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An Objective Study on Materials Used in Making Forging Dies for Complex Components

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Abstract: Forging is one of the reliable processes of making components with good hardness and life time. In the present era of power generation and bore well systems the component used at lubrication area must be rigid with low wear properties physically and thermally. This component with complex shapes needs a die to manufacture by hammering with heavy loads in hot condition. As taking in to consideration of above the die making materials are mostly die steels are high hard end alloys. The present paper discusses the importance of die material and the die development process draw backs, manufacturing criteria's by practical observation of component development. Complex culletlug taken as component for case study of practical approach and deviations in manufacturing for further research.

***Key words**: forging, hot forging, complex die, die materials.*

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I. INTRODUCTION

D2 Steel (Tool Steel) is one of the most widely used materials due to its unique high strength that is maintained at the elevated temperature and its exceptional wear resistance.D2 steel possessing high strength and toughness is usually known to create major challenges during its machining. Turning is the process known for its capabilities in providing machining efficiency in terms of higher machining rate and low tool wear apart from reasonably good surface quality. Turning is the traditional machining method that could be effectively used for the cost effective machining of D2 Steel. However, there is a critical lack of evidence regarding the application of turning process for the machining of a material like tool steel in the literature available till now. Hence the study was aimed to investigate the machining characteristics of D2 Steel under different process conditions. The machining characteristics investigated are; Thrust force, Feed force, Radial force, Surface roughness, and Material removal rate. The results showed that the response variables were strongly influenced by the control factors (input parameters).

The properties of cutting tool like hardness, toughness & wear resistance by forging & heat treatment process. Hence we selected D-series tool steel **(D1, D2, D3, D4)** for our test. Common applications of these tool steels are forging dies, die casting die blocks, drawing dies etc., the experiment evaluates Rockwell hardness test, Micro hardness test, Force analysis, Turning operation & wear test. The results revels that in force analysis during turning operation the heat treated D-series tool steels perform better than forged & heat treated tools. The forged & Heat treated D2 tool steel has low wear rate. Metal cutting is one of the oldest and most important material shaping process, which is widely, used in automotive, railway, ship-building, aircraft industry etc., Cutting tool is very important field in the manufacturing industry.

II. OBJECTIVES

Major focus of the paper is on the reliable life modelling of these metal-forming tools, and to discuss some possibilities to enhance their life.

- Design, tool material behaviour during use, involving selection of dimensions, corner radii and section changes.
- Heat treatment and mechanical properties at different heat treatments, since improper heat treatment is one of the most common causes of failure.
- Dominant damage mechanisms and conditions in a tool.

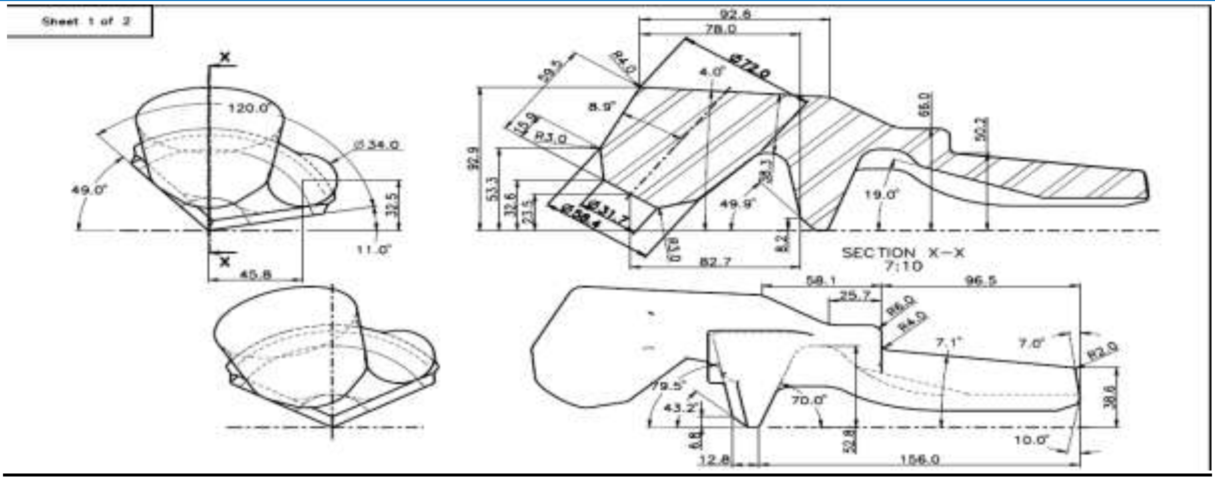


Figure shows the component drawing of case study for die making.

III. PRACTICAL OBSERVATIONS:

The following are the material properties of die steel AISID2

Chemical properties

C	Si	Cr	Mo	V
1.50%	0.3%	12.00%	0,8%	0.9%

Forging:

Heat slowly and uniformly to 700°C then more rapidly to 900/1040°C. Do not continue to forge D2 below 925°C. Reheat as often as necessary to maintain proper forging temperature. This is not an annealing process. After the forging is cold, it must be annealed as described below.

Annealing:

Heat the material uniformly up to 843/871°C, then slow furnace cool at a rate of not more than 10°C per hour. After annealing D2 a maximum hardness of 240 BHN may be achieved.

