

WELDING LIFE ENHANCEMENT OF STEEL FORGING DIES

Balu C Unni¹, Daijo P O², Faizal Khan P S³, Rinson T O⁴, Salim Jeeva⁵,
Sigimon⁶, Mathew Thomas⁷

¹⁻⁵(Department of Mechanical Engineering, Nirmala College of Engineering, Thrissur, Kerala, India)

⁶(Chief Engineer, Department of Die shop, SIFL, Athani, Thrissur)

⁷(Department of Mechanical Engineering, Nirmala College of Engineering, Thrissur, Kerala, India)

Abstract: *The cost of forging dies is the single most important variable affecting the cost of the forged products. These costs can be reduced by minimizing the use of costly die steels and by extending the life time for forging dies. Die steel forging dies soon begin to wear and require reworking to extend their life time, which means that the expensive die steel quickly diminishes with the dies ultimately being disposed of when the die steel has become too thin to work with. To avoid this die repair is carried out at required time. Mostly the method used for die repair is die welding .But the life that occurred from the welding repair is also exist for a small period. The main objective of our project is to increase the life of steel dies that used for forging.*

Keywords: *Life of forging dies, welding of dies, Reinforcement Welding*

1. INTRODUCTION

Forging is the working of metal into a useful shape by hammering or pressing. This is one of the oldest of the metal working arts. It is a manufacturing process involving the shaping of metal using localized compressive forces. The blows are delivered with a hammer (often a power hammer) or a die. A die is a specialized tool used in manufacturing industries to cut or shape material mostly using apress. Like molds, dies are generally customized to the item they are used to create. Products made with dies range from simple paper clips to complex pieces used in advanced technology. Due to the continues

operation most of the die material may have reach some defects in them. A die defect is a unique and unintentional flaw in a die and is created through excessive use or polishing of the die.

According to M.Amin and Liaqat Ali^[2] The performance of hot-forging dies, in which the die cavity is weld-deposited with a layer of modified H12 hot-work tool steel, has been studied, using a continuous monitoring of the die condition as well as macroscopic and microscopic examination. It was observed that the thickness of the hard upper ‘capping layer’ and that of an intermediate ‘buffer layer’ have a pronounced effect on

the life and performance of forging die. For a given size and shape of the die cavity. There was an optimal thickness of capping layer that would give the best performance; thicker capping layers are likely to exhibit brittle cracking, while thinner layer have a tendency for early deformation and wear. For buffer layer, a certain minimum thickness is needed to provide sufficient backup support. According to Dr. Taylan Altan^[3] In warm and hot forging, the dies are subjected to high contact pressures and temperatures. The selection of the die material, hardness and coating is critical for increasing die life in precision forging. In addition to traditionally used hot work die steels, latest studies have also shown improvements in die life by use of ceramics and surface treatments including vapor depositions techniques.

It has been reported by Hammock^[4] that flood welding can increase the life of the forging die by a minimum of 50 %. Flood welding eliminates the re-sink requirement of all the features of the die, extending the life of the die and greatly reducing machining and downtime costs. Huskonen^[5] is also of the view that profitability of the forging industry can be improved by using flood welding reclamation of the dies as welding can extend the die-life significantly and provides the opportunity to reuse the die repeatedly.

Liu et al^[6] in their studies using finite element analysis have shown that thermal stresses were the main cause of die failure in hot forging dies, and that die life can be

improved through the deposition of various suitable heat resistant materials on the working surface of the die along with an intermediate layer between the parent die and the working surface layer of the die.

Jeong^[7] has determined the heat transfer coefficients using various combinations of surface treatments and lubricants in warm forging. Similarly, Lee et al^[8] developed techniques for the estimation of hot forging die life by studying the effects of various lubricants and surface treatments. This paper reviews the latest state of technology on die materials and surface treatments used in hot and warm forging of steel.

2. FORGING AND FORGING DIES

Forging is defined as a metal working process in which the useful shape of work piece is obtained in solid state by compressive forces applied through the use of dies and tools. Forging process is accomplished by hammering or pressing the metal. It is one of the oldest known metalworking processes with its origin about some thousands of years back. Traditionally, forging was performed by a smith using hammer and anvil. Using hammer and anvil is a crude form of forging. The smithy or forge has evolved over centuries to become a facility with engineered processes, production equipment, tooling, raw materials and products to meet the demands of modern industry.

