EFFECT OF MICROSTRUCTURAL CONSTITUENTS ON ABRASIVE WEAR RESISTANCE OF CARBURIZED SAE 8822H STEEL

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ABSTRACT

The main object of the present work is to investigate the effect of various microstructural constituents on the abrasive wear resistance of carburized SAE 8822H steel. For this purpose the specimens were carburized and heat-treated at various parameters, so as to obtain different microstructural phases. Metallographic investigations were carried out using optical microscope, electron microscope, and x-ray diffractometer. The abrasive wear resistances were recorded in weight loss in grams method, using 120-mesh emery paper fixed on rotating disc of the wear-testing machine. The experimental results shows that the abrasive wear resistance of carburized SAE 8822H depends upon the presence of various microstructural constituents as discussed in results.

1. INTRODUCTION

SAE 8822H steel is used for manufacturing tractor's transmission parts, which under goes complex-loading conditions where the fatigue and abrasive wear is also involved. Therefore the present work is an initial attempt to investigate the effect of microstructural constituents on abrasive wear resistance of carburized SAE 8822H steel.

The main object of carburizing is to enhance the fatigue durability and wear resistance of machine parts made from various carburizing steels. Carburizing heat treatment results to produce high hardened fracture resistance case lying over a soft but tougher core [1-2]. For high fatigue and wear properties required in case and core structures in carburized parts are usually under goes various heat treatments followed by quenching and tempering [3]. As the carburizing process alter the chemical composition of case and core, therefore, the proper heat treatment after carburizing is also an essential parameters for controlling the microstructure in case and core for high fatigue and wear resistance [4]. The fatigue and wear damage in carburized case is essentially starts at the surface. Therefore improvements in fatigue and wear properties in case structure are still a research-oriented topic. Most of the previous work consists on fatigue resistance of carburized components [1-4, 6-9 and 11]. However vary little information is available on wear resistance of carburized parts. Abrasive wear damage is involved in most of the rotating machine parts, when a hard particle slide or roll under pressure across a surface or in contacting subsurface of parts [5,10]. Some of previous work was done to investigate the effect of various treatments on microstructure and fatigue resistance of carburized parts made from carburizing steel [3,5,6 and 11].

2. EXPERIMENTAL PROCEDURE

2.1 MATERIAL AND SPECIMEN PREPARATION

SAE 8822H steel which contained 0.25%C, 0.24%Si, 0.78%Mn, 0.012%P, 0.039%S, 0.37%Ni, 0.46%Cr, and 0.36%Mo by weight in hot forged condition in the form

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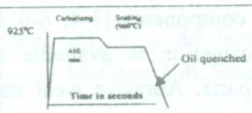
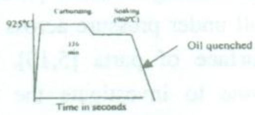
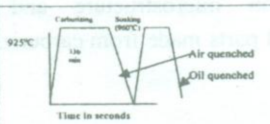
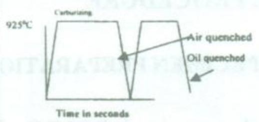
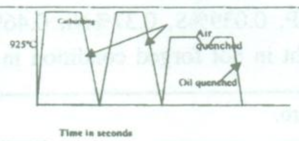
of pinion has been used in experimental work. The forged material was isothermally annealed at 925°C for 60 minutes and slowly cooled through the transformation range to refine the grain size and to improve Machinability. Specimens of 20 mm diameter and 40 mm length were machined from annealed material.

2.2 HEAT TREATMENT

All specimens were gas carburized to 925°C in continuous carburizing furnace using endothermic atmosphere enriched in propane. The carbon potential during carburizing and diffusion was maintained at 0.15-0.17 and 0.28-0.3 vol% Co respectively. The specimens were air cooled after carburizing for further reaustenitizing treatments. The specimens were grouped into 5 lots and each lot was given various heat treatments. The detail of this is given in Table 1.

