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Improving die life under hot forging conditions

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Abstract

The aim of this study, indicate of optimum die life application for using some coating methods of forging die against to wear also as use different die steel and different coating materials. And another aim is decrease in the die costs which occurs wear of the die. Hot forging efficiency in direct proportion to wear of the die. At dies, workpiece is flowing on the die surface during forging processes, at a result of this causes friction between workpiece and surface of the die. At all of cycle, thermal loads and flow friction occur and this situation causes softening of the die as to be thermal. Therefore, surface hardness of the die will decrease. Losing of surface hardness and which occurs friction between die and work piece will negative effect life of the die. As to be die material, three different die steel will be used (DIN 1.2344 (ORVAR® 2 MICRODIZED) and DIN 1.2344 (UNIMAX®) At this time, different coating will be applied. These are FEXOY® and ABP+DIETOX®. As a result of coated operation, will follow cycle time proper die material will be selected.

1. Introduction

In all manufacturing processes, forging technology has a special place because of producing special parts with minimum waste material. During this operation, it will occur some plastic deformations on each cycle in die material. In hot forging process conditions, die wear is specific under thermal loads, and mechanical loads. Under high temperature, between work piece and die will occur adhesive wear. Also, thermal shock conditions will occur due to temperature difference between layers of the work piece and die whereby, surface coating have to on the die material. Failure of the dies occur which used in hot forging process, due to plastic deformation, abrasive wear, thermal shock and fatigue. Approximately %70 of failure of dies is which introduced as abrasive wear. Therefore, for estimate of die life in hot forging process, it is required to analyze the abrasive wear condition [1-4].

Generally, design and shape of the workpiece should be proper with die. Temperature difference will occur between thin and thick sections of part. In hot forging process, thin section of die material cools relatively rapidly and becomes resistant to flow and occur abrasive wear of this region. Therefore, thin section of die should always be heated. Studies have shown that die wear is not constant throughout hot forging process. Forging cycle can show changing on die life [5].

Primary apprehension of design engineers is high fatigue life in the hot forging dies. Cracking on the dies generally starts at the surface of the die. After a few thousand forging cycles, crack increases.

Die life effects many factors, metallographic composition of the material, forging operation temperature, die design, condition of the workpiece surface, hardness and toughness of the die. With changing a factor, die life can adversely effect. Therefore, in hot forging processes in general long die life is essential in order that reduce the unit fee of the product [6-8]. By improving the physical and thermal properties with this coating process, the desired optimum die life can be achieved.

2. Material and Method

In this study, the wear-related tool life of the dies and the cycle time during the forging process were observed and evaluated. ORVAR® 2M and UNIMAX® were selected as the die material. The experiment was applied to both uncoated and coated dies. The cycle time in uncoated dies was between 400 and 500, while in coated dies, this value varied between 2000 and 3500.

2.1. Die Materials

Die material should have long tool life and lowest crack risks due to excellent ductility and toughness. In addition to this, it should have good temper resistance, excellent hardenability, good dimensional stability throughout heat treatment and coating operations. In addition to carbon, various alloying elements can be added to the steel structure in certain proportions to obtain higher strengths and structures that are more resistant to heat, cold, corrosion. UNIMAX® and ORVAR® 2M steel dies used in the process have improved properties compared to the reference hot work tool steel (H13) and high toughness under hot forging processes. Therefore, UNIMAX® and ORVAR® 2M tool steels have better properties when compared to H13 (1.2344) tool steel [9].

Table 1. Chemical composition and hardness of the die materials

	Chemical Content %						Hardness Value (HRC)
	C	Si	Mn	Cr	Mo	V	
UNIMAX®	0,5	0,2	0,5	5	2,3	0,5	56-58
ORVAR® 2M	0,39	1	0,4	5,3	1,3	0,9	44-46

