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A Review on closed die forging

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ABSTRACT - The purpose of this paper is to identify and comprehend Closed die forging procedures, as well as to analyse numerous forging flaws. The forging process produces completed objects in a reasonable length of time with little to no scrap. There will be a lot of work involved in making connections between the technical and economic aspects of the forging process. Knowing the forging process will require an understanding of concepts like exploitation factors and combining operations. Even though there have been numerous works in this field, prototype design typically relies on the trial-and-error method. This research examines the impact of temperature and grain refinement on a small copper gear with 12 teeth, closed-die forging, and a 0.4 mm shaft module. Forging. The process of forging places a strong focus on experience. In the research, this method has been utilised to model and evaluate closed die forging in terms of flash production following final impression filling. The project's objective is to develop a CAD/CAM system for the closed-die forging process. Preventing flow faults like laps and ensuring complete die fill with less flash and less forming stress are requirements for the perfect preform shape.

Key Words: machining, flaws, deformation, temperature, stresses

I. INTRODUCTION

In contrast to open die forging, close die forging involves the forced flow of the material into a closed shape known as a die. In comparison to open die forging, close die forging can produce more intricate geometries that are extremely close to the final component's dimensions. Rapid plastic deformation is produced by a few shots that push the material into the die's shape. Without any re-heating, the operation is carried out at the plastic temperature of the material being used.

Metal is inserted into a die that resembles a mould and is linked to an anvil during a process called closed die forging. Typically, the hammer die is also formed. The metal then flows and fills the die cavities as the hammer is struck on the workpiece. Within milliseconds, the hammer repeatedly makes contact. The number of times the hammer drops may vary depending on the size and intricacy of the component. Flashing is the term for the extra metal which escapes from the die cavities. The flash helps stop the formation of more flash because it cools more quickly than the surrounding material and is typically stronger than the metal in the die.

1. Closed Die Forging Application

Steel and aluminium components are mostly produced via closed die forging. Therefore, closed die forging has several applications. It might be used to make lifting and rigging components, forestry wear parts, agricultural wear parts, construction wear parts, and mining drilling bits, among other things. In a nutshell, any application that needs high-quality components might use this approach.

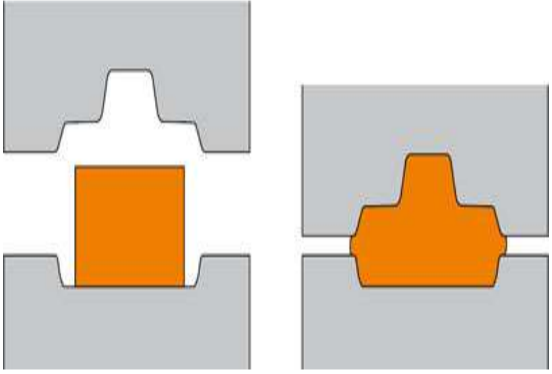

Fig -1: Closed die forging

II. CLOSED DIE FORGING ADVANTAGES AND DISADVANTAGES

Forging is the process used to shape metal utilising controlled plastic deformation while creating a metal object. Although there are many distinct forging techniques, closed die forging is one of the most used. In this method, heated round bars are pressed and their nets are shaped in closed dies. For all industries, including engineering, construction, aerospace, power production, defence, oil and gas, etc., this method yields the needed forms. In order to learn more about it, let's have a look at some of its main advantages and disadvantages.

2.1 Advantages of closed die forging :-

Net forms or shapes that resemble nets are produced during the forging process of closed dies. The product's strength and toughness are increased, and the method delivers excellent mechanical qualities. Through this method, a tight tolerance of around +/- 0.3 mm may be attained. It works well with metals including steel, brass, and aluminium as well as several other alloys. No material limitation, therefore. Better surface quality reduces machining costs. Environmental protection is provided since it is a greener, cleaner process than casting. high rate of production and good repeatability. It is possible to make parts up to 25 tonnes in size.