Table 1: Various Heat Treatment Specimen

S.#	Heat treatment operations
1	
2	
3	
4	
5	

2.3 MEASUREMENT OF SURFACE CARBON AND CASE DEPTH

The surface carbon and carbon gradient was measured from the test bar by machining at 0.2 mm interval. The chips were collected for the carbon analysis by carbon combustion method. The surface carbon content of specimens was found to be 1.1 to 0.8 weight percent. The effective case depths were also determined using Vickers hardness tester and measured 513 VHN from surface to words the core of all specimens using 500 grams load. The detail of this investigation is given in tables 2,3 and 4.

Table 2: Measurement of Carbon Concentration Gradient

Sp No:	C from surface to core in mm	0.0	0.20	0.40	0.60	0.80	1.0	1.20	1.40	1.40
1		1.1%	1.1%	.92%	.77%	0.65%	0.60%	0.55%	0.46%	0.40%
2		0.85%	0.80%	0.75%	0.63%	0.55%	0.50%	0.44%	0.40%	0.38%
3,4,5		1.00%	0.94%	0.85%	0.70%	0.60%	0.55%	0.52%	0.45%	0.40%

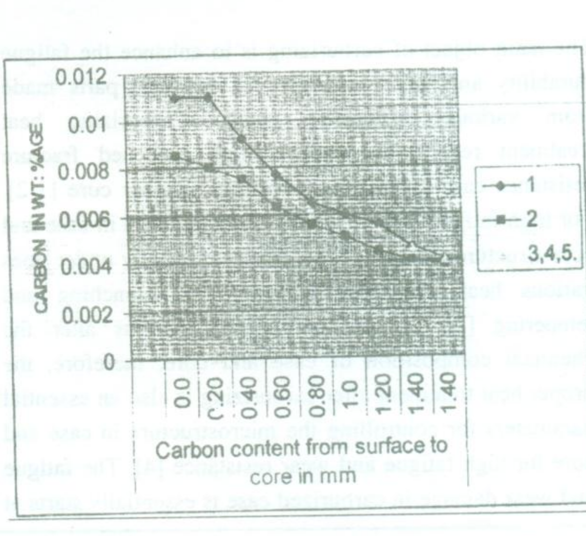


Fig. 1: Measurement of Carbon Concentration Gradient

Table 3: Measurement of Hardness

Specimen No.	Hardness' Before Heat Treatment	Surface Hardness	Core Hardness
1	161.35	772	455
2	161.35	805	441
3	161.35	726	434
4	161.35	772	441
5	161.35	778	434

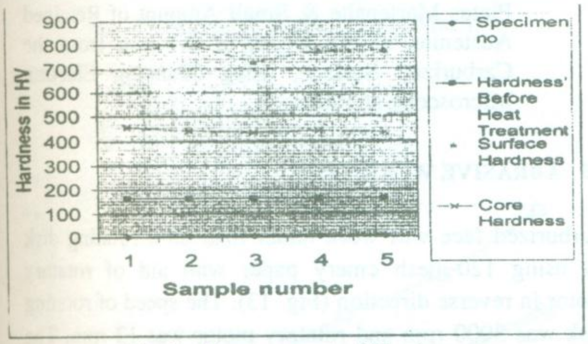


Fig. 2: Measurement of Hardness

Table 4: Measurement of Case Depth

Specimen No.	Effective Case Depth	Total Case Depth
1	1.50	1.80
2	1.10	1.60
3	1.60	1.60
4	1.60	1.60
5	1.60	1.60

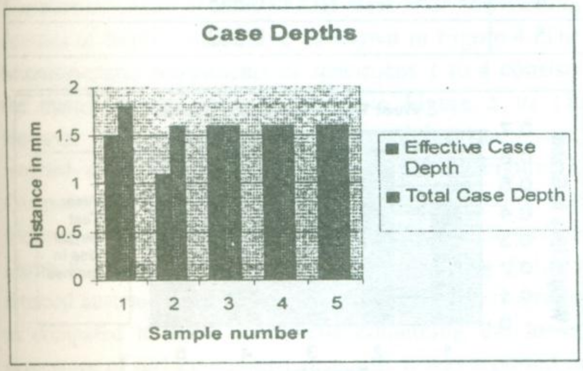


Fig. 3: Measurement of Case Depth

2.4 METELLOGRAPHY AND DETERMINATION OF MICROSTRUCTURAL CONSTITUENTS

Microstructural constituents were investigated by using optical microscope, and scanning electron microscope. The quantities of retained austenite and martensite were also investigated by using standard x-ray diffraction techniques. The area under the diffraction peaks (200) for martensite and (220) for retained austenite was measured as recommended by Phillips and George, et al [7and 8]. The results of this investigation are shown in Figure 4 to 11.