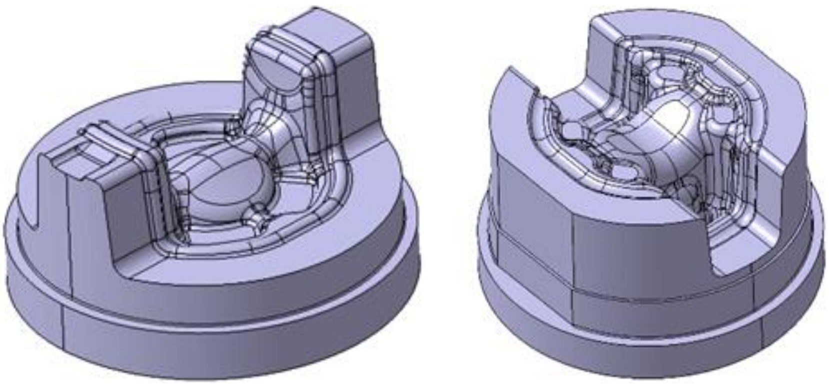

Figure 1. Die design in the CAD program

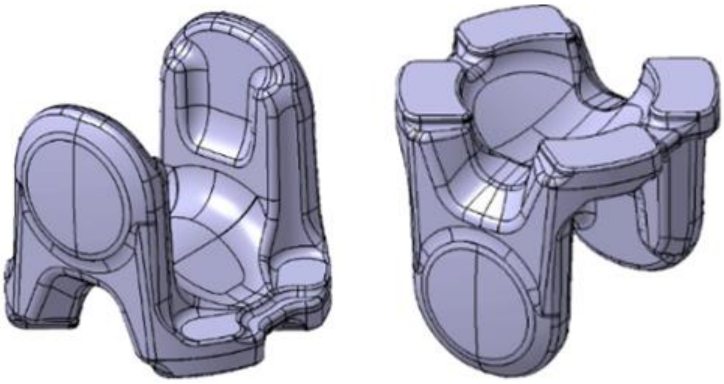

Figure 2. Part design in the CAD program

2.2. Uncoated Die

As tool steel, DIN1.2344A is used. After the forging process with 425 cycles, a fracture occurred in the radius region of the uncoated die. It has been observed that abrasions occur on the die surfaces along with breakage.

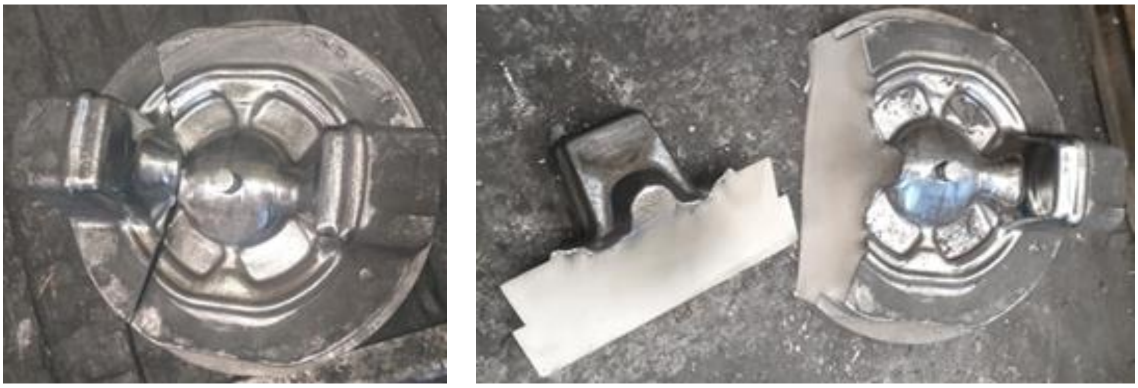

Figure 3. Uncoated die situations after the forging process

2.3. Orvar® 2M (1.2344) Material FEXOY Coating

FEXOY® coating obtains wear resistance, excellent lubricated and it uses at hot forging dies and metal injection operations. Thickness range of the FEXOY® is 12-15 µm. Chemical composition is diffusion process and FeO.

Figure 4. Coated die situations before the forging process

ORVAR® 2M material preform top and bottom dies are coated with FEXOY® material. After forging process, grinding operation was not applied surface of the die material. Coated dies, at first forging operation was completed at 2438 cycle uneventfully.

At second forging process was completed at 3499 cycles. However, after 2296 cycle and after 652 cycles, grinding operation was applied on surface of the die. After forging process, abrasive wear has been occurred at flange radius regions. Therefore, grinding operation was applied surface of that region.

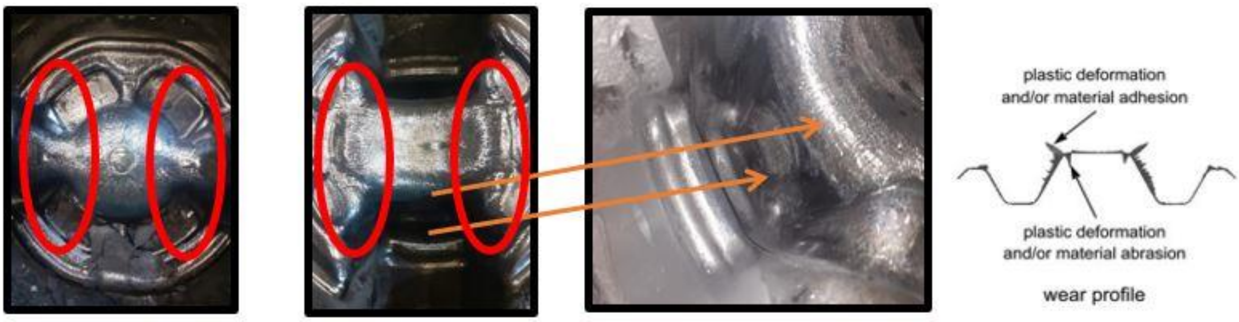

Figure 5. Abrasive wear surface of the die

2.4. Unimax® (1.2344) Material ABP+Dietox® Coating

ABP+Dietox® coating is a shot peening process that introduces compressive stress to the surface of material. It is a simple method for increasing fatigue and wear resistance of tooling materials. Coating material have similar properties with FEXOY® which applied to Unimax® die steel.

