Proceedings of "National Conference on Emerging Trends in Science and Advances in Engineering"
Organized by Phaltan Education Society's College of Engineering Phaltan, www.coephaltan.edu.in
International Journal of Innovations in Engineering Research and Technology [IJIERT]
ISSN: 2394-3696, Website: www.ijiert.org, July, 2023

Forging Die Design for Camshaft

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Abstract
Forging is a fundamental manufacturing technique. It establishes the mechanical qualities of the part in the initial stage of manufacture because it is a primary metal forming process. The forging industry is essential in the automotive industry. Many forged parts are required in many sectors to preserve product quality, shorten development cycle times, and reduce forging part production costs. Another issue is the waste of forging material as a result of the quicker production rate and complex shape. Camshaft yield rate is currently 58.5%. Optimise the process design of the camshaft die and control the camshaft yield %. In addition, the input weight for camshaft forging is to be reduced by forging die design improvements, which will result in increased production rate and lower part cost. As a result, the entire cost of the process and camshaft will be reduced.ent, which will result in increasing the production rate and decrease in the cost of the part. This will lead to reduce overall cost of the process and camshaft.

Keywords— Die Forging, Camshaft, Yield.

1. Introduction

Nowadays, it is critical for manufacturing organisations to acquire the ability to create and produce a wide range of high-quality items in a short period of time. Quickly releasing a new product into the market ahead of competition is critical for capturing a larger percentage of the market share and increasing profit margins. Because of the consumer need for variety, batch production, producers must design flexible manufacturing processes to enable a quick turnaround in product development. The primary goal of forging is to shape metal while still maintaining product quality, reducing development cycle times, and lowering forging part production costs. Increase the rate of creation of complex shapes with

Faek Diko B eng *et al.* Illustrate the metal simulation flow. It also studied the die design methodology using the CAD software. As well as it describes a PC-based interactive CAD system for closed die forging design. This system includes the facilities for drawing the die geometry, simulation of the deformation process and dies analysis under forming conditions [1].

T. Altan *et al.* explain the procedure of impression die forging. The design of any forging process begins with the geometry of the finished part. Consideration is given to the shape of the part, the material to be forged, the type of forging equipment to be used, the number of parts to be forged, the application of the part, and the overall economy of the process being designed. The finisher die is then designed with allowances added for flash, draft, shrinkage, fillet and corner radii, and positioning of the parting line. When using multistage forging, shapes of the die performs are selected, the blocker dies are designed, and the initial billet geometry is determined. In making these selections, we consider the design parameters such as grain flow, parting line, flash dimensions, draft angles, fillet and corner radii for design purpose [2].

Nikolai Biba *et al.* studied the development of forging simulation software has initiated the problem of its cost effective implementation in a forging company. This paper presents an approach to this issue based on experience gained through the development of the software, and long term collaboration with the forging industry in everyday practical work. The effectiveness is based on advanced user friendliness of the simulation software and its application to wide range of problems. This include the precise control of material flow during forming, material savings, increasing tool life by means of optimisation of pre stressed dies and the development of profiled dies that compensate for the elastic deformation of the tooling set. Special attention is paid to prediction of forging defects and finding ways to eliminate them. Also in this paper different simulation advantage are highlighted [3].

A.Cherouat *et al.* studied the numerical methodology developed in order to improve the cold 3D forging process with respect to the ductile damage occurrence. In this paper methodology is based on advanced constitutive equations accounting for the “strong” coupling between the elastic plastic behavior, and also the mixed isotropic and kinematic hardening and the isotropic ductile damage. Studied the mechanical and numerical aspects related to the associated initial and boundary values problem are briefly outlined. Application is made to be the cold forging of a 3D part by studying the influence of the material ductility as well as the friction nature between the part and the die on the damage occurrence [4].

Aktakka *et al.* in this study analyse the warm forging process, this process is strongly affected by the process temperature. In hot forging process, a wide range of materials can be used and even complex geometries can be formed. However in cold forging, only low carbon steels as ferrous material with simple geometries can be forged and high capacity forging machinery is required. Also the warm forging compromise the advantages and disadvantages of hot and cold forging processes. In this paper warm forging process, a product having better tolerances can be produced compared to hot forging process and a large range of materials can be forged compared to cold forging process [5].

Camshaft is utilised in the automotive industry, the goal of our effort is likewise related to the automotive industry. The customer desires a high-quality product at a low cost. The goal is to improve the yield %, forging weight ratio, press load, manufacturing pace, and overall price of the component. Improvements to the aforementioned point by die design and switching from horizontal to vertical forging.

2. *Problem definition*

Camshaft yield percentage for the present die design is 58.5%. The process design of the camshaft die is optimised, and the camshaft yield percentage is controlled. Additionally, the forging die design should be improved to reduce the input weight for the forging of the camshaft, which will increase production and lower the part's cost. This will result in a decrease in the process' total cost and camshaft cost.