Forging die may be defined as a complete tool consists of a pair of mating members for

producing work by hammer or press. Die pair consists of upper and lower die halves having cavities. The life of a forging die varies considerably depending on the size and design of the casting, the type of forging alloy, and the care and maintenance of the die. The life of a die can be prolonged by suitable treatment before and during forging by:

- Suitable preheating
- correct cooling
- Surface treatment
- stress tempering

There are various tool steels which are used in forging. Although in hot and warm forging, mainly hot work die steels are used due to their ability to retain their hardness at elevated temperatures with sufficient strength and toughness to withstand the stresses that are imposed during forging. There have also been some successful applications of other materials such as ceramics, carbides and super alloys although their application is limited due to design and cost of manufacturing. The selection of die material grade and subsequent treatment affects the mode of failure and rate of tool failure.

3. FAILURES IN FORGING DIES AND THEIR REPAIR

The majority of die failure is caused by wear or cracks along the edges and corners as a result of extreme and severe thermal stress; this is true for hammer, press and up-setter applications. Axle dies, crankshaft die and other deeply tapered dies show severe

cracking in the root of the impression, often through the bottom of the die, which is caused by the high compressive forces of the material as it is being forced into the tight die configuration. The most common defect that commonly seen in a forging die is die crack which reduce the life of the die considerably. A die crack occurs when a die, after being subjected to immense pressure during the minting process, cracks causing a small gap in the die. If this damaged die continues to produce the products, the metal will fill into the crack, thus revealing a raised line of metal in the finished products. To increase the life of die and get rid of the cavities formed the repair of dies are carried out. Usually for a steel forging dies welding repairs is mostly carried out.

For the given causes and types of forging-equipment failures, specialized welding techniques can be used to repair dies and extend their lives. When wear is the main factor in die life, a higher alloy welding material of greater hardness than the base material of the die block can be utilized. Optimum die life will be found, in all applications, by the choice of welding alloy that will prevent premature wear while preventing crack formations due to excessive hardness.

The operational sequence for the repair of the severely cracked forging hammer base is shown below:



Figure 1 the fractured base before repair



Figure 2 Work man repairs hammer base by welding



Figure 3 The finished repair

But even after the welding process the life of die obtained may be last for a little span of time. To increase this welding life we are using some screw fasteners like nuts and bolts inside the welding material. Before the welding process is done some screw fasteners are placed in the cavities that to be welded. Before the welding some screw fasteners like nuts and bolts are fixed between the cavities to be welded and the welding process is done together with this fasteners. These screw fasteners may of different material like MS, Cast Iron etc. This welded specimen is then tested under Brinell Hardness Testing machine in order to find its hardness and compare with that of the specimen that is welded without the placing of screw fasteners in it. Then comparing the reading obtained for both the specimens. By analyzing the reading obtained when different screw fasteners material used we can find that which material will provide the maximum welding life for the given forging die. Here we are experimentally proving our proposal and it's all details are given below.

4. EXPERIMENTAL PROCEDURE

The procedure of our project is described below.

A sample die material of size 100*70*50 mm is collected which is used as reference material. This die material is of "Alloy steel bar of grade 2714". Then this given material is tested under Brinell Hardness Testing Machine in order to determine the initial hardness of the specimen. The machine is of type with

maximum load of 3000kg and the diameter of the ball used is 10Mm. When the load is applied the ball will press against the material and the impression is made. The hardness is calculated by Brinells Hardness Testing machine is by using the Brinells Hardness equation^[1];

$$BHN = \frac{P}{\frac{\pi D}{2} (D - \sqrt{D^2 - d^2})}$$

Where,

D=diameter of the ball in mm

P=applied load in kg

d=diameter of the indentation in mm

Here the load used is 3000kg and the diameter of the ball is 10mm.The corresponding diameter of the impression formed is 3.2mm.So thus by the equation above hardness of the given material is

Thus the initial hardness of the die material is found and is to be 363 BHN.

