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Survey of Defects during Forging Process

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Abstract: The purpose of this paper is to recognize and understand the different processes of forging, and to investigate the different defects of forging. Initially some important forging words are discussed which are commonly used in this area. A brief summary on the classification of the forging process based on the working component temperature (hot, cold, and warm forging) and the arrangement of the dies (open, impression, and closed-die forging) is given. The parameters of die design, the requirements for die materials and the selection of proper die materials are discussed in brief. The forging equipment's (hammer and press) were also briefly described. Factors for the selection of forging machines, features and common forging applications are given. Factors for the selection of forging machines, f features and can forging applications are provided. Forging defects that are occurring regularly are discussed along with their causes and remedies. The fish bone diagram is then used through a brainstorming session to explore the possible causes of defects such as unfelling, mismatch and scale pits and to determine the causes, which may have the greatest effect.

Keywords: Forging, Billet, Flash, Forging defects,Forging process, Classification, Hammer, Die, Flash.

INTRODUCTION

Forging is characterized as a process of metal working in which the useful shape of the work piece is obtained in solid state by the compressive forces applied by the use of dies and instrument. Industrial forging is performed in modern times, either with presses or hammers powered by compressed air, electricity, hydraulics, or steam. Few examples of shapes obtained by forging process nowadays are-Crane handle, IC engine connecting rod, spanner, gear blanks, crown ring, pinion, etc. Over the years the smithy or forge has developed into a facility with engineered methods, manufacturing equipment, machines, raw materials, and goods to meet the demands of modern industry[1]. Process forging produces parts of superior mechanical properties with minimal material wastage. The starting material in this process has a relatively simple geometry; this material is plastically deformed into a product of relatively complex configuration in one or more operations. While forging process gives superior product quality compared to other manufacturing processes, there are some defects that will come slightly if proper care is not taken in the design of the forging processes. There are many imperfections that can be considered defects, ranging from those traceable to the starting materials to those caused by one of the processes of forging or by post-forging[2].

DISCUSSION OF FORGING TERMS

Some Important Forging Terms:

- *Forging Die:*

It can be identified as a complete tool which consists of a pair of mating members for hammer or press production of work. Die pair is composed of upper and lower die halves with cavities[3].

- *Billet:*

A slug cut out of rod to heat and forge.

- *Blocker:*

Preform die or impression, used in a single operation whe n the part cannot be made[4].

- *Cavity:*

The meaning in the tops and the bottoms die

- *Draft Angle:*

The taper on a vertical surface to allow for easy removal of the die or punch forging. The internal draft angles are greater (70 -100), while the outer draft angles are smaller (30 -5 0).

- *Fillet:*

It is a small radius provided at die cavity corners to ensure that material flows properly and smoothly into the die cavity. By reducing fast die wear it helps to improve die life.

- *Flash:*

The excess metal that flows out between the upper and lower dies required to achieve the desired shape of the forging.

- *Gutter:*

A small depression covering the cavity in the die for pressure relief and flash flow control

- *Parting Line:*

The place on the forging where, during the forging process, excess material in the form of a flash is allowed to exit the forging.

- *Shrinkage:*

The contraction which happens when a forging cools

- *Web:*

The thin metal segment remaining in a forging at the bottom of a cavity, or depression. Piercing or machining may erase the Internet.

- *Die Closure:*

Refers to the task of closing the top and bottom members of a forge die together during the process of actually making a forging.

❖ *Classification of Forging Processes*

- *Hot Forging:*

In forging, an initially simple part- a billet, is plastically deformed between two dies to obtain the desired final configuration. For understanding and optimization of forging operations, it is useful to classify this process in a systematic way. There are a large number of forging processes that can be classified as follows:

1. *Classification based on Temperature of the Work Piece:*

Hot forging (most commonly used): Forging is performed at temperatures above the metal's recrystallization temper ature[5].

a. *Cold Forging:*

Forging is performed at or above the metal's room temperature (under the recrystallization temp). The most widely cold forged carbon and regular alloy steels are. Cold forging is generally preferred when the metal, like aluminum, is already soft. This method is generally less expensive than hot forging and needs little or no finishing work for the end product. Cold forging is also less prone to problems with corrosion, and the final product has a better overall surface finish[6].

- *Advantages:*

With exceptional die life, output rates are very high, improves mechanical properties, less friction between die surface and work piece, quick lubrication, no oxidation or scaling on the job.

Disadvantages: Residual stress may occur, there is a need for heavier and more efficient equipment, better tooling is needed, tool design and manufacturing are crucial[7].

b. *Warm Forging:*

The temperature range for the warm forging of steel goes from above room temperature to below the temperature of recrystallization. For warm forging, the billet is heated below the recrystallization temperature, for steels up to 700 to 800 0C, to the flow stress and the forging pressures.

- *Advantages:*

High production speeds, excellent dimensional tolerances and surface finish for forged pieces, substantial material and machining savings, Favorable grain flow to enhance strength, greater formed component durability[8].

❖ *Classification based on Arrangements of Dies*

Open-die forging: Forging in which the flat dies of simple form are used to allow the material to deform freely in lateral directions of the load applied[9].

