FAILURE MODE APPRAISAL IN INNER LOWER CONTROL ARM AND PUNCH NOSE FAILURE WITH HEAT TREATMENT PROCESS OF TOOL STEEL

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ABSTRACT

In this paper experimental observation is based upon the empirical study rather than theory. Main objective is to study the effect on hardness of tool steel after heat treatment processes. The materials selected for this process are EN-31, EN-9, OHNS, D-2 and D3. This survey also helps to find out the failure mode appraisal in inner lower control arm and punch with their preventive methods. Fracture surface displays typical ductile fracture, and the outer and inner surface of the part punched off is full of little bowings around which there are many micro cracks caused by the stretch stress under biaxial strain/stress state After this experimental investigation aims to prepare heat treatment performance which is supposed to be very effective tool for defining the objective function.

Keyword : - *Heat treatment, Rockwell Hardness, Brinell Hardness, Vickers Hardness. etc.*

1. INTRODUCTION

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools. Their suitability comes from their distinctive hardness, resistance to abrasion, their ability to hold a cutting edge, and their resistance to deformation at elevated temperatures (red-hardness). Tool steels are used in cutting tools, punches, and other industrial tooling. Different tool steels are developed to resist wear at temperatures of forming and cutting applications. [3] 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]

1.1 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

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

Although these factors apply to punch made of tool steel, many are also applicable to other tool materials. The proper design of punch is as important as the proper selection of punch material. In order to withstand forces manufacturing process, a punch 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 punch life. Punch may be made in segments and pre-stressed during assembly for improved strength. [4]

2. EXPERIMENTAL APPROACH FOR METHOD & MATERIAL SELECTION

Step 1: Literature has been collected from research papers, journals, books etc. and literature gap analysis related to punch 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. In punch failure actual concentration is related to nose of punch and their effect on the inner control arm.

Figure 2.1: Failure of Punches

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, EN-9, D-3, D-2 and OHNS 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.

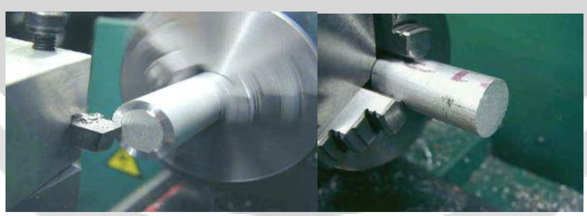

Figure 2.2: Turning of Tool Steel

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. All the samples i.e. EN-31, EN-9, D-3, D-2 and OHNS can be cut with power hack saw and turning which is carried out under the Lath Machine.

Step 4: Composition testing of untreated tool steel i.e. EN-31, EN-9, D-3, D-2 and OHNS.

Chemical composition is the most important influence upon shearing performance of the tool steel. Each alloying element in tool steel such as tungsten, chromium, molybdenum, vanadium, has a specific role in determining the mechanical properties. In chemical testing the components and purity of many raw or in-process materials, and finished product find out. Also Measure multiple constituents simultaneously. It takes about 5-6 minutes for the chemical composition testing of a single material. The readings of the test are shown on the Display of Computer in Tabulated Form. It Shows the Percentage Composition of Each Element. After Testing Chemical Composition of the material, the values compared with that of values as per International Standards. The Testing of a Single Sample is done 2-4 times from Different point on the smooth surface of the sample. The same Procedure for chemical testing is also done for EN-31, EN-9, D-2, OHNS and D-3 also.

Step 5: Tensile testing of tool steel with measure their all parameters.