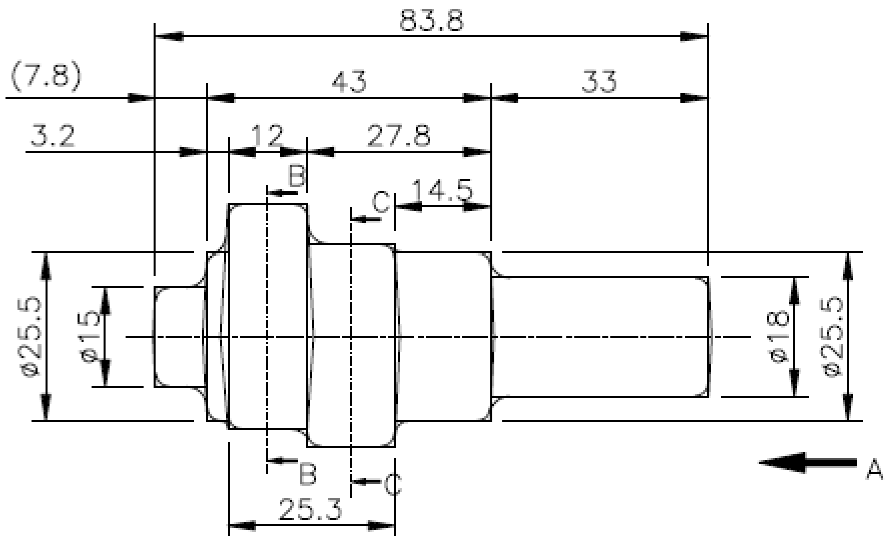

Figure 1: Horizontal Die Forging Process of Camshaft

2.1 Justification of problem selection

Table1. Horizontal Forging Process Parameters

Sr. No	Parameter	Ingot 1	Ingot 2	Ingot 3
1	Ingot Weight	0.400 kg	0.450 kg	0.500 kg
2	Ingot Diameter	38 mm	38 mm	38 mm
3	Ingot Area	1134.11 mm^2	1134.11 mm^2	1134.11 mm^2
4	Ingot Length	44.87 mm	50.48 mm	56.09 mm
5	Ingot Volume	50887.5 m^3	57249.87 m^3	63612.22 m^3
6	Ingot Temperature	700 – 750 ^{0}C	700 – 750 ^{0}C	700 – 750 ^{0}C
7	Press Load	250 ton	250 ton	250 ton
8	Die Contact	Under filling	Under filling	Filling

Different types of ingots simulated on SIMUFACT software then following results were obtained.

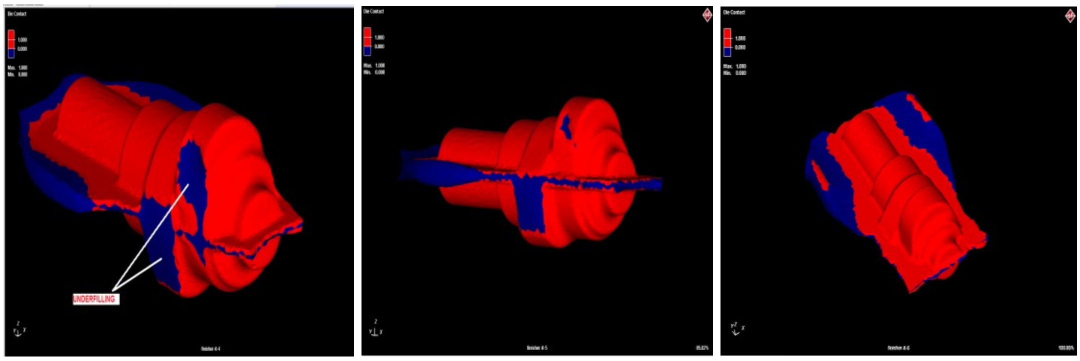

Figure 2: Simulation of Horizontal Die Forging Process for 0.400 kg, 0.450 kg, 0.500 kg Respectively

For ingot 0.400 kg

In existing forging process (horizontal forging process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.4×1.06

=0.424 kg.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Yield % = 72 %

As per the simulation of the ingot 0.400 kg yield percentage is 72 %. But final result is under filling of the die cavity. We compare this result with other results thus this ingot is not suitable for this process.

For 0.450 kg Ingot

In existing forging process (horizontal forging process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.45×1.06

=0.477 kg.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Yield % = 64.98 %

As per the simulation of the ingot 0.450 kg yield percentage is 64.98 %. But final result is under filling of the die cavity. We compare this result with other results thus this ingot is not suitable for this process.