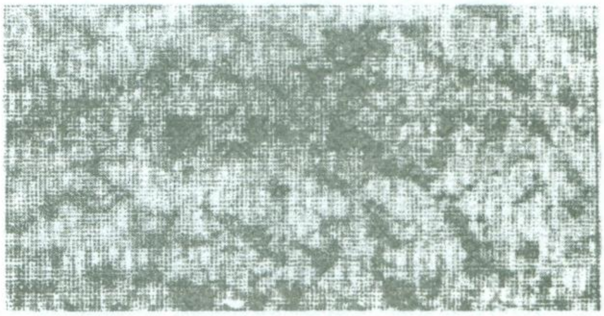


Fig. 4: Shows Ferrite Pearlite Microstructure of SAE 8822H Steel Before Heat Treatment 2000X

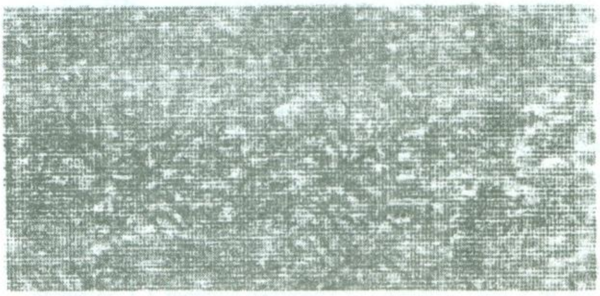


Fig. 5: Shows 30% Retained Austenite White and Martensite using Optical Microscopes 2000x

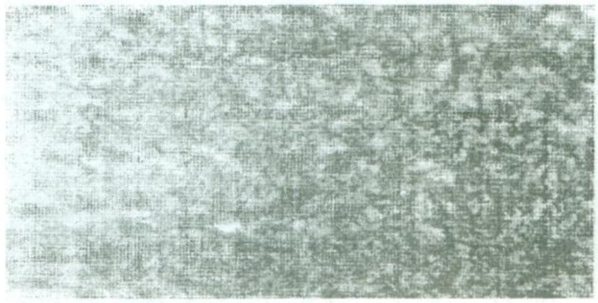


Fig. 6: Shows 25% Retained Austenite Martensite using Optical Microscopes 2000x

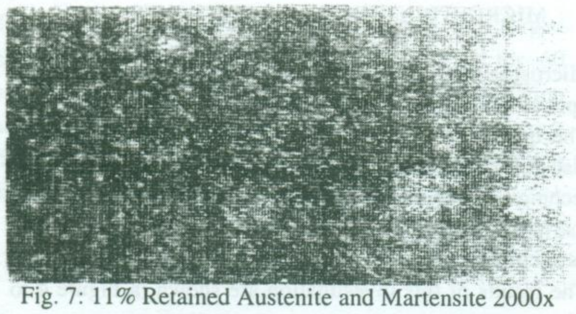


Fig. 7: 11% Retained Austenite and Martensite 2000x

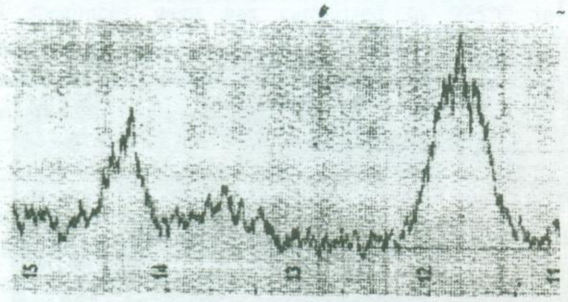


Fig. 8: X-ray Diffraction of Specimen Number 1, Containing (200) Peaks of Martensite & (220) Peaks of Retained Austenite, using X-Ray Diffractometer

