Designing a Forging Die to Improve Productivity in Forged Front Axle Beam – A Review

Amar H. Mane[1] R.K. Kawade[2]
[1]PG Student [2]Professor
[1,2]Department of Mechanical Engineering
[1,2]DYPIET Pimpri, Pune

Abstract— In today's competitive industrial world there is a growing demand for more efficient and economic manufacturing process to reduce production cost, increase productivity, reduce lead time and at the same time improve product quality. Underfill is one of the major problem observed in forging. Underfill occurs in process due to improproper ventilation, sticking and dies wear out problem. It can be easily visualize and measure with the help of gauge. The presence of underfill will scrap the job. Front axle beam is forged on hammer machine. In forged front axle beam Underfilling problem can be solved with the help of upsetter die. Hammer and upsetter are different machines used in forging, generally round material is used in upsetter machine for forging. This review study focuses on the correcting the underfill problem in front axle beam.
***Key words*:** Underfill, front axle beam, upsetter die

I. Introduction

Front axle is the one of the most important safety parts, and it is also the biggest and most heavy forging parts in Automobile, which request front axle to higher strength and fatigue strength. The parts are complex shape, symmetrical shapes, but big section fluctuate, especially the steel position and stopper position, its cross-section is not only deep but narrow, and it is one of the most difficulty long shaft type forging.

In forging the material is deformed applying either impact load or gradual load. Based on the type of loading, forging is classified as hammer forging or press forging. Hammer forging involves impact load, while press forging involves gradual loads. Based on the nature of material flow and constraint on flow by the die/punch, forging is classified as open die forging, impression die forging and flashless forging. Open die forging: In this, the work piece is compressed between two platens. There is no constraint to material flow in lateral direction. Upsetting is an open die forging in which the billet is subjected to lateral flow by the flat die and punch. Due to friction the material flow across the thickness is non uniform. Material adjacent to the die gets restrained from flowing, whereas, the material at center flows freely. This causes a phenomenon called barreling in upset forging.

Impression die forging both die and punch have impressions, shapes which are imparted onto the work piece. There is more constrained flow in this process. Moreover, the excess metal flows out of the cavity, forming flash. Flashless forging – in this the work piece is totally constrained to move within die cavity. No excess material and hence no flash forms. Flashless forging involves high level of accuracy. Designs of shape of die cavity, finished product volume are important. Following are the types of forgings, which are as follows [1-3].

A. *Open die forging-*

In open die forging a cylindrical billet is subjected to upsetting between a pair of flat dies or platens. Under frictionless homogeneous deformation, the height of the cylinder is reduced and its diameter is increased. Forging of shafts, disks, rings etc are performed using open die forging technique. Square cast ingots are converted into round shape by this process. Open die forging is classified into three main types, namely, cogging, fullering and edging. Fullering and Edging operations are done to reduce the cross section using convex shaped or concave shaped dies. Material gets distributed and hence gets elongated and reduction in thickness happens. Cogging operation involves sequence of compressions on cast ingots to reduce thickness and lengthen them into blooms or billets. Flat or contoured dies are used. Swaging is carried out using a pair of concave dies to obtain bars of smaller diameter.

B. *Closed die forging-*

It is also known as impression die forging. Impressions are made in a pair of dies. These impressions are transferred to the work piece during deformation. A small gap between the dies called flash gutter is provided so that the excess metal can flow into the gutter and form a flash. Flash has got a very important role during deformation of the work piece inside the die cavity. Due to high length to thickness ratio of the flash gutter, friction in the gap is very high. Due to this the material in the flash gap is subjected to high pressure. There is high resistance to flow. This in turn promotes effective filling of the die cavity. In hot forging, the flash cools faster as a result of it being smaller in size. This enhances the resistance of the flash material to deformation resistance. As a result of this, the bulk of work piece is forced to deform and fill the die cavity more effectively – even intricate parts of the die cavity are filled.