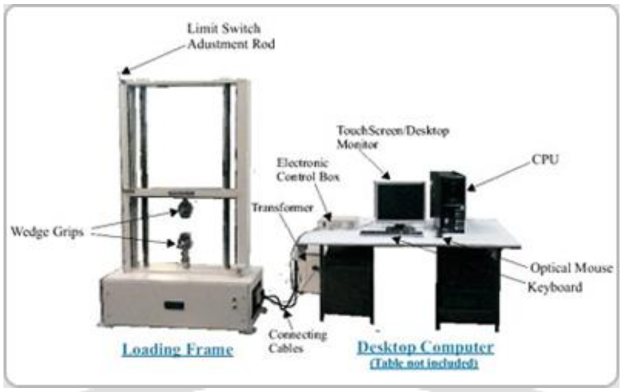

Figure 2.3: Tensile test on Tool Steel

Table 2.1. Physical Properties of Tool Steel

Material	EN-31	EN-9	D-3	D-2	OHNS
Thickness/ Dia. (mm)	16.96	16.17	16.56	16.37	15.73
Area (mm^2)	226.00	205.44	215.47	210.55	194.41
Gauge Length (mm)	85.00	81.00	83.00	82.00	79.00
Final GL (mm)	104.98	95.70	85.26	91.68	93.96
Yield load (KN)	111.02	99.94	97.20	87.12	85.90
Ultimate Load (KN)	158.90	159.56	204.56	152.46	158.76
Yield Stress (MPa)	491.23	486.47	451.11	413.77	441.85
UTS (MPa)	703.08	776.68	949.37	724.09	816.62
% E	23.51	18.15	2.72	11.80	18.94

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 6: Applying heat treatment process such as annealing, hardening and tempering for EN-31, EN-9, D-3, D-2 and OHNS.

Using the heat treatment process one after one to maintain the required mechanical properties under the temperature range i.e. 800 ^{0}c to 820^0 c in annealing process and in hardening process 750^0 C to 850^{0}C.

Step 7: Hardness testing of treated tool steel i.e. EN-31, EN-9, D-3, D-2 and OHNS.

Figure 2.4: 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 in research 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.

Type of sample: - Round piece, Material - EN-31, EN-9, D-3, D-2 and OHNS.
Heat treatment: - Annealing, Hardening & Tempering.

3. RESULTS AND DISCUSSION

Table 3.1. Composition of tool steel after composition testing of test materials.

Material	EN- 31	EN-9	D-3	D-2	OHNS
C %	0.92	0.51	2.34	1.58	1.28
Si %	0.29	0.29	0.43	0.58	0.58
Mn %	0.34	0.74	0.28	0.3	1
S %	0.007	0.002	0.005	0.005	0.02
P %	0.02	0.019	0.026	0.02	0.027
Cr %	1.42	---	12.2	11.01	0.45
V %	---	---	0.11	1.02	---
W %	---	---	0.001	---	1.5
Mo %	---	---	---	1.05	---
Ni %	---	---	---	---	0.16

Type of the sample: - Round piece
Material sample: - EN-31, EN-9, D-3, D-2 and OHNS.
To check the maximum and minimum carbon contents and chromium contents in EN-31, EN-9, D-3, D-2 and OHNS samples tool steel materials.

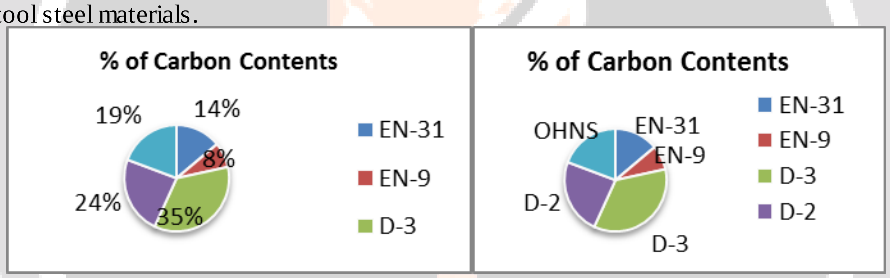

Figure 3.1: Carbon % of Tool steel material

Conclusion- In various types of material original carbon contents Shows the originality of Material used for testing leads to validity of performances outcomes that carried out in further comparative statements. Using this bar chart shows the maximum carbon contents in particular type of material.

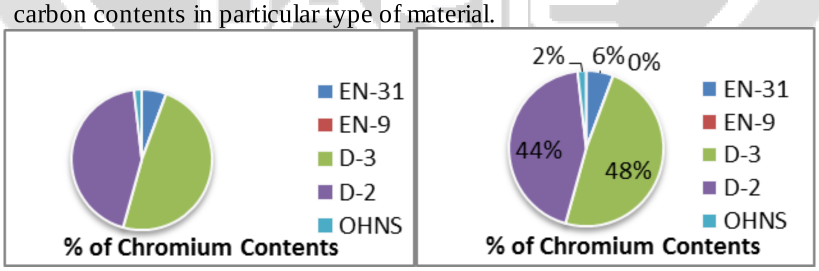

Figure 3.2: Chromium % of Tool steel material

Conclusion: - In above graphical representation shows the maximum chromium content in each type of material. As a result, chromium is very frequently used as a decorative, and simultaneously corrosion-resistant, coating. Under this conclusion D-3 and D-2 material chromium contents are high as compared to OHNS, EN-31 and EN-9.