2.2 Disadvantages of closed die forging :-

This method is costly since there is a larger impact involved. It could, however, be appropriate for mass manufacture. Large, complicated items might not be a good fit for closed die forging. There is a dimension restriction with this technique. Thus, when utilised for mass manufacturing and to increase product strength and toughness, this procedure is often a cost-effective one.

III. DEFECTS

Forging has flaws even though it's one of the greatest production procedures for improving mechanical qualities. These flaws should be investigated and prevented. By carefully considering the amount of the work material, proper forging die design, and the process, forging faults may be managed.

Care should be given during the procedure, and the smith must have prior forging experience, to avoid this forging error. Unfilled sections, cold shuts, scale pits, die shafts, flakes, inappropriate grain development, insufficient forging penetration, surface cleaning, and residual stresses in forging are examples of forging faults.

3.1 Unfilled section :-

Some areas of the piece were left empty due to these forging flaws. It results from faulty die design, a lack of raw materials, subpar forging processes, and inadequate heating. The design of the die, heating, and availability of raw materials must all be done with sufficient care to prevent the development of the problem.

3.2 Cold shut :-

These forging flaws manifest as minute cracks at the object's corners. It results from the forging die's poor design, the object's sharp corners, and over-chilling of the forged output. By increasing the fillet radius of the die, these forging flaws can be prevented.

3.3 Scale pits :-

This forging flaw results from incorrect forged surface cleaning. Scale pits are typical in forging operations conducted outdoors. It results in erratic deputations on the surfaces of the forging. The forged surface can be sufficiently cleaned to prevent this flaw.

3.4 Die shift :-

When the upper and lower dies are out of alignment, a die shift forging fault results. The product will have incorrect dimensions as a result. When the dice is properly aligned, the flaw may be avoided. To ensure that both sections of the workpiece match, place half of it on the higher die and half of it on the bottom die.

3.5 Flakes :-

These forging flaws result from poor cooling of the forged product. When forged items cool quickly, internal fractures develop, which weakens the product's strength. When cooling is done properly, flakes can be avoided.

3.6 Improper grain growth :-

These forging flaws result from faulty metal flow during the casting process, which alters the product's structure's predetermined grain. By creating a superior die design, it may be prevented.

3.7 Incomplete forging penetration :-

These forging flaws are caused by quick or light hammer blows that result in incomplete forging. By using the forging press correctly or keeping it under control, it may be avoided.

3.8 Surface cracking :-

Surface cracking is a forging flaw that develops when the forging process is carried out at low temperatures, which causes cracks to appear on the workpieces. Working at the right temperature will help you regulate it.

3.9 Residual stresses in forging :-

When the forged components are not appropriately cooled, this kind of forging flaw occurs. Slow cooling of the forged component can both prevent it from happening and cause it.

IV. LITERATURE REVIEW

An Overview of Forging Processes

Forging is a procedure that emphasises experience. In this discipline, a considerable lot of expertise and knowledge have been gained over the years, mostly through trial-and-error techniques. With little to no scrap, the forging process creates finished goods in a relatively short amount of time. As a result, there are material and energy savings. Forgings can be more expensive than components made by other methods, such as casting or machining, but they result in products that are more dependable and have superior mechanical and metallurgical qualities. As part of an efficient continuous improvement programme, it is crucial to progress any process in the direction of removing all flaws since faults lead to high rejection rates. An mindset of doing things correctly the first time is the foundation of a high-quality programme.

Effects of temperature and grain refinement

In metal-forming operations, the behaviour of material flow and die filling are significantly influenced by temperature and grain size. When the process is scaled down from conventional to micro dimensions, its effects are much more pronounced due to so-called size effects. produce inhomogeneous material properties, which result non form inaccuracy and dispersion of product attributes. This study looks at how grain refinement and temperature affect a tiny copper gear with 12 teeth, a closed-die forging, and a module of 0.4 mm shaft. The development of a micro forging system with heating devices for conducting the tests performed at a high temperature. Additionally, equal-channel angular extrusion and heat treatments were used to regulate the copper's mean grain size in a range between 4 and 46 microns. According to the experimental findings, raising the forming temperature and fine-tuning the grain can enhance material flow behaviour, leading to better tooth cavity filling, more uniform hardness distributions, and smoother tooth profiles.

