ISSN No:-2456-2165

Normalizing Temperature and Time Effect on Micro Structure and Change in Mechanical Properties of Forged Steel Billet for Axle Production

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Abstract: - Normalizing is the process in which a metal is heated to a temperature below it's melting point and allowed to cool in air in order to make it more ductile, relieve strress on doing so, the microstructure also changed. In our experiment, Normalizing process was applied on the Forged Rear Axle of Temperature 870-880 c and time of 2 Hours 20 Minute for proper development of the Ferrite and Pearlite Phase. It was observed that as Normalizing Temperature increases, the Hardness decreases as well as Strength also decreases. At the temperature of 870-880 c , Better Micro structure of Uniform distribution of Ferrite and Pearlite is achieved.

Keywords: - *Forged Steel, Axle, Normalizing.*

I. INTRODUCTION

Axle is one of the most important elements of the Automobiles like Cars, Bushes, Trucks and containers for the fitting of the Wheels and driving it. For the better life of the axle, the Strength and Micro structure of the material is very essential point to control it. We took Forged Axle piece for the experiment. After Forging, the Carbon distribution on the axle piece specially on the Flange side changes and irregular distribution of Carbon is achieved, to relieve it, Normalizing process is carried out. Normalizing heat treatment was carried out on it to achieve the micro structure of Uniform Distribution of Ferrite and Pearlite. On applying the Normalizing Temperature, the Strength decreases, Machinability increases, Hardness reduces. This is obtained for the better Machinability of the Forged Axle Piece.

There are some reports about the effect on the micro structure and the Mechanical Properties. Axle carries very high and fluctuating load so this is very important aspect to study about the properties of the axle on applying the Normalizing Temperature for the better application of Axle for the Automobile.

II. USE OF MATERIAL

The material used for our experiment is Steel of Grade En8DCr for axle manufacturing. The Chemical composition, Mechanical Properties of this material is shown below in the report. This chemical composition was calculated on the Spectrometer Bruker Q4TASMAN on sparking the test sample which was cut from the raw material billet and grinned on the Emery Paper 220 no.

Chemistry	% C	% Mn	% S	% P	% Si	% Cr	% Al
Min	0.4	0.7	0.02	.....	0.15	0.35	0.02
Max	0.45	0.9	0.04	0.035	0.35	0.4	0.035
Actual	0.43	0.83	0.023	0.015	0.234	0.37	0.022

Table 1:- Chemical Composition of the Material

This Chemical analysis is calculated on the Spectrometer by Spark ignition.

The hardness of the forged and without normalized material was calculated

Hardness = 240 BHN

The related Ultimate Tensile Strength of this material can be calculated as

Ultimate Tensile Strength (MPa) = 3.4 (Hardness in BHN)

*UTS = 3.4 * 203*

UTS = 690.3 MPa

The Hardness was calculated on the Brinnel Hardness Tester on the load 3000 kgf and the ball diameter was taken as 10 mm. The material was free from cracks and seams checked by Magnetic Particle Inspection and no any cracks was found at the inner side of the material checked by Ultrasonic Testing. The Grain size of the material was calculated as 7.0 ASTM with the help of optical microscope with image analyzer.

III. PROCESS PARAMETER

The Normalizing process was conducted in the Oil fired Continuous furnace. The oil used in the furnace was C.B.F.S. Oil (Carbon Black Feed Stock). The Axle of 63 diameter with flange from forging was taken in this experiment and the weight of the piece was 26.33 kg. The soaking temperature was set to 870 c was set . There was one pieces of Axle loaded in the tray and pushed it with the hydraulic pusher for in the furnace.

The preheating temperature was 750 c and the material passed through it . After that the material passed through the heating zone which is the soaking zone and the temperature of soaking zone was 870 c . After completing the soaking time, the material is removed from the furnace and slowly cooled in the air. The different soaking time was given to the piece and their corresponding micro structure was observed which is discussed in the following paragraph.

The soaking time is given to the piece at which best micro structure as Ferrite and Pearlite was achieved as 2 hours 20 minutes. After normalizing of the piece, the micro sample was cut from the flange side.

For the comparison of the micro structure, we normalized the material at the different different cycle time which is explained as

- Temperature = 870 c, Cycle Time = 1.0 hours
- Temperature = 870 c, Cycle Time = 2.0 hours
- Temperature = 870 c, Cycle Time = 2.0 hours 20 min

The process flow diagram of the normalizing for plane Carbon Steel is shown in the figure below as Fe-Fe3C phase diagram.

