

Attaining Higher Strength and Ductility in Low Carbon Steel by Oil Quenching

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ABSTRACT: WCB grade belongs to ASTM STANDARD, This grade is generally subjected to the Normalizing and Annealing heat treatment processes. WCB (UNS Code J03002) is covered by [ASTM A216](#) standard, which specification covers carbon steel castings for valves, fittings, flanges and other pressure-containing parts for high temperature service and the quality required for assembly with other castings or wrought steel parts by fusion welding. These grades are all “cast” grades meaning they are made through “casting” which is a manufacturing process where a liquid material is poured into a mold and allowed to harden. We perform the heat treatment process apart from the annealing and normalizing that oil hardening to observe the changes in the mechanical properties and microstructures of the specified steel. As a result we get the ductility with high strength.

KEYWORDS: heat treatment, oil hardening, mechanical properties, WCB, ASTM

I. INTRODUCTION

WCB (UNS Code J03002) is covered by [ASTM A216](#) standard, which specification covers carbon steel castings for valves, fittings, flanges and other pressure-containing parts for high temperature service and the quality required for assembly with other castings or wrought steel parts by fusion welding. These grades are all “cast” grades meaning they are made through “casting” which is a manufacturing process where a liquid material is poured into a mold and allowed to harden.

The purpose of heat treating carbon steel is to change the mechanical properties of steel, usually ductility, hardness, yield strength, or impact resistance.

As WCB is a hypo eutectoid steel therefore ideally it can be subjected to all the Annealing processes, normalizing and hardening treatments.

As per the specification of ASTM standard only Full annealing and normalizing process is carried out over this grade of carbon steel.

II. CHEMICAL COMPOSITON OF WCB

ELEMENTS	AMOUNT
Carbon	0.30 max
Manganese	1.00 max
Silicon	0.60 max
Sulphur	0.045 max
Phosphorus	0.040 max
Copper	0.30 max
Nickel	0.50 max
Chromium	0.50 max
Molybdenum	0.20 max
Vanadium	0.03 max
All total of residual element	1.00 max

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

III. MECHANICAL PROPERTIES REQUIRED

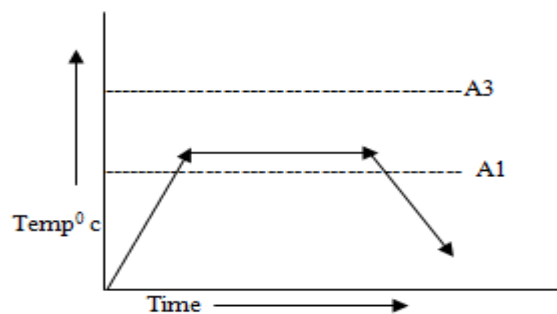
PROPERTY	VALUE
Tensile strength	485-655 Mpa
Yield strength	250 Mpa min.
Elongation in 2in or 50mm	22.0% min
Reduction of area	35% min
Hardness	137HB min.

IV. HEAT TREATMENT PROCESSES

Conventionally as per the standard ASTM A216 for the WCB grade annealing and normalizing is performed to obtain the above mechanical properties.

A. ANNEALING

Component is heated to the temperature of 920 degree Celsius with the heating rate of 120 degree Celsius to 150 degree Celsius per hour, allowed to soak for 1 hrs. at 920 degree Celsius for getting homogeneous austenite structure and then the component is cooled in **furnace** itself at the cooling rate of 56 degree Celsius per hour.



Heating cycle for annealing

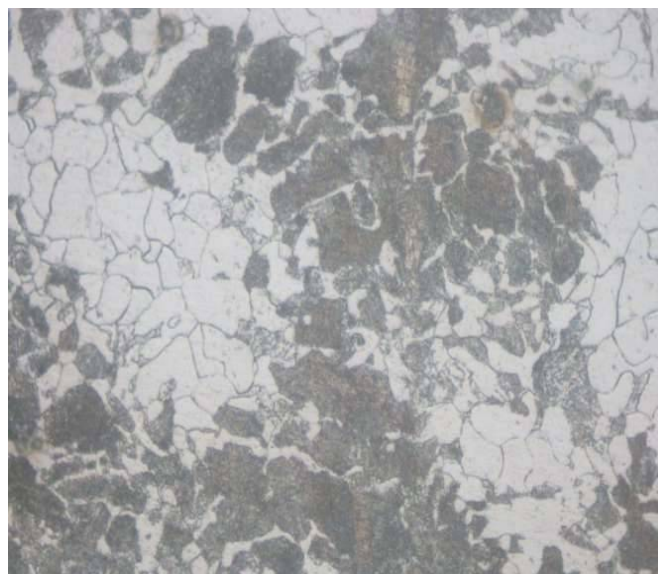


Fig: microstructure of annealed specimen at 500X

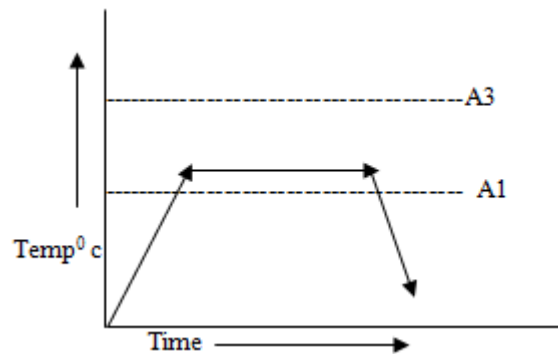
International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, Februray 2016

B. NORMALIZING

Specimen is heated to the temperature of 920 degree Celsius with the heating rate of 120 degree Celsius to 150 degree Celsius per hour, allowed to soak for 1 hr at 920 degree Celsius for getting homogeneous austenite structure and then the component is cooled in **air** at the cooling rate of 56 degree Celsius per hour.