For 0.500 kg Ingot

In existing forging process (horizontal forging process) yield % is the ratio of net weight to gross weight.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.31 kg

Gross weight = Cut weight × 1.06

= 0.5×1.06

=0.53 kg.

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

$$\text{Yield\%} = \frac{0.50}{0.53} \times 100$$

Yield % = 58.5 %

As per the simulation of the ingot 0.500 kg yield percentage is 58.5 %. But final result is filling of the die cavity. We compare this result with other results then thus ingot is suitable for this process.

3. Methodology

3.1 Die Set

Figure 3: Actual Die Tooling

In Figure 3: die is the specialised tool used in this research work. Die is a special tool used for shaping the material mostly using a press. In this research work die is given the desired shape of camshaft. In Figure 3: upper halves and lower halve of die are shown in respectively. Lower halve is fix on the press with the help of fixture and upper halve moves upward to downward and vice versa in the press.

3.2 Ingot

Figure 4: Actual Ingot

In Figure 4: this ingot is used in actual camshaft forging process. This ingot is shaped with the help of die and mechanical press. When applying pressure on die automatically pressure acts on the ingot and then ingot takes the desired shape of die. Following consideration is important at the time of ingot selection.

3.3 Mechanical Press

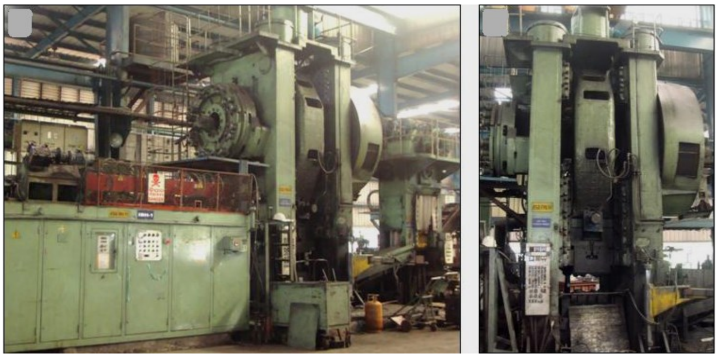

Figure 5: 600T Mechanical Press

The actual trial was taken at the forging division of M/s Siddeshwar Ind. Pvt. Ltd, Pune. Mechanical cranked press of capacity 600T was used for the forging operation. The Figure 5: shows the setup of 600T mechanical press. The inline induction heating arrangement was used for heating the ingot to required temperature.

3.4. Induction Heater

Figure 6: Inline Induction Heater

In Figure 6: The inline induction heating arrangement is used for heating the billet to required temperature. The billet heating temperature range is 700 – 750 ^{0}C which is related to warm forging process. Induction heating is a non contact method of heating a conductive body by utilising a strong magnetic field. Supply frequency 50 Hz - 60 Hz induction heaters incorporate a coil directly fed from the electric supply, typically for lower power industrial applications where lower surface temperatures are required.

3.5 SIMUFACT Software

SIMUFACT is internationally operating software, whose head quartered is located at Hamburg, Germany. Software is used for the design and optimization of manufacturing processes my means of process simulation. Use of the SIMUFACT software to compare the simulation results of horizontal die forging process and vertical die forging process. Such as yield percentage, input forging weight, gross weight and trimming press load.