Physical properties

Density - 7.7 x 1000 kg/m^3

Melting point-1421°C

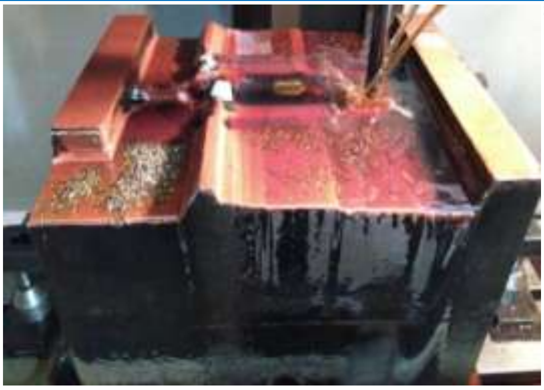
Mechanical Properties	Metric
Hardness, Knoop (converted from Rockwell C hardness)	769
Hardness, Rockwell C	62
Hardness, Vickers	748
Izod impact unnotched	77.0 J
Poisson's ratio	0.27-0.30
Elastic modulus	190-210 GPa

Thermal properties

Thermal expansion-10.4 x 10^{-6}/°C

Treatment temperature-20 to 100^{0}C

Machinability criteria: The material should be machined with tools of high carbon steel to get better finishing and quality component output.



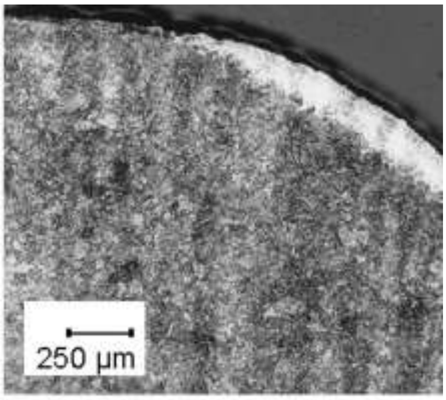

Above images are the Machining of die for the present component by using CNC vertical milling center as per the specifications required.

Finished machining of die

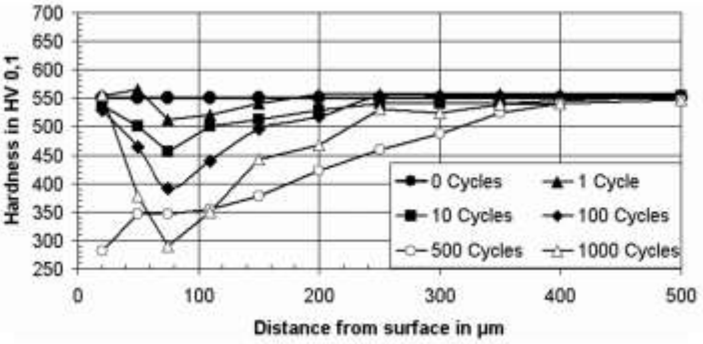

Furnace with practical approach of 800^0 C Out put component of present project

IV. Results and discussions

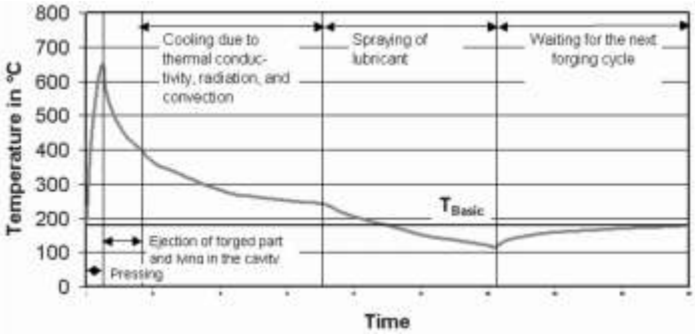
Picture shows the assembly of cullet components



Micro structure SEM image of the die after first stroke with one ton hammer and the first forging cycle immediately increases the hardness in the outmost surface.Then the progressing forging operation leads to a further increase of the hardness in the outmost surface. Here the high thermal impact on the tool austerities the hot-work tool steel again which is then subsequently quenched by the sprayed lubricant. Approximately 100 µm below the tool´s surface the hardness drops to a minimum. This is directly related to the thermal influence on the tool. The thermal influence is no longer high enough to re-harden the steel but as the temperature still exceeds the tool´s final tempering temperature the hot-work tool steel softens.



Graph shows the surface hardness variations with number of stroke cycles



Time-temperature-profile in the surface of a forging die

V. CONCLUSIONS

A considerable plastic deformation on the tool surface after 500 strokes coincides with an extreme loss in hardness. During the previous forging operation the high thermal impact generated a zone of approx. 80 µm thickness with a ferrite, soft microstructure which thus favored the plastic deformation of the surface. After 1000 forging cycles the hardness in the surface increases again. The softened surface observed after 500 cycles could not withstand the subsequent mechanical impacts any longer so that it was worn off during the following forging cycles. The newly created surface due to the contact with the material to be forged the surface temperature of the die rises drastically to temperatures between 650 and 700 ◦C. The lubricant sprayed onto the die's surface cools the outmost surface of the die immediately. This thermal cycle is repeated with every forging cycle and finally supports thermal fatigue within the die´s surface. Thermal fatigue finally results in a network of cracks which occurs on the surface. These cracks not only reduce the quality of the forged parts but as the number and depth of these cracks grow during further forgings they are also an origin of further damage.

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