Table No. 3.2: Hardness of tool steels after Heat Treatment

Test Material	Heat Treatment	Rockwell C- HRC	Rockwell B- HRB	Brinell Hardness (HB)	Vickers (HV)
EN-31	Annealing	18	95	212	218
	Hardening & Tempering	50	117	469	505
D-3	Annealing	27	103	262	262
	Hardening & Tempering	56	0	572	694
EN-9	Annealing	18	95	212	218
	Hardening & Tempering	50	117	469	505
D-2	Annealing	12	91	186	184
	Hardening & Tempering	60	0	627	0
OHNS	Annealing	12	91	186	184
	Hardening & Tempering	50	117	469	505

Conclusion For EN-31:- In annealing and hardening and tempering process the Rockwell hardness grade HRB of material is to be change from 95 Rockwell HRB in annealing and 117 Rockwell HRB in hardening and tempering is to be shown in table.
Conclusion for D-3:- In the above table shows the Rockwell C-HRC hardness of D-3 material under annealing heat treatment process is 27 C-HRC and after hardening and tempering it is 56 C-HRC.
Conclusion for EN-9:- In the above table shows the Rockwell B-HRB hardness of EN-9 material under annealing heat treatment process is 95 B-HRB and after hardening and tempering it is 117 B-HRB.
Conclusion for D-2:- In the above table shows the Rockwell C-HRC hardness of D-2 material under annealing heat treatment process is 12 C-HRC and after hardening and tempering it is 60 C-HRC.
Conclusion for OHNS:- In the above table shows the Rockwell B-HRB hardness of OHNS material under annealing heat treatment process is 91 B-HRB and after hardening and tempering it is 117 B-HRB.

4. COMPARATIVE RESULTS AFTER HEAT TREATMENT PROCESS

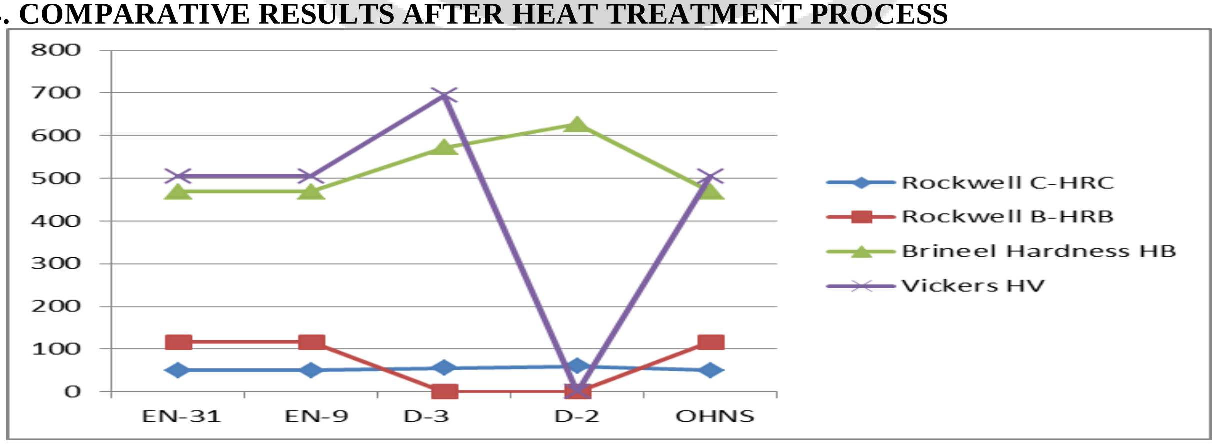

Figure 4.1: Graphical representation of Hardness of Tool Steel after Annealing

After Annealing :- If we consider annealing heat treatment process Brinell Hardness- Grade of material D-3,EN-9,D-2 and EN-31 material shows the 572HB, 469HB, 627HB and 469HB. After annealing heat treatment process Brinell hardness of D-2 tool steel material is higher as compared to D-3, EN-9, OHNS and EN-31. It means that the D-2 tool steel material is harder than the remaining tool steel material. Generally its hardness is increase or decrees after the hardening and tempering process.