Then we created a groove in the material for giving resemblance of the crack as shown in the figure



Figure 4 Die grooved for resembling crack

Then the groove is welded by arc welding by using electrode of type “CPHFD011”.Again the welded portion is tested in the Brinells Hardness Testing machine to determine its hardness. By testing the diameter of the impression formed is 4.4mm and then by brinells equation the hardness is

$$BHN = \frac{3000}{\frac{\pi * 10}{2} (10 - \sqrt{10^2 - 4.4^2})} = 187$$

Thus it show that the hardness of the die material after the welding is decreased and the life of the material. To increase the hardness and there by life instead of normal welding we provide “Reinforcement Welding” by placing external material on the die cavity.

For reinforcement welding we use stainless steel type 316 screw fasteners of diameter 10mmThe material is drilled and the fastener is placed in the groove and the welding is done. The material welded by placing the screw fasteners in it. We used fastener “Stainless steel Fastener type 316” for welding.



Figure 5 Fasteners used for welding

By placing this fasteners the welding of the crack is carried out.



Figure 6 Die after reinforcement welding.

After the reinforcement welding the die material is again tested under Brinells Hardness Testing machine for determining its hardness. After the reinforcement welding of the material the diameter of the impression formed by testing is 3.55mm and then by brinells hardness equation, the hardness is 293.

Thus it shows that the hardness of the material after the reinforcement welding increases than that of the normal welded die.

Thus we can say that the life of a die can be increased by doing welding by placing an external fastener material For making our result further valid we are providing the value of hardness that obtained for different screw fastener materials is given below

Here we use ten different fastener materials for conducting reinforcement welding and the die material is tested each time by after the welding by placing different fasteners and the hardness values are found out. The hardness values obtained will be different for different reinforcement materials because of the change in the specifications of the different fastener materials used.

Table 1 showing the difference value of hardness for different screw fastener materials

Sl.No	Type of fastener material	Diameter of the impression formed(mm)	Corresponding value of BHN
1	Carbon steel Fastener Grade8.8	3.29	342
2	Alloy Steel Fastener Grade10.9	3.3	340
3	Alloy Steel Fastener Grade 12.9	3.23	356
4	Stainless Steel Fastener Grade A2	3.79	255
5	Stainless Steel Fastener Grade 18-8	3.98	231
6	Stainless Steel Fastener Grade A4-70	3.43	314
7	Stainless Steel Fastener Grade 80	3.24	352
8	Carbon Steel Fastener of Grade 5	3.4	319
9	Carbon Steel Fasteners of Grade 2	3.78	257
10	Stainless Steel Fasteners type 316	3.55	293

From the table it can understand that the alloy steel fastener of grade 12.9 provides the highest hardness of 465 BHN and thus we can say that the reinforcement welding that done by using the fastener of type alloy steel fastener grade 12.9 will provide the maximum welding life to the die material.

5. RESULT AND DISCUSSIONS

From the results obtained from the above table we can say that the welding life of die steel which is using for the forging operation can be increased by providing Reinforcement Welding instead of normal welding. The die after Reinforcement welding obtain an increase in its life compared to that of dies which only have normal welding. The value of hardness that obtained by testing the material before welding is 363 BHN which is the hardness of the parent material. Then the material is welded for removing the crack and the material again tested after welding and this time it's hardness considerably decreases to 187 BHN.

Thus it shows that the hardness of the parent material considerably decreases which result in the decrease in its life. Thus as per our proposal, the welding repair of the crack in the die is carried out by placing an extra fastener type material and together with this Reinforcement Welding of the material is carried out. After the welding the material is again tested for hardness and this time the value of hardness obtained is 293 BHN, an increase compared to that of the reading obtained when the material is tested only with normal welding. Thus it is

experimentally proved that the life of a forging die can be increased by doing Reinforcement welding instead of normal welding for removing die failure like cracks.

For proving our assumption more valid we present the hardness of the die obtained when the reinforcement welding is done with different fasteners materials and from the result when welded with fastener type of Alloy Steel Fastener of Grade 12.9 give the maximum value of hardness which is nearer to the hardness value of the parent materials.

6. CONCLUSION

It is successfully proved that the welding life of a forging die can be increased by using Reinforcement welding instead of normal welding which will be a cost effective process. The value of welding is reducing cost, improved turnaround time and keeping the industry competitive. The Reinforcement Welding of the die material is cost effective process by which we can extend the die life and thus can reduce the budget provided for the forging dies and their maintenance which will in turn reduce the cost of the forged products.

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