the allowances are added into the machined dimension to calculate the dimension of the forged product.

Actual outer Diameter = 256 mm
Machining Allowances = 260 mm
Shrinkage Allowances = 1.015*260 = 263.9mm
Final Forging Diameter = 278.11mm

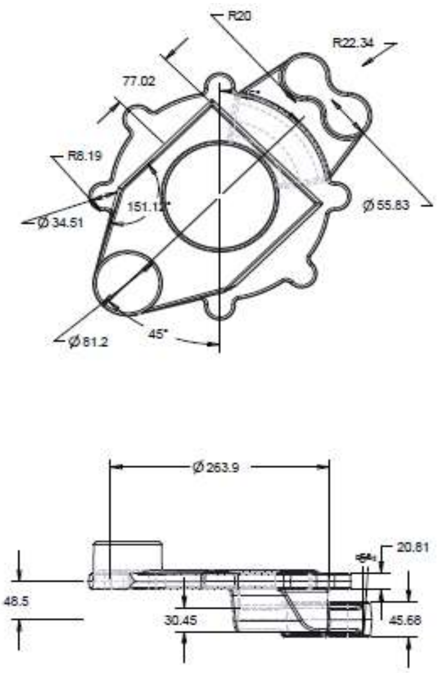

Fig 3: Machined Dimension

B. *Dimension of Flash*

Stock size, mm	Flash dimensions, mm	
	Thickness	Width
Up to 38	0.8	4.8
38 to 50	1.2	5.6
50 to 63.5	1.6	6.4
63.5 to 76	2.4	8.0
76 to 102	3.2	9.6

Table 1: Dimension of Flash

Reasonable guide for flash thickness: 3% of the maximum forging thickness. Minimum flash width per side: 6.35 mm.

C. *Dimension of Gutter*

Stock size, mm	Gutter dimensions, mm	
	Thickness	Width
Up to 38	3.2	25.4
38 to 50	4.8	25.4 to 31.75
50 to 63.5	4.8	3.75 to 38
66 to 75	4.8	31.75 to 38
76 to 100	6.4	38 to 44.5

Table 2: Dimension of Gutter

The following figure is the cross sectional view of the flash gutter of die. These are the standard dimensions that company used in producing die for the product for under the category of weight 25kg. These dimensions are considered for the thickness of the stock.

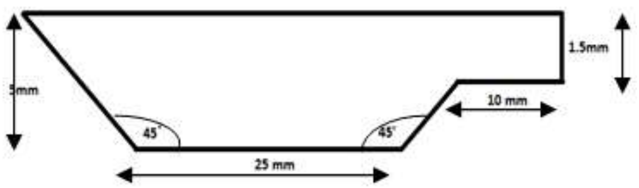

Fig 4: Dimension of Gutter

D. *Die Design and CAD Model of Die*

The selection of this die-material is based on the observation of hardness, Rockwell C property of the raw material 35C8 and different die materials like hot die steel H11, H13 and H21. Hardness of raw material is 13 BHN and 52.2 BHN for die material H11. Here we can see that the hardness of raw material is very less than that of the die material. But if we consider the H21 & H13, it is not economical.

1) *Intermediate Stages:*

Billet:
Material: Carbon Steel
Cross Section Area: 85*85 mm^2
Length: 336.74 mm
Volume: 2432766.88 mm^3

Fig 5: Material: Carbon Steel

Stage 1: Material Distribution

This is the 1st stage which shows how the material is distributed between the two die halves from the billet to give the approximate shape of the blocker.

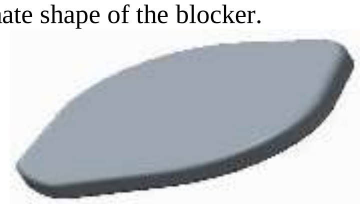

Fig 6: Material Distribution

Stage 2:- Blocker

This is the blocker stage in which the material is getting in to the approximate shape of the rear axle.

Fig 7: Blocker

Stage 3:- Rear Axle

During this stage, material is getting formed in the final shape of the rear axle.

Fig 8: Rear Axle

2) *Forging Die:-*

Following fig. shows the forging die for rear axle torque plate into which impressions have been cut are keyed into the movable ram of the forging press and the stationary anvil cap.

Dimensions:
Width: 850mm
Length: 1000mm
Thickness: 350mm

Fig 9: Lower Die

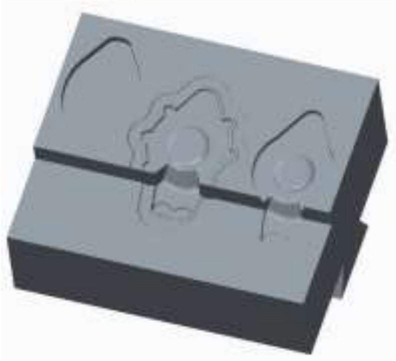

Fig 10: Upper Die

E. Finite Element Analysis of Die

To check the feasibility of the die, we carried out the Finite Element Analysis of the dies which shows the stress-strain that is induced in the die. From the analysis it is inferred that the die design is safe and it will work properly and have more service life and feasibility.

1) Analysis for Displacement

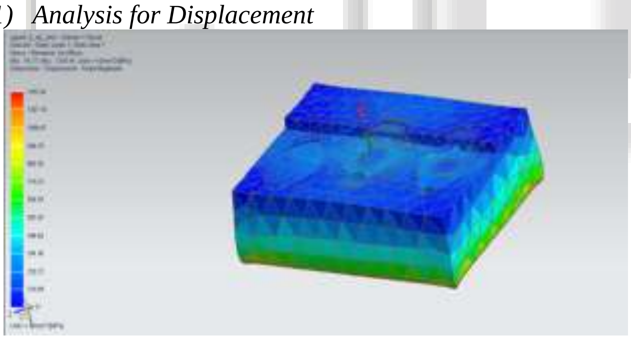

Fig 11: Analysis for Displacement

2) Analysis of stress

Following image shows that the stresses induced in the die are below the limit. Hence, we can use the die for forging purpose.

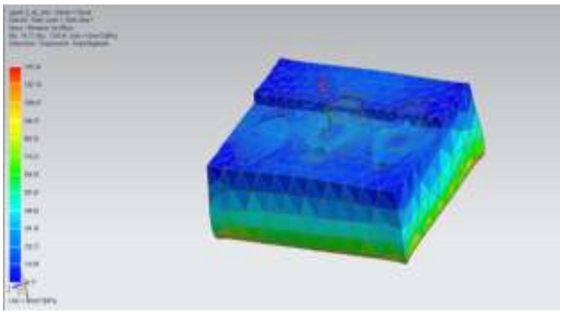

Fig 12: Analysis of stress

3) Analysis for strain

Following image shows strain induces in the die.

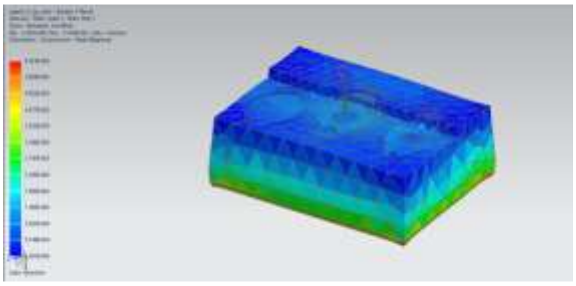

Fig 13: Analysis for strain

III. CONCLUSION

As result of the analysis we can see that the stress & strain produced in the die are below the limit. Hence the die design is safe & we can use the die to manufacture the product.

Further, die wear analysis can be carried out which helps in improving the die life & quality of the product.

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