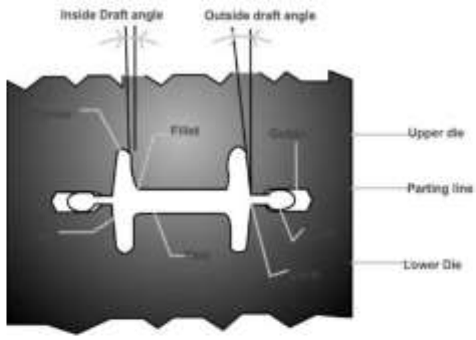

Fig. 1: Parameters of impression die forging

Flash is subsequently trimmed off in order to obtain the required dimension on the forged part. Often multiple steps are required in closed die forging. Flash is to be properly designed so that the metal could flow and fill the intricate parts of the die cavity. A thin flash with larger width requires higher forging loads. Before getting forged to intermediate shape inside the primary die set called blocking die, the billet is fullered and edged. This is called preforming. Subsequently, it is forged to final shape and dimensions in the finishing die. Closer dimensional accuracy is possible in closed die forging. However, higher forging loads are required. Parts with wider and thinner ribs, or webs are difficult to forge as they require higher forming loads. Impression dies are usually provided with taper called draft of 5o in order to facilitate easy removal of the finished part. Die preheating may be required to prevent the die chilling effect which may increase the flow stress on the periphery of the billet. As a result, incomplete filling or cracking of the preform may occur.

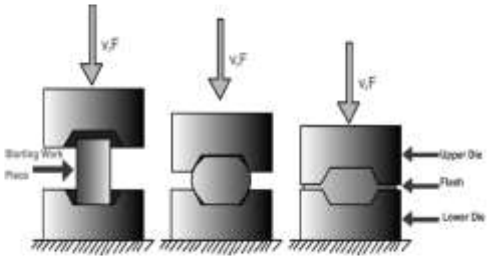

Fig. 2: Stages of closed die forging process

Secondary die is the different from the primary one which is using for forging of front axle beam. Secondary die are using for to eliminate the under fill problem. Upsetter is the machine which is different from Hammer. In upsetter we can use only round material for forging. Upsetter is having fixed die, moving die and holder which contain punch. In upsetter, there may be 2 pass, 3 pass, 4 pass or 5 pass in die. Application of this upsetter is we can forge job which is having the impression on the front side of cutting material. That is, we forged material which is having space to locate tong on one end of material during forging.

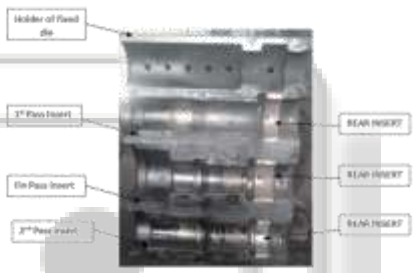

Fig. 3: Upsetter die

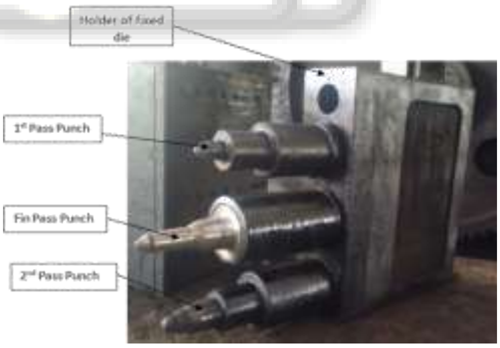

Fig. 4: Upsetter die and header

Front axle beam diagram is as shown in figure

Fig. 5: Front axle beam

The completely filled pad section is as shown below

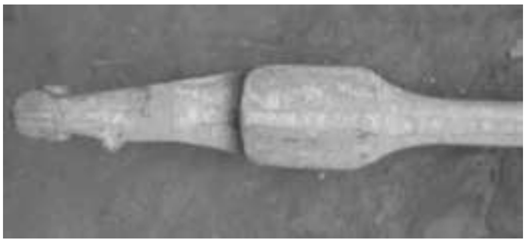

Fig. 6: Completely filled pad section of front axle beam

The underfill pad section of front axle beam is as shown in figure.