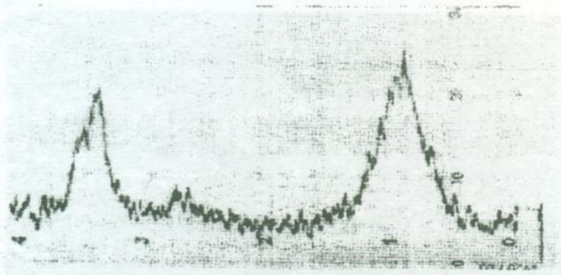


Fig. 9: X-ray Diffraction of Specimen Number 2, Containing (200) Peaks of Martensite & (220) Peaks of Retained Austenite, using X-Ray Diffractometer.

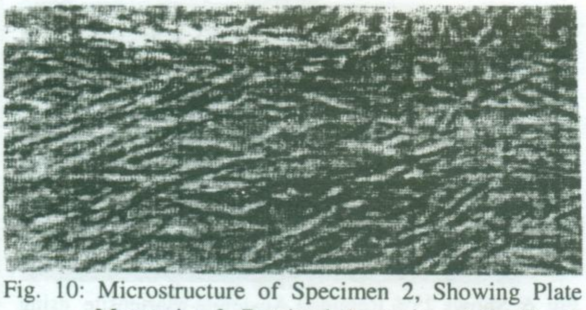


Fig. 10: Microstructure of Specimen 2, Showing Plate Martensite & Retained Austenite, at the Depth of 0.1mm from the Carburized Surface, using Scanning Electron Microscopes at 5000x

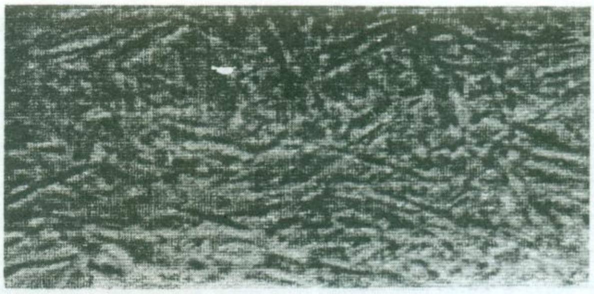


Fig. 11: Microstructure of Specimen 4, Showing Large Plates Martensite & Small Amount of Retained Austenite, at the Depth of 0.1 mm from the Carburized Surface, using Scanning Electron Microscope at 5000x.

2.5 ABRASIVE WEAR TEST

Carburized face was worn under load on a rotating disk by using 120-mesh emery paper with aid of rotatory motor in reverse direction (Fig. 13). The speed of rotating disk was 3000 rpm and rotatory motor was 12 rpm. The weight applied was 2680 grams. Each lot was worn at same parameters. The emery paper was changed after each hour period of testing and the weight loss in grams of each lot was recorded on electron balance. The abrasive wear test results of each lot vs time are shown in Figure 14.

