INVESTIGATING THE MECHANICAL AND METALLURGIAL PROPERTIES OF CARBURIZED 16MnCr5 steel

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ABSTRACT

16MnCr5 low alloy steel was carburized at 925^{0}C. Carbon enriched up to 0.6% in case. The effective case depth is 0.47 - 0.50 mm. The tensile strength and hardness measured is 387.077N/mm^2 and 720 HV. SEM analysis and fractography results shown are ductile fracture at the core and brittle fracture in the case.

Keywords: carburizing, fractography, low alloy steels

1. INTRODUCTION

Steel is a Fe-C alloy. It is designated by carbon and other alloying elements present in it. Structural applications, offshore requirements, machine elements, defence sectors, power transmissions, air craft are found to be the major applications. Mechanical, thermal and chemical properties play a vital role in choice of steels. Properties of the steel are improved by the heat treatment and surface treatments.

Number of investigations is studied on surface treatment of low alloy steels. Behaviour of different types of steels under different surface treatment is studied as follows. Steel with 0.20-0.25% C is surface treated by carbonitriding may improve the hardness range from 720-940HV. During carbonitriding precipitation of Fe4N is decomposes of an austenite phase in a discontinuous manner. Fe4N compound is precipitates in grain boundary [1]. AISI 1020 and 5115 steel are surface treated under carburizing and carbonitriding. Increase in hardness value is found in carbonitriding in both steels is 743HV and 820 HV respectively [1].

AISI 5140 (41Cr4 steel) are borocarburized to form two zones. First iron boride zone (FeB and Fe2B) that exhibiting low case depth of 100 µm in first method and have reached 125 µm in second method. The second zone is carburized zone it formed by the influence of chromium in 41Cr4 steel [2].

2. EXPERIMENTAL WORK

Chemical Analysis

Chemical analysis test was performed to check elements present in the As-received 16MnCr5 steel using OES-foundry MASTER, GERMANY spectrometer.

Table 1 chemical composition for As-conditioned 16MnCr5 steel

Element	C	Si	Mn	P	S	Cr
Weight %	0.159	0.211	0.20	0.140	0.0260	1.10

Table 2 chemical composition for carburized 16MnCr5 steel

Element	C	Si	Mn	P	S	Cr
Weight %	0.600	0.203	1.19	0.0130	0.0240	1.11

Carburizing Process

16MnCr5 steel is received in rod form dia Ø22mm and 300mm length. Carburizing experiment carried out in SQF batch furnace. Specimens are loaded into container using suitable fixture. Furnace sealed and allowed to reaching at 900^{0}C. Flame curtains are open to allow additives to burn out. Heating is continued until it reaches 925^{0}C. Propane 1%, Natural gas 4% is introduced and maintained for 2hrs 10 minutes to progress case get deeper due to high carbon content potential 0.95 wt% set in furnace is known as boosting. For diffusion the enriching gas supply is stopped and till temperature

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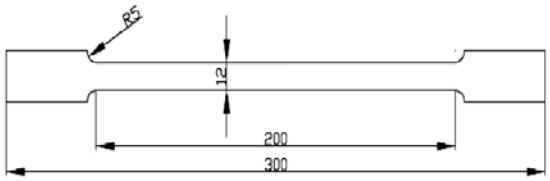
maintains at 925^{0}C and hold for 50mins. Temperature is dropped to 900^{0}C and equalized for 1 hr. Tempering is achieved at 120^{0}C for 2hrs.

Tensile Test

Gauge length prepared for As received and carburized 16MnCr5 steel as per the ASTM



standard A356 /A356M.Gauge length is 200mm and overall length is 300mm and filled radius is 5mm. in UTM machine FIE. Model; UTM 40.SR.No;11/98-2450. Tensile specimen shown in fig.1

Fig 1 Tensile test specimen prepared as per ASTM standard A356 /A356M

Hardness Test

To check the indentation behavior and scratch resistance of the surface of the 16MnCr5 steel are tested using Rockwell's hardness testing machine.

Micro Structure

For microstructure analysis specimen surface polished by different grades of emery sheets, disk polished, and etched with 4% nital. Optical microscope used at different magnifications.

Micro Hardness

Micro hardness was evaluated by using micro hardness tester for As-conditioned, and carburized specimens.

Fractography

Fractography analysis performed to check the method of failure and oxide formation in as received and surface treated specimens.

3. RESULTS AND DISCUSSION

Chemical analysis values are compared between the as received, carburized specimen shows enrichment of carbon content is increased to 0.6%.

Tensile strength increased for Carburized specimen 387.077 N/mm^2 and for as-received is 163N/mm^2. Percentage of elongation is 6% for carburized specimen and 20.5% for as-received specimen. Percentage of area reduction is found maximum at as-received specimen up to 17.355% and for carburized specimen is 8.884%

Rockwell hardness values are found for As-received steel is 20 HRC and for carburized specimen core hardness is 38 HRC and case hardness is 59 HRC.

Percentage of ferrite 82.71% and pearlite 17.29% in as-received specimen was shown in fig.2.

