Implementation of design for manufacturing in hot forging

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Abstract. The manufacturing of components in Hot forging method is seen in detail. The concept of Design for Manufacturing in Product design and development is discussed. The Role of Design for Manufacturing will be implemented in this project for the reduction of cost of production, Reduce the wastage during production and also to increase the production rate. Here in this project the Six Case study will be taken for the design of manufacturing in Hot Forging. The cost evaluation in the hot forging process is evaluated.

Key words. Design for Manufacturing; Hot Forging; Product Design and Development.

1. Introduction

Design for manufacturing is a concept of Engineering which is widely used for product designing which is done for improving the easy fabrication of the product. This concept is almost followed in all the engineering disciplines, but implementation of concept differs widely depends on the manufacturing technology. Here in this project the design of manufacturing is been practiced in the Hot Forging Technology.

Forging is a type of manufacturing process where the metal is shaped as per the shapes in the Die. There are three type of Forging: Cold Forging, Warm Forging & Hot Forging. This manufacturing process of metal shaping can be done through Hammering, Pressing & Rolling. The General concept of forging is that the metal is deformed plastically to the desired Shape by giving a high fatigue resistance and strength.

1.1. Manufacturing Process:

The Manufacturing process of Hot Forging has the process flow of Billet Shearing, Billet Heating, Forging and Trimming & Shot blasting.

The Forging is formed in three stages such as Rolling, Moulding & Finishing. The stages of forging process are as follows:
2. Literature Survey

The literature survey to be done for forging is broadly divided into various categories which are depending upon the research done as below: Various Techniques of Hot Forging, The modifications done in the Techniques, Results observed and the case studies have also been discussed.

2.1. Defect Removal:

The Major area of forging research carried out is the Defect removal technique because the greater number of losses occurs due to the rejections or rework of product to remove the forging defects in the forging industry [1]. The various types of forging defects that occurs on the Forged Product are lapping, mismatch, scales, Surface cracks, unfilling, etc. [5] These defects can be resulted due to the poor design or poor extrusion of manufacturing or also due to the material related problems. Those defects were been investigated and rectified by various researchers by doing a case studies on integral axle arm [7], Axially symmetrical and flanged components, Synchronizer ring, Stud bolt, Steel End Plate, etc.

2.2. Ease of Manufacturing:

The Capability of manufacturing a components is also an important aspect which ensures a greater importance in the industries which aids in the manufacturing of a part. This also helps in manufacturing a product with minimum forging load. The product can be executed only through a proper die design, choosing of proper billet shape and size and optimized level of process conditions [2]. These requirements are been explained through various case studies and researches taken up by many researchers which includes Forging parts like Wear Specimen and Centre Guide, helical forging, Alloy wheels, etc.

2.3. Process Optimization:

The process of Forging can be optimized by altering various process parameters like Die Stroke Speed, friction coefficient, temperature, etc. [6]. An optimized process is carried out to achieve a good quality of product with minimal forging loads [8]. Various components have also been studied like starter motor ring gears, compressor blades, helical gears, pneumatic clamp, spindles, etc.

Table 1 – Manufacturing processes of Forging

| Process Name | Pictorial Representation |
|--------------|--------------------------|
| Rolling      | ![Rolling](image1)        |
| Moulding     | ![Moulding](image2)      |
| Finishing    | ![Finishing](image3)     |
2.4. **Preform Design:**

Preform design includes the factors like changing the billet shape, change of flash thickness and width, increasing the corner and fillet radii to reduce the forging loads and also to ensure the complete filling of Die impression [3]. A good preform design results in the proper distribution of metal in the die cavity. Many case studies have been taken up by many researchers include Pinion and Helical gear, Connecting rod, etc.

2.5. **Die Analysis:**

Die life plays an important role in the forging industry because the major cost of production is the die Cost [9]. Fatigue Analysis of the dies are done using the FEA which gives a good estimation of forging dies and tools life [4]. The surface of die is also an essential criteria because it improves the coefficient of friction which is involved in the metal flow during forging process.

3. **Implementation Of Design For Manufacturing In Hot Forging**

3.1. **Forging Route Change**

- **Material Used:** The material used in this part is S10C.
- **Customer:** PRF > SEAHAN STAMPING > HANON > GENEREAL MOTORS
- **Application:** A Fan Pulley is mounted in car of Air Conditioner Sub-subheadings.

3.1.1. **Problems Identified**

- High Draft Angle.
- More Forged Weight compared to Machined Weight.
- Thickness not under control.

3.1.2. **Recommendation:**

- The Draft angle can be reduced.
- Thickness tolerance can be reduced.
- Mass of the part can be reduced.