ABP+Dietox coating process is defined shot peening process that applied compressive stress to the surface of die material.

ABP coating develops and strengthens microstructure and surface of the die. It improves mechanical properties of the die. Therefore, fatigue cracking can be minimized and die life increases [10].

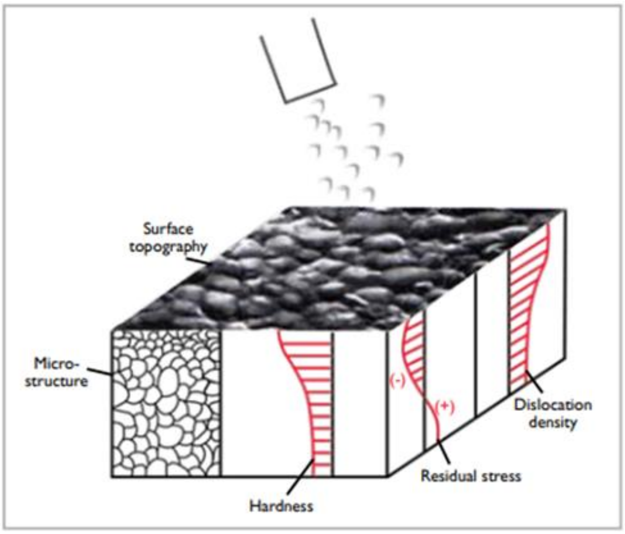

Figure 6. Die surface situation of ABP coating

Figure 7. Coated die situations before the forging process

Unimax® preform top and bottom die material was coated with ABP+Dietox® coated material. Unimax® die material has 14 joule average toughness. With coating material preform dies worked up to 2177 cycle. As a result of these, it has been observed that die life of the coated preform die is higher than uncoated preform die.

Figure 8. Coated die situations after the forging process

It has been observed that abrasive wear occurs on the radius of the coated die after 2177 cycles of forging. This die was then grinded and continued to be used again. Abrasive wear is shown in Figure 9.

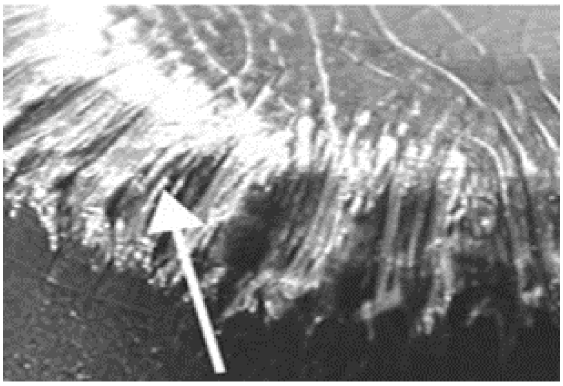

Figure 9. Abrasive wear after forging operation

In this article, it has been observed that the die life and performance of the preform die steels used in the forging process have increased with different coating techniques.

- After the uncoated dies worked for 400-500 cycles, breaks and cracks were observed.
- It has been observed that the dies with coating on the surface are subjected to grinding process after working for 2000-3500 cycles and continue to produce again.
- Fibering and abrasion were observed on the radius of coated and uncoated dies.
- It has been determined that the production is not interrupted frequently after the coating is applied and the total dies change time for the part is reduced.

It has been observed that the die cost decreases with the die coating.

3. Conclusion

As a result of this study, the life of the preform dies to be used for the production of parts in the hot forging method and the cracks, abrasions and fibering formed on the die surface during the process were taken into account. The appropriate coating material has been selected by considering the hardness drop in the die caused by friction and thermal shocks caused by the material flow and other problems.

Different coating techniques were applied to two different types of dies and maximum die life and number of cycles were determined in both dies according to uncoated die. Depending on the researches and applications made, it is observed that die coating materials have a positive effect on die life.

In addition, as a result of the work, there has been a noticeable decrease in die and labor costs.

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Author contributions

Esat Erdinç Önel: Methodology, Software, Data curation, Reviewing and Editing. **Sait Gül:** Writing-Original draft preparation, Visualization, Validation, Writing-Reviewing and Editing. **Adil Yağmur:** Software, Data curation, Writing-Reviewing and Editing

Conflicts of interest

The authors declare no conflicts of interest.

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