Failure Analysis of Die Block

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Abstract— The die fatigue life is determined by the design of metal-formed product and die, forming process configuration, die stress and the entire metal-forming system.In the metal formed industries die is an important tool for fabrication of metal formed product. At the same time failure of tool steel take place because of many numbers of causes and insufficient material selection criteria. Main objective is to select the most preferable material forDie Block. For the hardness test, Tensile test and Impact test is done. By that test we get the appropriate results.

Keywords— Heat treatment, Annealing, Normalizing, hardening, Tempering, Hardness.

I. INTRODUCTION

Die is an important tool for deformation or fabrication of metal-formed products. Die is a work holding device, designed specifically for a particular design of a product. Die is rigidly held on the base of the press. To have good die performance and service life, the die should be optimally designed and precisely fabricated. [9]The block or plate made from high-quality steel and mounted on the bottom portion of the die set to which section or parts of the die. It is subjected to extreme pressures and wear conditions. Hence the die block is made of superior quality of tool steel. [10] Tool steels are broadly divided into six categories like cold work, shock resisting, hot work, high speed, water hardening, plastic mould and special-purpose tool steels. Among them, cold work tool steels are the most important category, as they are used for many types of tools, dies and other applications where high wear resistance and low cost are needed. [2]

II. TOOL STEEL FAILURES

Failures of punch in manufacturing operation generally results one or more of the following causes:

1. Improper design
2. Defective material
3. Improper heat treatment and finishing operations
4. Overheating and heat checking (crack caused by temperature cycling)
5. Excessive wear
6. Overloading
7. Misuse
8. Improper handling. [5]

A. Some of the major factors leading to die failures are described below

Although these factors apply to die block made of tool steel, many are also applicable to other tool materials. The proper design of die block is as important as the proper selection of die material. In order to withstand forces in manufacturing process, a die must have proper cross-sectional and clearance. Sharp corner, radii, and the fillets, as well as abrupt changes in cross section, act as stress raiser and can have detrimental effects on die block life. [4]

III. EXPERIMENTAL APPROACH FOR METHOD & MATERIAL SELECTION

Step 1: Literature has been collected from research papers, journals, books etc. and literature gap analysis related to die block failure.

Fig. 1 Die Block Failure

In today's industrial growth greater demands on products and materials, from which they are made. Years ago, many designers never figured out stress and strain, elasticity, fatigue, or similar values.

Under this failure analysis main purpose is selection effective tool steel material with appropriate grade is necessary in most common manufacturing industry. A tool steel material grade EN-31, D-3 and D-2 is selected for project work. The main reason to select the material is availability of material their heat treatment process and cost of tool steel.

Step 2: Industrial survey for selection of tool steel and preparation of objective function.

More number of tools steel materials are used in manufacturing industry under these most preferable material selection criteria is to be used under the cost of raw material and related to its heat treatment process. Overall analysis is necessary for maintain the objective function of the project work.

Step 3: Cutting and turning of tool steel specimens.

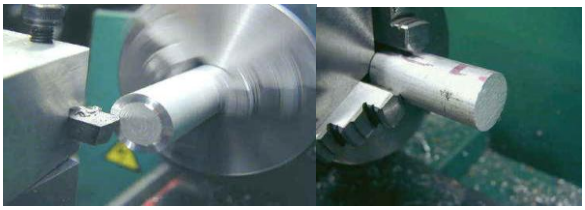

Fig. 2 Turning of tool steel

There was requirement for two samples of each material for the heat treatment and testing purpose. So we cut the sample in 16 mm diameter with 250 mm to 100mm length. Three samples i.e. EN-31, D-3 and D-2 can be cut with power hack saw and turning which is carried out under the Lathe Machine.

Step 4: Tensile testing of tool steel with measure their all parameters.

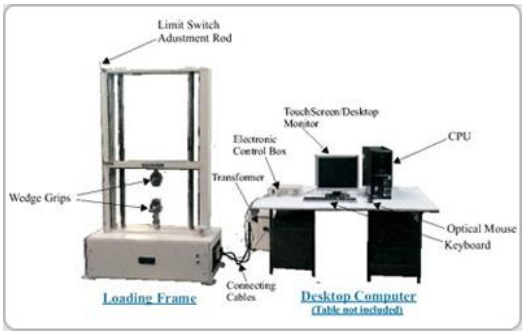

Fig. 3 Tensile test on Tool Steel

In tensile testing of tool steel measure the specimen Diameter, Gauge length also carried out yield load, ultimate load, yield stress, ultimate tensile strength and percentage of elongation. Overall tensile test is carried out on the Universal Testing Machine.

Step 5: Hardness testing of treated tool steel i.e. EN-31, D-3 and D-2.

Fig. 4 Rockwell Hardness Tester

There are many types of material testing equipment, hardness testing machines provide the simplest and most economical testing methods and they play a vital role inresearch through to production and commercial transactions. Under which most suitable Rockwell hardness tester is used also Steel Hardness Calculator Used for Conversion of Values. Using that calculator we calculated HRB value & Brinell Hardness HB, Vickers HV.

Step 6:Impact testing of EN-31, D-2, and D-3

Notched-bar impact test of metals provides information on failure mode under high velocity loading conditions leading sudden fracture where a sharp stress raiser (notch) is present. The energy absorbed at fracture is generally related to the area under the stress-strain curve which is termed as toughness in some references. Although two standardized tests, the Charpy and Izod, were designed and used extensively to measure the impact energy, Charpy v-notched impact tests are more common in practice.