![Figure 1: Pulley Forging](image)

a) Hammer Route  b) Press Route
3.2. **Implementation of Forging Design**

**Material Used:** The material used in this part is EN-8D.

**Customer:** PRF > RANE > TRACTORS AND FARM EQUIPMENT LIMITED

**Application:** The movement of Drop Arm results in motion of the stub axles.

### 3.2.1. Problems Identified:

- No Draft Angle provided
- No Ejection angle in opposite directions.
- The part is not angles vertically aligned.
- Sharp edges and No Radius provided in corners.

### 3.2.2. Recommendation:

- The Ejection angle has been provided.
- Orient profile has been provided.
- The Part is aligned vertically
- Sharp edges has been removed and radius has been provided.

This is a preparatory step in which billet (rod) is compressed on one side for the amount of 32mm (Fig.2). This operation is foreseen for the mass distribution along the longitudinal axis of the work piece in order to enable better die filling in successive, following operation.

![Figure 2: Design of Manufacturing in Forging](image)

a.) Before Implementation of DOM  

b.) After Implementation of DOM

3.3. **Commonization of Similar Parts**

**Material Used:** The material used in this part is EN-8D.

**Customer:** PRF > RANE > TATA MOTORS

**Application:** A roller follower having two or three teeth engages with the worm teeth and is carried on two sets of needle rollers supported on a short steel pin.

### 3.3.1. Problems Identified:

- The two parts has the similar profile and two die has been carried out.
- Two Setting time found for the two part forging process.
- The Mechanical properties and supply condition of the both parts found same.
3.3.2. **Recommendation:**

- The Two parts can be communized to a single part.
- The single die can be used for the production of both the parts.

**Figure 3:** Superimposing of two machined 2D with Communized forging 2D  

a.) Rocket Shaft 1 2D Super Imposed  

b.) Rocket Shaft 2 2D Super Imposed

**Figure 4:** Final Forging drawing after Commonization

3.4. **Common Moulder for LH & RH Finisher**

Material Used: The material used in this part is EN-8D.  
Customer: PRF > RANE > POLARIS  
Application: The Tie rod end is used in the alignment of wheels which provides the adjustment for the wheel to keep the tires free from wear out on the either edges.

**Figure 5:** Die Layout – Communized LH & RH
3.4.1. Problems Identified:
- The two parts has similar profile with two orientation LH / RH and two die has been used.
- Two Setting time found for the two part forging process.
- The Mechanical properties and supply condition of the both parts found same.

3.4.2. Recommendation:
- The process stages of two parts can be communized in a single die.
- The common moulder can be used for the production of the both finisher.

3.5. Common Moulder for Long and Short Parts:

Material Used: The material used in this part is EN-8D.
Customer: PRF > RANE > NEXTEER > FORD MOTOR CORPORATION

3.5.1. Problems Identified:
- The two parts has the similar profile with only change of Length and two die has been used for the production.
- Two Setting time found for the two part forging process.
- The Mechanical properties and supply condition of the both parts found same.

3.5.2. Recommendation:
- The process stages of two parts can be communized in a single die.
- The common moulder can be used for the production of the both finisher.

Figure 5: 2D Sketch of Socket Forging
a.) Socket Forging Long  b.) Socket Forging Short

Figure 6: Communized Die for Long & Short Socket Forging
3.6. Two Impression in a Single Die

Material Used:  The material used in this part is S35C.
Customer: PRF > RANE NSK > TATA MOTORS LIMITED
Application: Steering Yoke is the most common type of steering that is driven by the steering wheel from the user.

3.6.1. Problems Identified:
- The Smaller part covers only the 50% of the Standard Die size
- The Life of the parts gets completed in single die sinking is very less.
- The Excess Die area found unused.

3.6.2. Recommendation:
- The two set of all three stages is provided in the single die.
- Two rectangular lock is provided at two diagonal ends to control mismatch.

![Figure 7– Die Layout with two set of Die Cavity](image)

4. Conclusion:

Design for manufacturing is an important aspects of reducing overall costs during product development. The Role of Design for Manufacturing in this project has given the great reduction of cost of production, Reduce the wastage during production and also to increase the production rate [10].

Some of the important findings from the each case study is given below:

- In the first case study, we recommended to change the Forging process from Friction drop hammer forging to Mechanical press Forging. Due to this process modification, raw material used has been reduced up to 7% from the existing method and with the result of above change Cost reduction of Rs.5.54 / Part was achieved.
- In the second case study, we recommended a new design change in customer Part drawing based on the complexity in the forging process. This made the part feasible for production in hot
forging.

- In the third case study, we recommended different part drawings into common single die set which gave the cost reduction of 50% from the existing die cost.
- In the fourth case study, we recommended a single die set for two Left and Right Oriented part (Socket Forging) to reduce the cost of die and the die setting time.
- In the fifth case study, we recommended a single die set for different dimensional with similar part profile (Socket Forging) to reduce the cost of die and the die setting time.
- In the Sixth case study, we recommended the improvement in existing die layout and thereby doubled the production rate.

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