Heating cycle for normalizing

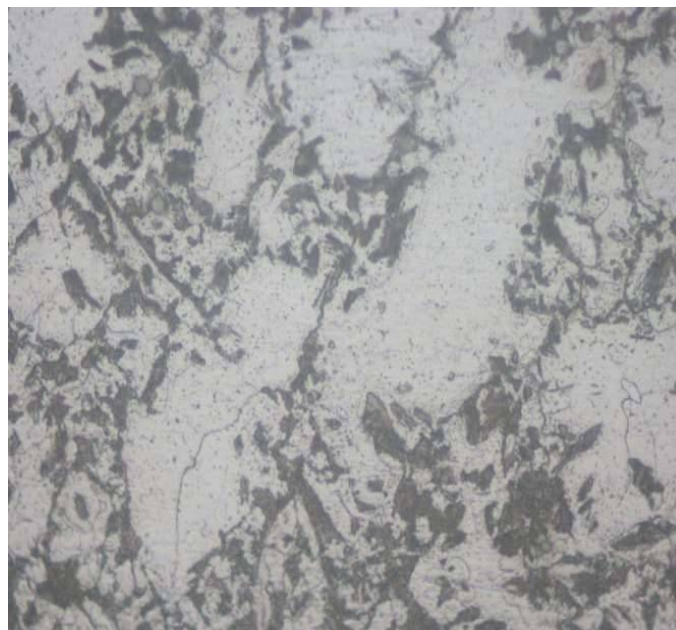


Fig: microstructure of normalized specimen at 500X

V. EXPERIMENTAL PROCEDURE

A. OIL QUENCHING

Specimen is heated to the temperature of 920 degree Celsius with the heating rate of 120 degree Celsius to 150 degree Celsius per hour, allowed to soak for 30min at 920 degree Celsius for getting homogeneous austenite structure and then the component is **quenched in oil**. Specimen is stirred into the oil bath for 30 minutes. Size of the specimen is Length- 20 cm, Width- 2.5 cm, Height- 2.5 cm. We clubbed our specimen with the bunch of 7 hammer steel, which is to be partially hardened. Size of the hammer steel is 1m in length and 20mm diameter. The both our WCB specimen and hammer steel quenched together in oil.

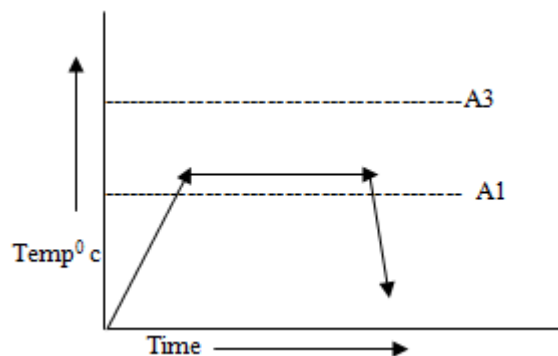
International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

As the hammer steel is heated to temperature of about 920°C and it is held at this temperature for 1hr. when the hammer steel and WCB specimen quenched into the oil transfer of heat is taking place between the oil and components. This results into the rise of the temperature of bath. This temperature affects the WCB specimen.

Due to rise in the temperature of the bath the cooling rate gets slower and there is enough time for the formation of the pearlite and ferrite hence the ductility increases. At the same time oil is also giving the cooling effect to the WCB specimen so higher strength is also achieved.



Heating cycle for oil hardening

VI. RESULT

After following the above experimental procedure we get the following result:

TENSILE TEST RESULT

OUTER DIAMETER (mm)	6.31
AREA (mm^2)	31.27
Gauge length(mm)	25
Yield load (KN)	12.20
Peak load (KN)	18.60
Y.S. (N/mm^2) ≥ 250	390.790
UTS (n/mm^2) $\geq 485-655$	594.82
FINAL Gauge LENGTH (mm)	32.11
Elongation(%) $\geq 22\%$	28.44
FINAL DIAMETER (mm)	4.18
Reduction area (%) ≥ 35	56.12

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016



Fig: microstructure of oil quenched specimen at 500X

VII. CONCLUSION

Here we can conclude with our experimental procedure that the WCB component immersed into the oil having slightly higher temperature than the room temperature after heating to austenizing temperature we can attain high strength and ductility too.

ACKNOWLEDGMENT

Here we acknowledge Mr. SWAPNIL DAGA M.D. of SHREE HANS ALLOYS LIMITED who provided us the samples for this study and we also great full to MR. BHARAT owner of KARMYOG HEAT TREATMENT PVT.LTD. Where we performed the heat treatment processes. At last but not least we are thankful to INDUS UNIVERSITY who provided us this golden opportunity to present our study.

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