OPTIMIZATION OF TOOL LIFE FOR CLOSED TYPE FORGING TOOL

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Abstract *-- In this review paper, some of the commercially available die materials were compared based on their hardness data available in material data sheets. These materials are used for hot and warm forging in mechanical presses. This paper also includes the results of a study by ERC/NSM, in which wear and plastic deformation on warm forging dies was successfully estimated by using Finite Element Analysis. Some of the studies on ceramic die materials presented in literature were reviewed. Surface treatment techniques such as nitriding and weld overlays, as well as ceramic coatings, are also discussed. 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 cost effective applications of other materials such as ceramics, carbides and super alloys although these applications are limited due to design restrictions and costs.Hot working die steels used at temperatures between 310 °C and 650 °C contain additions of chromium, tungsten, vanadium and molybdenum to provide deep hardening characteristics and resistance to abrasion and thermal softening at high temperatures. Molybdenum increases resistance to thermal softening, vanadium improves wear and thermal fatigue characteristics. Tungsten alloy steels are not resistant to thermal shock and must not be cooled intermittently with water.*

I. INTRODUCTION

In this review paper, some of the commercially available die materials were compared based on their hardness data available in material data sheets. These materials are used for hot and warm forging in mechanical presses. This paper also includes the results of a study by ERC/NSM, in which wear and plastic deformation on warm forging dies was successfully estimated by using Finite Element Analysis. Some of the studies on ceramic die materials presented in literature were reviewed. Surface treatment techniques such as nitriding and weld overlays, as well as ceramic coatings, are also discussed. 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 cost effective applications of other materials such as ceramics, carbides and super alloys although these applications are limited due to design restrictions and costs. Hot working die steels used at temperatures between 310 °C and 650 °C contain additions of chromium, tungsten, vanadium and molybdenum to provide deep hardening characteristics and resistance to abrasion and thermal softening at high temperatures. Molybdenum increases resistance to thermal softening, vanadium improves wear and thermal fatigue characteristics. Tungsten alloy steels are not resistant to thermal shock and must not be cooled intermittently with water.

II. FAILURE REVIEW

Depending on the conditions of the process and the characteristics of the material and surface conditions, one could encounter various modes of tool failure. These are:

- Wear (abrasive, adhesive and oxidation)
- Thermal fatigue or heat checking
- Mechanical fatigue
- Plastic deformation

Of these, wear (abrasive and adhesive) and mechanical failures are the most common forms of failure Figure 4(a). Of the two mode of wear, abrasive wear is the more common form of wear. Adhesive wear is not very common in hot and warm forging of steels because of the presence of lubricant film and/or scales and oxide layer. It does become a mode of die wear when the lubricant film is non-existent either because there is no lubricant application or when excessive sliding and deformation thins the lubricant film. Good tooling design and material selection can overcome gross cracking and mechanical fatigue. Thermal fatigue, in almost all cases, serves as a catalyst to accelerate abrasive wear.
The main physical phenomenon that control the abrasive wear in a metallic surface sliding past another surface are relative sliding distance, normal pressure and hardness of the surface.

Design of forging dies, choice of forging and heating equipment, die material selection and surface treatments used have a tremendous effect on the wear characteristics as these factors affect one or more of the controlling fundamental physical phenomena. This relationship is illustrated in Figures 1 and 2.