Hot closed die forging – State-of-Art and future development

The HCDF technology is about to enter a brand-new phase of growth. While many issues, such as those involving intermediate perceptions, such as blockers, have already been explored, there are still many more that demand further research. Future research projects might be divided into two groups: the first will focus on collecting data for new materials in a normal manner, while the second will take a more innovative approach to computer and physical modelling and simulation of the forging process. The area of process planning that looks the most intriguing and innovative is die design. Connections between the technical and economic components of the forging process will require a lot of work. Ideas like exploitation factors and combining operations will be crucial in understanding the forging process.

Effects of flash design on hot die forging process parameters

With the use of appropriate numerical simulation software packages, the finite element approach has lately been developed as one of the most effective tools for the investigation of diverse metal forming processes. This technique has been used in the research to simulate and analyse closed die forging in terms of flash production at the conclusion of final impression filling. It has been determined that it might be utilized as a first phase of flash land design at hot die forging based on both FEM simulation and analytical description. The assessment of the elastic deflections of the die and the machine under consideration should come next, and if necessary, flash thickness adjustment should come after that.

Shape Design Using Isothermal Surfaces in Closed Die Forging

A crucial stage in the development of hot forging technologies is preform design. The ideal preform shape must prevent flow flaws like laps and guarantee complete die fill with less flash and decreased forming stress. Preform design is frequently dependent on the trial-and-error technique despite the fact that there have been many works in this sector. Preform design can be done using a method that uses equipotential or isothermal surfaces found in the domain between two forms that represent the workpiece and the finished forging. There have not been many actual implementations of this approach. In order to generate a preform shape and a die block design based on that shape, it is necessary to make an appropriate but not immediately apparent choice of the most appropriate equipotential surface to be turned into a CAD model. In order to complete this process, various geometrical changes must be made between the simulation and design programmes, which might be challenging to do using general-purpose CAD software. To automate the data transition from finding the isothermal surfaces used as prototypes of the preform shape with subsequent die block creation and further simulation verification of the technology, the authors of the work have integrated QForm metal forming simulation software with a specially developed variant of a CAD system in the work that is being presented.

Development of a CAD/CAM system for the closed-die forging process

Modern metal forming technique is dependent on the use of computer-aided engineering (CAE), computer-aided design (CAD), and computer-aided manufacturing (CAM). Thus, the finite element method (FEM) has gained significant importance in current and advanced research as the modelling process for the examination and comprehension of deformation mechanics has become a key problem. Relevance, especially when modelling the processes of deformation. The goal of this endeavour is to create a CAD/CAM system for the procedure of closed-die forging. The three steps of system development are metal flow modelling, die failure analysis, and design. machining code creation and implementation, as well as optimization. The FEM was utilised in the initial step to model the axisymmetric procedure of forging copper using a closed-die. The technique is used to investigate metal flow, die filling while maintaining the nonlinearity associated with the significant change in geometry, the continuous change in the contact surface condition, and the work-hardening properties of isotropic materials. A finite element analysis and optimization programme is created in the second stage to investigate the die fatigue life and to enhancing the die design. Using commercially accessible finite element software, the first and second stages of the finite element analysis were completed. LUSAS software is used. In the third stage, CAD/CAM software is used to create and implement a machining code for the optimised die. called a CNC machine and UniGraphics.

Modular Analysis of Geometry and Stresses in Closed-Die Forging

The development of subroutine programmes or modules for computing stresses and loads in forging components uses the slab approach. Geometrical factors like surface area and form complexity were computed for each forging cross section. A computer programme was created by putting the modules together to calculate the part's volume, a geometric shape-difficulty factor, the forging load, and the centre of loading.

If the friction factor is properly chosen, the forging load may be anticipated within reasonable approximations even if it changes significantly with the friction factor's value. Analysis of metalforming issues is made more challenging by the dependence of stresses, loads, and energy on friction. The utilisation of the ring test, together with the knowledge obtained from carefully carried out analysis, like the one described in this study, would, however, increase the precision in calculating the friction factor and forecasting forging loads and stresses.