- *Features:*

Less dimensional precision, Suitable only for simple work forms, Requires more operator ability, generally used for a job before being forged (to give approximate shape), this is simple and less costly, and it is simplest of all forging operations.

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- *Impression-die Forging:*

Forging that shapes the material to fill a die cavity created by the upper and lower die halves. The dies are not completely closed and allow a certain material to escape as Flash. Flash formation builds pressure within the work piece's bulk, helping material flow into unfilled impressions. Requires more complex (and costlier) fatalities[10].

- *Significance of Flash:*

Originally, excess metal is taken to ensure die is filled with metal to prevent any voids. Excess metal is squeezed out of the die cavity like a thin metal strip, called Flash. To reduce the flash area a flash gutter is provided. Thin flash increases the system's flow resistance and builds up the pressure to high values ensuring all complicated cavity shapes are filled.

- *Closed-die Forging:*

Forging in which the material in the cavity formed by the upper and lower die halves is entirely limited. It allows to form more accurately shaped parts, no flash is formed in this process therefore no waste of material, Higher interface pressures required, Requires very precise control of material volume and proper die design. Closed-die forging is a type of impression-die forging, which is not dependent on flash forming for complete die filling. Metal is deformed in a cavity that allows the excess metal to escape little or no, thus putting greater demands on die design.

- *Features:*

Work is forged roughly close to the final shape by blocking the die, work is forged to the final shape and dimensions by finishing the die, both the blocking die and the finishing die are machined into the same die block. Depending on the complexity of the job, more dies are needed, two die halves close-in and work is deformed under high pressure, high dimensional accuracy / close tolerance control, ideal for complex shapes.

- *Die Design Parameters:*

The design of the die depends on the knowledge of the strength and ductility of the work piece material, material sensitivity to the rate of deformation and temperature, frictional characteristics, work piece shape and complexity, and die distortion under high forging loads.Die material requirements: Strength and durability at high temperatures, resilience and uniform hardening capability, resistance to mechanical and thermal shocks, resistance to abrasion wear due to scales on the work piece Selection of proper die material depends on: Die scale, structure and work piece property, shape No complexity. Type of forging process, cost of die content, and number of forgings needed, heat transfer from work piece to dies, etc.

- *Forging Equipment's:*

Forged components are either shaped by a hammer, or pressed. Forging on the hammer is done using repeated blows in a succession of die impressions. The continuous development of forging technology requires a sound and basic understanding of the capabilities and characteristics of the equipment. The equipment, i.e. presses and hammers used in forging, influences the process of forging, as it affects the rate of deformation and the conditions of temperature and determines production rate.

- *Forging Hammer:*

Hammer and anvil are the most frequent forms of forging equipment. Multiple impact blows between contoured die define this technology. There are two types of anvil hammers basically: Gravity-drop hammers and Power drop hammers. The upper ram is connected with a board (board-drop hammer), a belt (belt-drop hammer), a chain (chain-drop hammer), or a piston (oil, air, or steam-lift drop hammer) in a simple gravity-drop hammer. The upstroke happens immediately following the hit. A power-drop hammer's operating principle parallels that of an air-drop hammer. In the down stroke, the ram is powered by wind, cold air or hot air pressure during addition to gravity. The board (weight) is repeatedly elevated by friction rolls and dropped onto the die.

- *Forging Press:*

In press forging, the metal is shaped not with a series of blows like in hammer forging, but with a single continuous squeezing action. There are two principal types of presses: mechanical and hydraulic. For force production, hydraulic presses use the fluid pressure and a piston. It is a computer which is restricted in load. It has more to do with gripping than hammering movement.

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Thus die can be smaller and have a longer life than a hammer.

- *Features of Hydraulic Press:*

Ram velocity can be regulated and varied during the stroke, it is a slow speed machine and therefore has longer contact time and higher die temperatures, the slow squeezing action gives near tolerance to forgings, the initial cost is higher than hammers. The durability and greater capacity are the benefits of a hydraulic press over a mechanical press.

- *Selection of Forging Machine:*

The selection of the forging machine depends on the requirements of force and energy, the material to be forged (soft material-using press, hard material-using hammers), the size and complexity of the forging, the strength of the work piece material, the sensitivity of the material to the rate of deformation, the rate of output, the dimensional precision, the maintenance, the degree of operation required, the level of noise, the cost.

❖ Characteristics of Forging:

Typically includes separate parts, can be used on hot or cold materials, sometimes requires additional finishing processes such as heat treatment, machining or washing, can be performed at rapid or slow deformation levels, can be used for very small or very large parts, and improves the physical properties of a component by monitoring and refining the material flow or grain. Common Applications of Forging-Passenger cars, vans, coaches, trailers, bikes, and bicycles. Ball and roller bearings. Generating / transmitting electric power. Machinery and machinery for the industrial and commercial sector. Tools of the side. Technology of the industry. Machinery for transmitting mechanical power. In-house combustion engines. Machinery and machinery for the oil fields. Machinery (construction, processing and handling of materials) off lane.

- *Forging Defects:*

When a forge shop starts to encounter defects in its operation, they will attempt to identify the root cause of the problem, take corrective action and enforce procedures to avoid its recurrence.Incomplete forging penetration: The arrangement of the dendritic ingot at the forging inside is not broken. Actual forging only occurs at the surface.

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