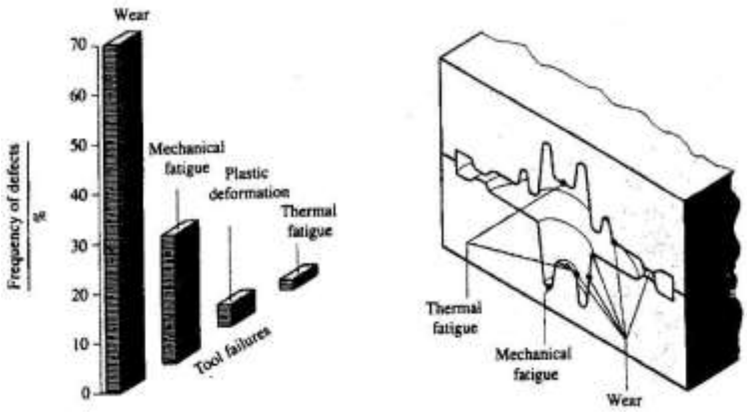


Figure 1 Frequency and location of typical die failures in forging

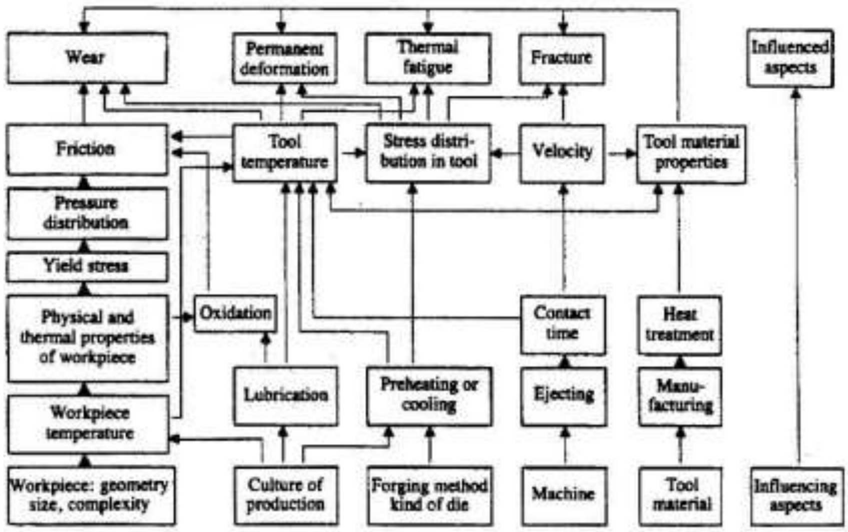


Figure 2. Complex interaction of forging parameters and wear Some aspects of forging and process design that affect wear and fracture.

From the above illustrations, the factors affecting die failure can be subdivided into

- Tooling Issues – Die material selection, heat treatment, surface engineering, die manufacture and design
- Billet Issues – Billet preparation, steel type
- Process Issues – Forging temperature, lubricant type and application, forging cycle times and other forging practices.

Effects of various process parameters and billetmater als are described in Appendix A. The team felt that these, by careful choice of physical constants like heat transfer coefficients, friction factors and yield strengths obtained.

Densitykg/m^3	7,800	7,700	7,600
Modulus of elasticity N/mm^2	210,000	180,000	140,000

either through past work or new but well understood testing, one can model and recreate the process using Finite Element Method (FEM). FEM would provide forging designers stress-strain cycling, temperature history at a die location and sliding velocities – factors that cause die failure. *Mechanism and models of die and failure.* The main forms of failure in hot and warm precision forging are abrasive and adhesive wears, oxidative wear,thermal fatigue, mechanical fatigue and gross cracking of dies. In several cases, two or more of these mechanisms act together to wear down the die. For fundamental insights into the different wear mechanisms.

III EXISTING MATERIAL

H13 Tool Steel

Currently some commercial die materials used in industry for forging process, one of the die materials using in industry is H13**.** This die material is used for forging the large quantity product like body control valve

A. General

Bohler-Uddeholm H13 is a chromium- molybdenumvanadium alloyed steel which is characterized by:

- Good resistance to abrasion at both low and high temperatures.
- High level of toughness and ductility.
- Uniform and high level of machinability and polishability.
- Good high-temperature strength and resistance to thermal fatigue.
- Excellent through-hardening properties.
- Very limited distortion during hardening**.**

B .Chemical Composition

C	**V**	**Mo**	**Cr**	**Si**	**Mn**
0.39	**0.9**	**1.3**	**5.3**	**1.0**	**0.4**

This grade has been manufactured to our internal specifications, and audited to meet our guidelines.

C.Physical Properties.

Hardness	52 HRC
Tensile strength	1990 Mpa
Yield strength	1650 Mpa

C. Heat treatment

1) Hardening

Pre-heating temperature: 1110–1560°F (600-850°C),normally in two pre-heating steps.

Austenitizingtemperature:1870–1920°F(1020–1050°C), normally 1870–1885°F (1020–1030°C).