The highest shape-difficulty factor was achieved for the portion that is thought to be the most difficult to fill based on experience. This factor is meant to define the geometrical complexity of a certain forging so that the designer may decide how many performing stages are required in forging this part, along with other considerations. The shape-difficulty factor, first proposed by Soviet employees, is described in this study in the hope that it may find broader use in forging design practise. To quantify the complexity of a forging, more approximate variables such as surface to volume ratio, rib (or shaft) height to web (or flange) ratio, or volume ratio of circumscribing parallelepiped to the forging are utilised at this time.

The modular technique of analysis given here may be extended to various nonsymmetrical forgings. The current work is being expanded to forecast the preform configurations required to forge a particular item and integrate computer-aided production of the forging dies through N/ C machining. In this regard, computer subroutines are being created to exploit surface specifications made in APT language to generate coordinates of the points defining various cross sections of a forging. Thus, a real combination of computer-aided design (CAD) and computer-aided manufacturing (CAM) will be achieved for enhancing efficiency in the design and manufacture of specific types of forging dies.

V. COMPARISON WITH OTHER METHODS

5.1 Closed Die Forging vs Open Die Forging

A cylindrical billet gets disturbed during open die forging between two flat dies. The cylinder's diameter increases as its height decreases during frictionless uniform deformation. Shafts, discs, rings, and other items are forged using the open die forging process. This method turns cast square ingots into round ingots.

closed die forging is a precision forging method because it uses accurate tooling or dies. Therefore, closed die forging can produce components with significantly higher precision, especially for tiny and medium-sized parts. And only huge goods may be forged using open dies.

5.2 Closed Die Forging vs Investment Casting

Investment casting, which differs from closed die forging, is the casting process in which liquid metal is poured into moulds to create the desired forms. The similarity between these two processes is that they can both produce components with precise dimensions and tolerances: closed die forging and investment casting. Investment casting, however, can quickly develop flaws that closed die forging can successfully obviate.

Another benefit of closed die forging is that the pressing of billets will significantly boost the products' strength. Therefore, closed die forging is particularly suited for components where safety is a concern, including lifting and rigging hardware.

5.3 Closed Die Forging vs Machining

The option of directly machining from bars to achieve desired dimensions is also available for basic shaped products. There will be significantly more raw material waste than with closed die forging. Additionally, closed die forged components will have significantly superior physical characteristics and operational performance than machined ones.

VI. CONCLUSIONS

Forging is a procedure that emphasises experience. In this discipline, a considerable lot of expertise and knowledge have been gained over the years, mostly through trial-and-error techniques. In metal-forming operations, the behaviour of material flow and die filling are significantly influenced by temperature and grain size. The HCDF technology is about to enter a brand-new phase of growth. While many issues, such as those involving intermediate perceptions, such as blockers, have already been explored, there are still many more that demand further research. This technique has been used in the research to simulate and analyse closed die forging in terms of flash production at the conclusion of final impression filling. The assessment of the elastic deflections of the die and the machine under consideration should come next, and if necessary, flash thickness adjustment should come after that. The ideal preform shape must prevent flow flaws like laps and guarantee complete die fill with less flash and decreased forming stress. Preform design is frequently dependent on the trial-and-error technique despite the fact that there have been many works in this sector. Modern metal forming technique is dependent on the use of computer-aided engineering (CAE), computer-aided design (CAD), and computer-aided manufacturing (CAM). The development of subroutine programmes or modules for computing stresses and loads in forging components uses the slab approach. If the friction factor is properly chosen, the forging load may be anticipated within reasonable approximations even if it changes significantly with the friction factor's value. Analysis of metalforming issues is made more challenging by the dependence of stresses, loads, and energy on friction. The highest shape-difficulty factor was achieved for the portion that is thought to be the most difficult to fill based on experience. The modular technique of analysis given here may be extended to various nonsymmetrical forgings. Thus, a real combination of computer-aided design (CAD) and computer-aided manufacturing (CAM) will be achieved for enhancing efficiency in the design and manufacture of specific types of forging dies.

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