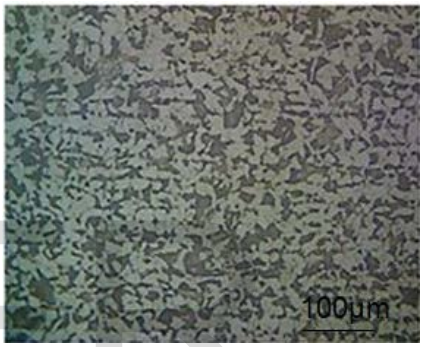


Fig.2 Microstructure of 16MnCr5 steels shows ferrite and pearlite at magnification of 200 X

Case and core having a Fine martensite and carbon martensite at 200X shown in fig.3 (a,b).

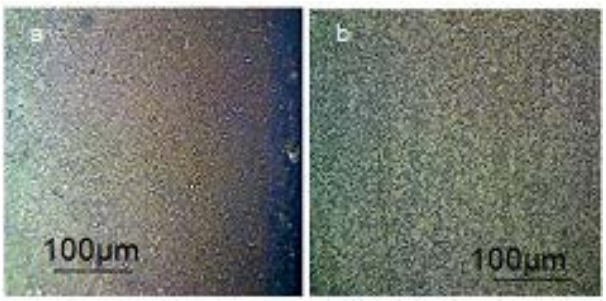


Fig 3.a & 3.b shows the microstructure of carburized specimen having both core and case

Micro hardness value for As-received is 230HV. After carburizing core has 370HV surface has 720HV.

Fractography conducted on tensile tested specimens in As-received and carburized. In as received specimen fracture is said to be ductile with neck formation seen around the fractured

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region. Carburized specimen shows inter granular fracture.

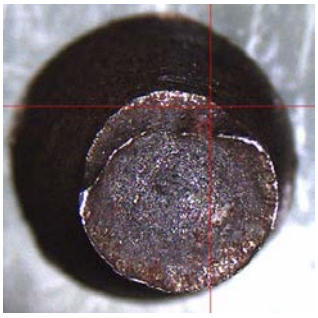
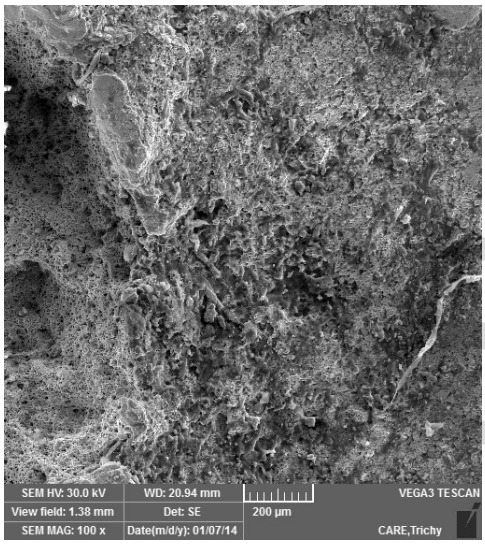


Fig - 4 macro image of tensile fractured as-received specimen



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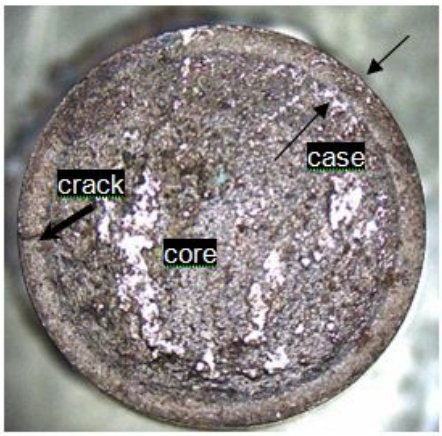

Fig – 5 fractography image shows micro voids and dimples in ductile fractured As-received specimen.

Fig - 6 macro image of tensile fractured carburized specimen

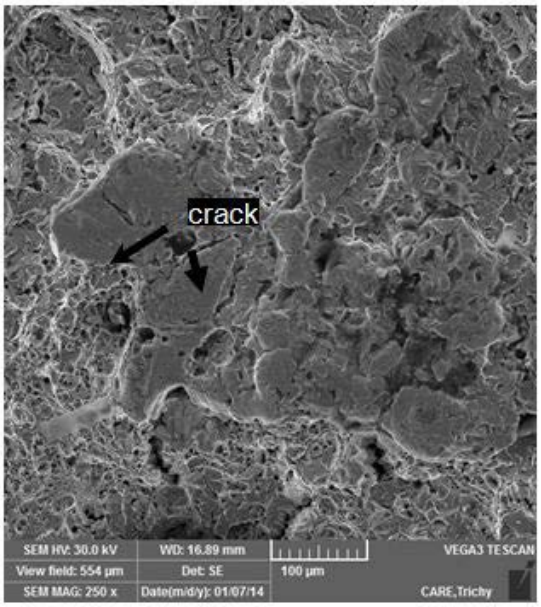

Fig – 7 Fracture in Carburized specimen showing inter granular fracture with dimples.

4. CONCLUSION

16Mncr5 steel was successfully surface treated by carburizing. Fine martensite is observed in the surface. Micro hardness of 720HV is improved in carburizing. Tensile strength of 387.077 N/mm^2 improved in carburized specimen

In carburizing carbon enriches up to 0.6% with case thickness of 0.45 to 0.50 mm.

Enriched diffused carbon increases the surface hardness. From the above experimental result shows improved hardness found in carburizing 59HRC.

Fractography has done for tensile failed specimens. In as-received specimen micro voids are observed it initiates the crack propagation and crack regions shown with dimples and vein formations.

Carburized specimen shows thin line formation of crack in macro image. Intergranular crack formations found with dimples in fractography image.

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