2) Quenching Media

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench to equalize surface and core is recommended wher distortion control and quench cracking are a concern.
- Martempering bath or fluidized bed at 840–1020°F(450– 550°C),then cool in air.
- Martempering bath or fluidizedbed at approx. 360–430°F (180–220°C)then cool in air.
- Warm oil

Temperature		Soaking Time minutes	Hardness before Tempering
°F	°C		
1,875	1,025	30	53±2 HRC
1,920	1,050	15	54±2 HRC

IV. MATERIAL SELECTION

Introduction

The selection of the die materials is a very significant decision in the production of precise components by forging. Appropriate selection of die materials is imperative to get acceptable die life at reasonable cost. Die wear is mostly influenced by the hardness of the die material and other material properties such as toughness and ductility. Selection of proper die materials is very important for reducing the production costs and setting narrow tolerance for the forged part. In this review paper, some of the commercially available die materials were compared based on their hardness data available in material data sheets. These materials are used for hot and warm forging in mechanical presses. Some of the studies on ceramic die materials present in literature were reviewed. Surface treatment techniques such as nitriding, weld overlays as well as ceramic coatings were also investigated.

Die Materials For Forging Of Steel.

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.

Table 3 Comparison of basic characteristics of tool and die steels.

Application	AISI Steel Type, Group	Hardness Rc
Blanking Dies and Punches (Short Run)	O, A, W	58-60
Blanking Dies and Punches(Long Run)	A, D M	60-62 61-63
Bending Dies	O, A, D	58-60
Coining Dies	S W D H	52-54 57-59 58-60 52-54
Drawing Dies	W,O D	58-60 50-62

Dies — Cold Extrusion	W D M	59-61 60-62 62-64
Dies — Embossing	W, L, O, A, D	58-62
Dies — Lamination	D, A, M M, D	60-62 58-60
Dies — Sizing and Ironing	W	59-61
Punches—Embossing	S	58-60
Punches — Trimming	W, D, O. A	58-60
Punches—Notching	M	60-62

Selected material

According to this table the different die materials are used for various application. Most commonly used dies are D and A in AISI group. So we had taken two material group for study which is A and D. Based on the study D2 has more yield and ultimate strength than the any other materials in those group So we had taken the D2 as replacing material for life improvement of die for the industry which we doing our project.

V. MATERIAL REPLACEMENT

Selected material for replacing the existing material D2 tool steel is an air hardening, high-carbon, high- chromium tool steel possessing extremely high wear resisting properties. It is very deep hardening and is practically free from size change after proper treatment. This tool steel's high chromium content gives it mild corrosion resisting properties in the hardened condition. D2 tool steel is available in the form of DeCarb- Free(DCF) bars. DCF bars have been cold finished in the mill prior to shipment, eliminating the need for bark removal by the tool and die fabricator.

Physical Properties

Density – 7696 kg/m^3

Specific Gravity- 7.75

High-carbon, high-chromium steels such as D2 tool steel achieve their excellent wear resistance due to a chemical balance which renders them notch sensitive and low in ductility. Meaningful tensile data are unavailable. The practical experience indicates that compressive loads in excess of 400,000 psi (2758 Mpa) can be withstood if evenly applied at low rates of loading.