If we again consider the Vickers hardness test result the hardness of D-3 material is 694 HV which is higher as compared to OHNS, EN-9, D-2 and EN-31 tool steel material.

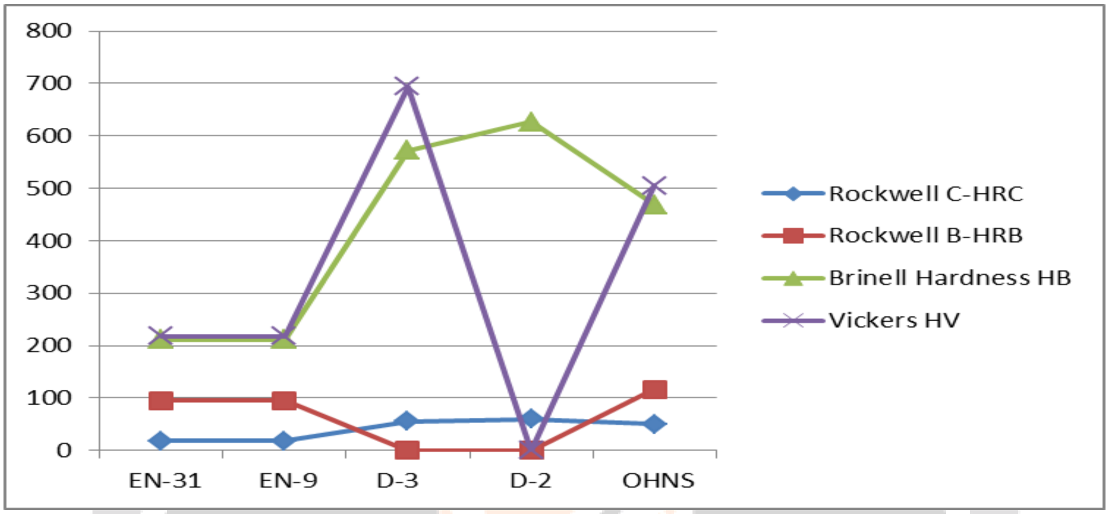

Figure 4.2: Graphical representation of Hardness of Tool Steel after Hardening and Tempering

After Hardening and Tempering: - After hardening and tempering heat treatment process Brinell hardness HB of D-3 and D-2 material is 572 HB and 627HB. D-2 material shows the maximum Brinell hardness as compared to EN-31, EN-9, D-3 and OHNS. Also in Vickers hardness HV for D-3 material is 694 HV and OHNS material is 505 HV means Vickers hardness of D-3 material is maximum as compared to EN-31, EN-9, D-2 and OHNS.

Comparison: After annealing specimen becomes harder than untreated specimen. After annealing hardness is more as compared to untreated specimen. But specimen has not obtained good microstructure. After hardening and tempering specimen are hardest then other three specimens also having a good corrosion resistance.

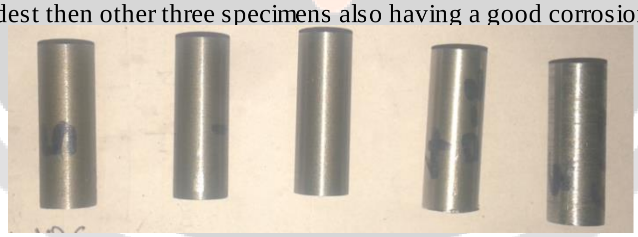

Figure 4.3: Overview of the test sample used for heat treatment process

5. CONCLUSION

This experimental study is to be very useful approach for selection of tool steel grade which will more beneficial for industrial point of view. From the literature review, it is observed that less research work has been seen for Tool Steel i.e. EN-31, EN-9, D-3, D-2 and OHNS after Heat Treatment Processes Such As Annealing and Hardening & Tempering. Also very less work has been reported for Tool Steel. It is observed that the effect of hardness of work piece material after treatment of Tool Steel i.e. EN-31, EN-9, D-3, D-2 and OHNS have not been explored yet, so it‘s interesting to Study the Effect on the Hardness of five Sample Grades of Tool Steel i.e. EN-31, EN-9, D-3, D-2 and OHNS after Heat Treatment Processes Such As Annealing and Hardening & Tempering.

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