4. Modelling of forging die

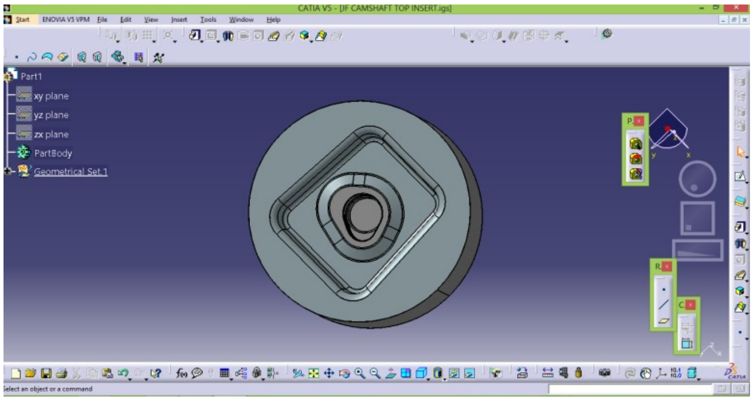

Figure 7: Modelling of Camshaft Forging Die Top Insert in CATIA V5 Software

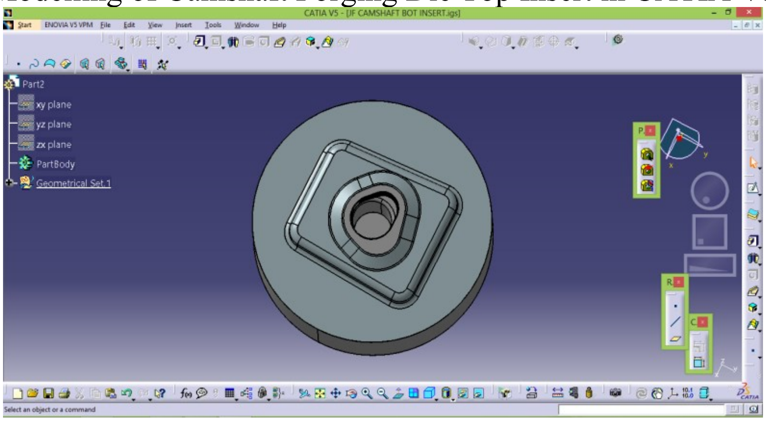

Figure 8: Modelling of Camshaft Forging Die Bottom Insert in CATIA V5 Software.

In Figure 7: and Figure 8: shows the modelling of camshaft forging die with top and bottom insert respectively. These models dimensions are as per the component dimensions in given above component drawing. Show the design of die model in CATIA V5 software in Figure 7: and Figure 8: respectively.

3. Results and Discussion

Vertical Forging Process

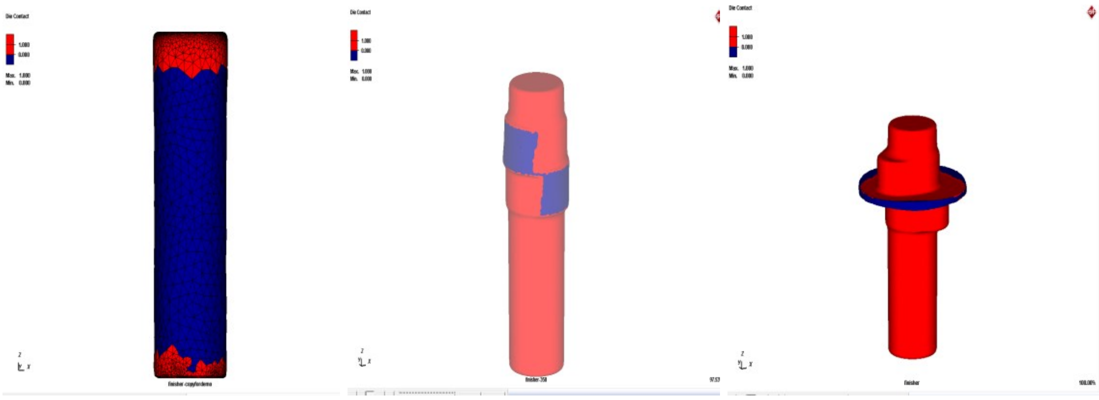

Figure 9: Simulation of Vertical Die Forging Process for 0.300 kg, 0.350 kg, 0.400 kg Respectively

For 0.300 kg Ingot

In improved forging process (vertical process) yield % is the ratio of net weight to gross weight

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06 kg

= 0.3× 1.06

= 0.318 kg

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Yield % = 113.20 %

As per the simulation of the ingot 0.300 kg yield percentage is 113.20 %. But final result is under filling of the die cavity. We compare this result with other results then thus ingot is not suitable for this process.

For 0.350 kg Ingot

In improved forging process (vertical process) yield % is the ratio of net weight to gross weight

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06 kg

= 0.35× 1.06

= 0.37 kg

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Yield % = 97.29%

As per the simulation of the ingot 0.350 kg yield percentage is 97.29%. But final result is under filling of the die cavity. We compare this result with other results then thus ingot is not suitable for this process.

For 0.400 kg Ingot

In improved forging process (vertical process) yield % is the ratio of net weight to gross weight

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Net weight = 0.36 kg

Gross weight = Cut weight × 1.06 kg

= 0.4× 1.06

= 0.43 kg

$$\text{Yield\%} = \frac{\text{Net Wt.}}{\text{Gross Wt.}} \times 100$$

Yield % = 83.72%

As per the simulation of the ingot 0.400 kg yield percentage is 83.72. But final result is filling of the die cavity. We compare this result with other results then thus ingot is suitable for this process.

5. Conclusion

Yield Increased by 25.2%, from 58.5% to 83.72%. Since the yield % is based on the ingot's ratio of net weight to gross weight. As a result, we optimise the ratio and raise the process' yield %. Reduce the weight of the input forging from 0.500 kg to 0.400 kg. Given the length requirement and the raw materials cross section of 38, the input gross weight for the horizontal process is 0.500 kg. Given the requirement for length and the raw materials cross section of 24, the input gross weight for the vertical forging process is 0.400 kg.

Acknowledgement

The author would like to thank Principal, Prof. Dr. N. G. Narve, from PES’s College of Engineering Phaltan for their valuable guidance and for skilful assistance with the work.

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