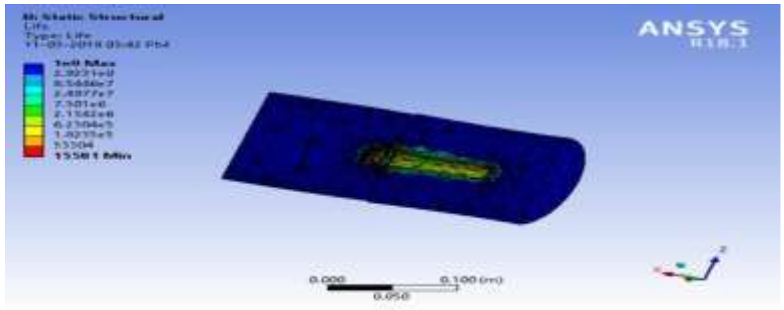
VI. HEAT TREATMENT

Hardening

D2 tool steel is extremely sensitive to overheating during hardening. It is therefore imperative that care be taken to insure that the hardening temperature is within the recommended range of 1800/1875°F (982/1024°C). If overheated, D2 tool steel, like other high-carbon, high-chrome tool steels, will not reach its maximum obtainable hardness and will shrink badly. Don't overheat it. Without preheating, place the tool right in the hot furnace and let it heat naturally until its color uniformly matches the color of the thermocouple in the furnace. Tools should be soaked at temperature 20 minutes plus 5 minutes for each inch of thickness, the quenched in air. Control of decarburization can be achieved by using any one of the several modern heat- treating furnaces designed for this purpose. If endothermic atmospheres are used a dew point between 20/40°F (6.7/+4.4°C) is suggested. In older type, manually operated exothermic atmosphere furnaces, an oxidizing atmosphere is required. Excess oxygen of about 4 to 6% is preferred. If no atmosphere is available, the tool should be pack hardened or wrapped in stainless steel to protect its surface.

VII. ANALYTICAL COMPARISON BETWEEN D2 AND H13

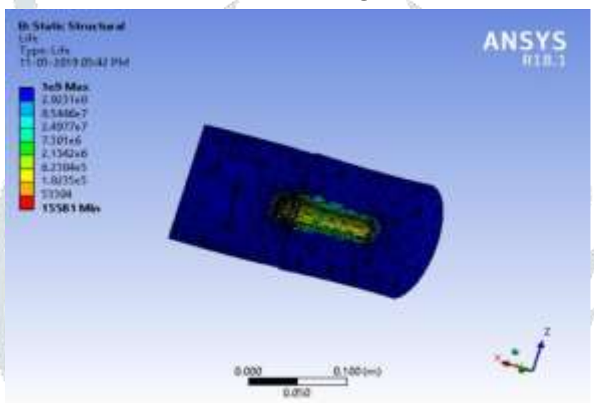
ANSYS software is used for analyses the existing material and replaceable material to show the difference in life cycle, total deformation, elastic strain and elastic stress. It ease the evaluation process of tool life and the profit for the new material intend to change. Life cycle difference for D2 and H13 for 70 ton load.



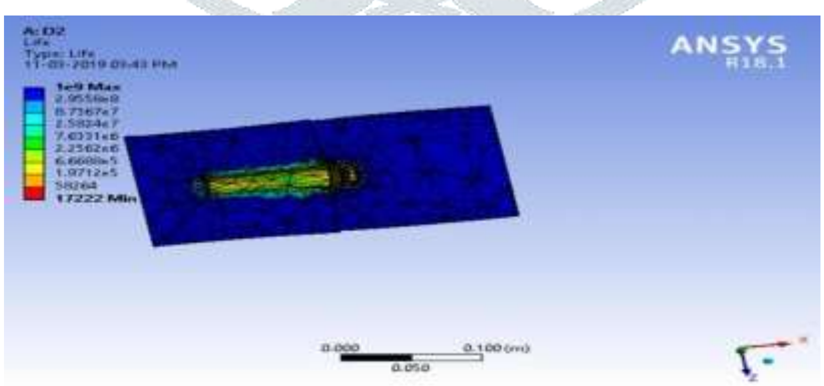
H13 Fig 4

The minimum life of H13 is 15581 cycles, the minimum life of D2 is 17222 cycles. So totally 1641 cycle higher than the existing material.

D2 Fig 3



Load life comparison graph for H13 and D2 material



VIII. CONCLUSION

In the industry forging is the beginning manufacturing process. If the cost efficiency is controlled in forging section the total production cost can be reduced. In the small scale industries the manually operated forging press is used for the cost concern. Whether the process and machines advancement to increase the productivity they need more production like large scale industry. Die costs can constitute up to 30% of the production cost of a part and also affect its profitability directly (die manufacturing cost) and indirectly (repair, press downtime, scrap, rework etc). We replaced the D2 material for the existing material which have more tensile and yield strength than the existing material. It have more toughness against the fracture than the existing material. So we analysed the D2 material in ANSYS software, with the result of ansys we compared and calculated the cost efficiency which give reasonable efficiency than the existing material.

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