The red marked section is the underfill portion of front axle beam.

Underfill problem in front axle beam is 90% came in pad section which is deep cavity in forging die.

Fig. 7: Underfill pad section of front axle beam

II. LITERATURE REVIEW

G.D. Satisha, N.K. Singhb, R.K. Ohdarb suggested optimization of pad section of front axle beam using DEFORM. FEM-based computer simulation has been used to optimize the design parameters and input billet cross-section for front axle beam. These techniques are cheaper than performing tryouts with actual dies and equipments. Optimization can be achieved quickly and efficiently through the use of simulation software. Modelling provides more information about the process i.e. load requirement and metal flow at different stages of the process.

Ru-xiong Li, Song-hua - Jiao, Kin-lv Wang, suggested a Roll-Forging Technology of Automotive Front Axle Precision Performing and Die Design. In the production of automotive front axle forging, rolling technique is used for improving product quality.

Esa Ervasti, Ulf Stahlberg suggested a Qausi-3D Method used for increasing the material yield in closed-die forging of from axle beam. According to the quasi-3D approach, author concluded that circular shapes along the length of the billet are beneficial when forging a component such as a front axle beam. Thus it seems reasonable to recommend the avoiding of square cross-sections for similar problems.

Chun-Yin Wu, Yuan-Chuan Hsu suggested the influence of die shape on the flow deformation of extrusion forging. The draft angle and the fillet radius affect the extrusion load, strain and its distribution and flow deformation at different levels.

Zhong-Yi Cai suggested precision design of roll-forging die and its application in the forming of automobile front axles. The roll-forging technique of front axels has many advantages in technology and economy, for instance, the investment on this technique is only about 22% of that on die forging by mechanical forging press, and the products of this technique have high mechanical properties and long fatigue life.

Ryuichiro Ebara, Katsuaki Kubota performed Failure analysis of hot forging dies for automotive component, this paper influencing variables and causes of hot forging die a failure, characteristics of die failures, analysed Examples of failed hot forging die and its counter measures are briefly summarized. The hot forging die failure is complicated with various kind of influencing variables such as die material, die design,die manufacturing and forging operations. Failure analysis of hot forging die failure must be conducted for each failed hot forging die. Die design and lubrication method is necessary to improve.

Victor Vazquez, Taylan Altan suggested Die design for fashless forging of complex parts. Flashless forging results should be compared with results obtained from forging with flash. This will help to determine more clearly the advantages and disadvantages of flashless forging, flashless forging could result in significant material savings, and however, a more strict control of the volume of the preform is necessary.

Chun-Yin Wu, Yuan-Chuan Hsu studied the influence of die shape on the flow deformation of extrusion forging. The flow deformation of extrusion forging is similar to that of the initial pre-forging of closed-die forging and is frequently found in the forming process of high strength parts. Therefore, understanding the influence of the die shapes on metal flow deformation will be beneficial in designing a forging die or in determining the parameters of the forging process. In this paper, the finite element method was used to analyse the influence of die shapes with different draft angles and fillet radii on the extrusion forging deformation. Experiments using two sets of dies with different shapes were performed, and the results were compared with the predictions of the finite element method for the same deformation mode. Thus, the results of the deformation analysis in this study were extended to the design of a more complicated pre-forging die and in the planning of a forming process.

III. CONCLUDING REMARK

Underfill problem is one of the major problem in forging. This is one of the different methods for correcting underfill problem of front axle beam with the help of upsetter die. We are designing a new die for rework of forged front axle beam on upsetter machine, which is different than forging die of front axle beam. That regular die is used in hammer machine. With the help of this upsetter die the rejection for front axle beam for underfill problem will be 1 to 3%.

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