Fig. 5 Charpy Impact Testing Machine

A. Charpy Impact test

The Charpy impact test, also known as the Charpy V-notch test, is a destructive testing method which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notchtoughness and acts as a tool to study temperature-dependent ductile-brittle transition.

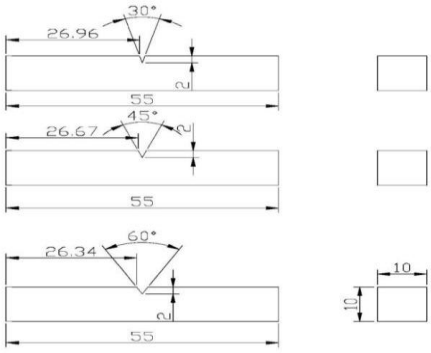

Fig.6 Dimension of Test Specimen

Charpy impact test is practical for the assessment of brittle fracture of metals and is also used as an indicator to determine

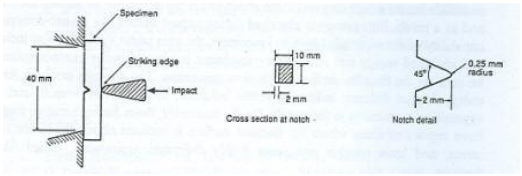

Fig.7 Specimen and loading configuration for Charpy V-notched impact test.

suitable service temperatures. The Charpy test sample has a sizes (10 X 10 X 55) mm³ with three V- Notch 30°, 45° and 60° of 2 mm depth will be hit by a pendulum at the opposite end of the notch

IV. RESULT AND DISCUSSION

Table No. 1 Tensile test parameters

Material	EN-31	D-3	D-2
Thickness/ Dia. mm	16.96	16.56	16.37
Area mm^2	226.00	215.47	210.55
Gauge Length mm	85.00	83.00	82.00
Final GL mm	104.98	85.26	91.68
Yield load KN	111.02	97.20	87.12
Ultimate Load KN	158.90	204.56	152.46
Yield Stress Mpa	491.23	451.11	413.77
UTS Mpa	703.08	949.37	724.09
% E	23.51	2.72	11.80

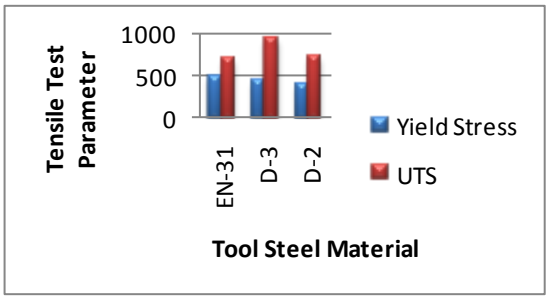

Fig. 8 Graphical representation of Tool Steel material vs tensile test parameter

Conclusion- Above graph shows tool steel material having Yield stress and UTS its value. So we see D-3 material having more value than EN-31 & D-2 material.

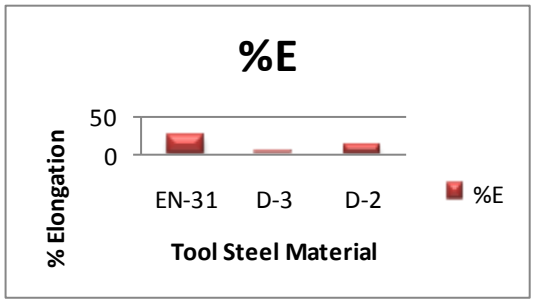

Fig. 9 Graphical reprentation of Tool Steel Material vs %E

Conclusion – Above graph shows Tool steel material vs %E. In that we see that % E of EN-31 is more as compare to D-3 & D-2.

Table No. 2 Hardness after Heat TreatmentAnd Impact test of tool steel EN-31, D-2, D-3

Test Material	Hardening & Tempering Rockwell C-HRC	Charpy Impact Test Joules
EN31	50	6.66
D-3	56	4.66
D-2	60	4

Conclusion – Above table shows the hardness value and impact test value. In that we see that the Rockwell hardness value of D-2 material is high which is 60HRC and Impact testing value for EN-31 is high which is high.

V. COMPARATIVE RESULTS AFTER HEAT TREATMENT PROCESS OF ROCKWELL C-HRC AND IMPACT TEST

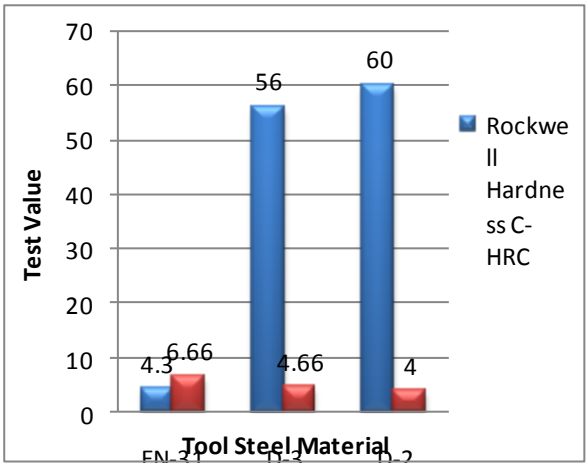

Fig. 10Graphical representation of Hardness of Tool Steel after Hardening and Tempering and Impact test value

B. After Hardening and Tempering and Impact Testing : - After hardening and tempering heat treatment process Rockwell hardness of D-2 is higher as compare to EN-31, D-3. In case of Impact test method EN-31 have higher value as compare to D-3, and D-2.

VI. CONCLUSION

From above study and observation EN-31 material is preferable because the Die block material should have high ductility and toughness property. So their will less breakage of die block.

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