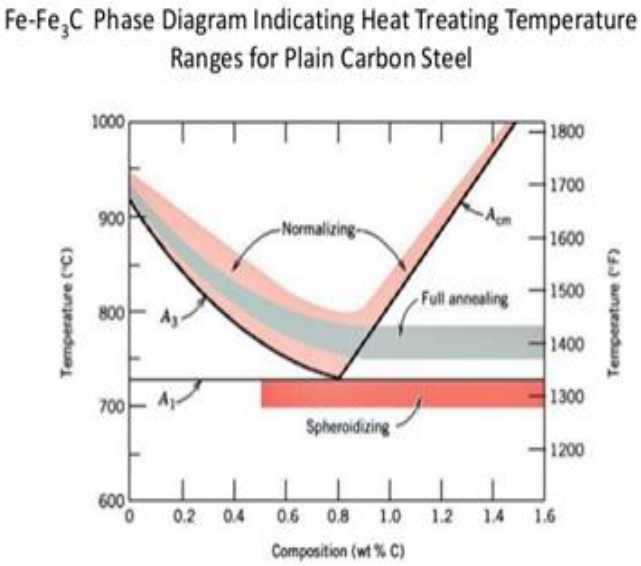

Fig 1:- Iron-Iron Carbon Phase Diagram for the Plane Carbon Steel

We compared the micro structure at this particular temperature and found the different result as explained below

IV. RESULT AND DISCUSSION

Before normalizing, the micro structure was discontinuous and unable for the machinability. The micro structure is observed at 400x on the microscope with image analyzer as given.

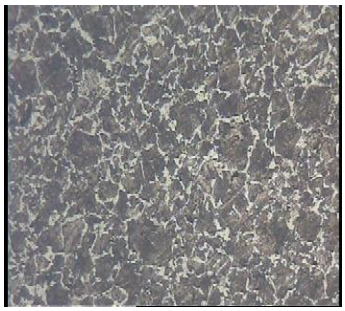

Fig 2:- As Forged Micro Structure at Magnification 100x

As shown in the figure, the distribution of Ferrite is discontinuous and we have to change it's structure for attaining uniform distribution.In First Trial, the sample is given to the temperature of 870c and soaking time was 1 hour. At this cycle time, the microstructure was not found satisfactory (fig 2) and under soaking is achieved. The Ferrite distribution is not uniform. This occurs because heat is not reached at the the material for the sufficient time.

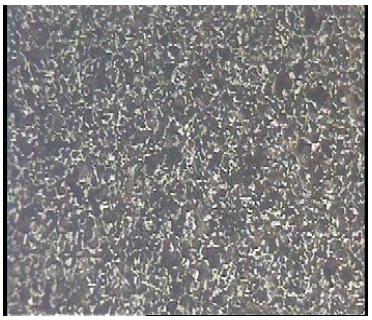

Fig 3:- Normalized Micro with Cycle Time 1.0 Hours at 100x

In second trial, the microstructure (Fig 3) was not something better than first trial but undersoaking is present and

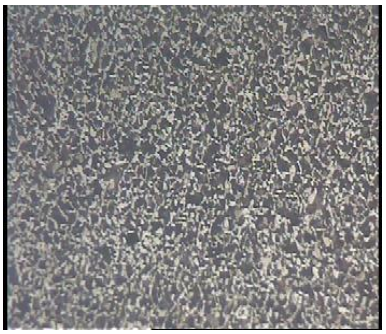

Fig 4:- Microstructure at Cycle Time 2.0 Hours at 100x

ISSN No:-2456-2165

In third trial, the soaking time was 2 hours 20 minute. The microstructure was found Uniform distribution of Ferrite and Pearlite with fine grain structure.

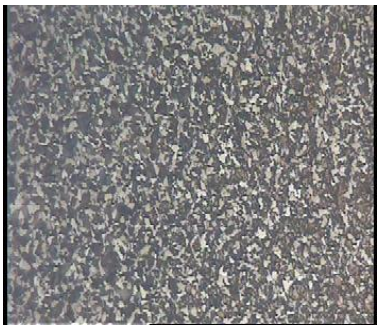

Fig 5:- Microstructure at Cycle Time 2 Hours 20 Minute at 100x

The fine grained pearlite microstructure is tougher than coarse grain ones. Normalizing reduces the internal stresses of the Carbon Steel. It also improved microstructural homogeneity., enhances thermal stability and response to heat treatment.

The thickness of Carbon steel can have a significant effect on the cooling rate.

The Hardness of the sample after normalizing was observed as **187 BHN** on the Brinnel Hardness Tester.

The related Ultimate Tensile Strength of the material was calculated as

UTS = 3.4 * 187
UTS = 635.8 MPa

Thus it was observed that the hardness reduced after normalizing of the material and material became more ductile than original forged piece. On doing that the machinability of the material improved.

V. CONCLUSION

From the experiment for the grade of steel En8DCr for the production of axle, we found the changing in microstructure and mechanical properties as discussed:

- The microstructure was found better at the temperature of 870c and the cycle time was 2 hours 20 minute as Uniform distribution of Ferrite and Pearlite with fine Grains.
- The Hardness was changed from 203 BHN (in forged piece) to 187 BHN (as normalized) thus the material machinability was improved.
- There was also found change in the ultimate tensile strength of the material from 690.3 to 603.8 MPa, thus the material became more ductile.

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