Table 5: Measurement of Abrasive Wear

S. No.	Wear Test Weight Loss in Gram
1	0.455
2	0.639
3	0.639
4	0.645
5	0.302

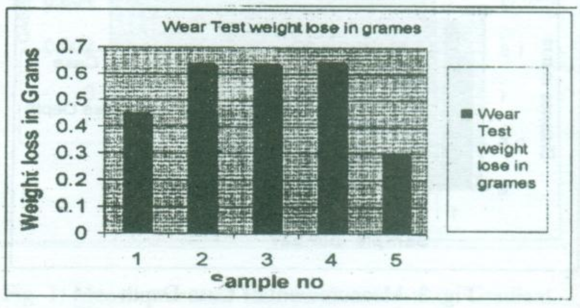


Fig. 12: Measurement of Abrasive Wear Resistance

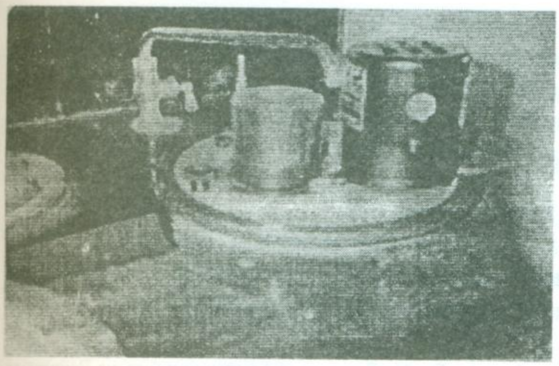


Fig. 13: Abrasive Wear Testing Machine

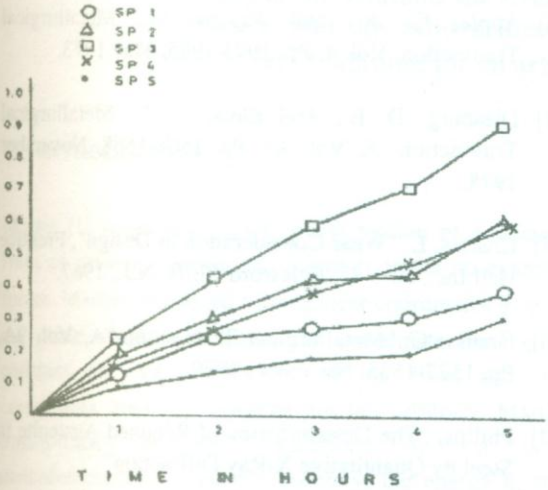


Fig 14: Abrasive Wear Resistances of Steel Samples

3. RESULTS AND DISCUSSIONS

The microstructure of SAE 8822H steel after normalizing consists of ferrite and pearlite as shown in Figure 4. The Microstructural constituents of specimens 1 to 4 consists the martensite and retained austenite Figure 5 to 11. However the specimen number 5 containing martensite, retained austenite and carbide is shown in Figure 7. Comparison of the abrasive wear profile among the specimens which contains the retained austenite at surface shows that the specimen number 1 containing heights retained austenite (30%) has lowest weight loss in grams as compared to those specimens containing the lower percentage of surface retained austenite. It was reported in early literature that retained austenite is soft which would decrease the abrasive wear resistance and must be avoided in carburized components, later on it was conventionally wisdom that it must be present in the carburized components. The increasing amount of retained austenite would decrease the fatigue and wear resistance of the carburized cases [1 and 5]. Fournella, R. A., et al investigating the effect of retained austenite on fatigue resistance of carburized components observed that increasing the amount of retained austenite in the carburized cases does not decrease the fatigue resistance. They have also observed that under cyclic loading condition retained austenite work hardened and transforms into martensite provided the additional mode for surface comprehensive stress, which would result to increase the fatigue strength of carburized case. Jason J. Spice and David K. Matlock investigate the effectiveness of three different techniques, designed to improve the bending fatigue life in comparison to conventionally processed gas-carburized 8620 steel. The bending fatigue samples were machined from forged gear blanks from the same lot of material used for the pinion gear tests, and all processing of laboratory samples and gears was done together. Fatigue data were obtained on standard as carburized parts and after three special processing histories: shot peening to increase surface residual stresses; double heat treating to refined austenite grain size. He has observea that shot peening also proved to be the most effective way to improve fatigue life at both imposed torque levels. The results of this study show that data on laboratory samples can be used to interpret the fatigue performance of gears.

The highest weight loss in grams was found in the specimen containing lowest weight percent of retained austenite (11%), as the same was reported by Apple, C.A., and Krauss, G[3& 6]. They were of the opinion that martensite contains larger number of submicro cracks which decreases the fatigue strength of carburized case. In case of specimen number 5 which shows the fine martensite, retained austenite and spherical fine carbides has the lowest weight loss as compared to all other specimens and resulted the over all highest abrasive wear resistance [11]. The same effect was observed by number of investigators [3, 9, and 10]. Apple and Krauss have observed that a double reaustenitizing treatment has provided fine martensite, which increased the fatigue strength of carburized case. Siepak, J has observed that high-retained austenite is beneficial for contact wear resistance. Jokhio, et al has investigated the effect of reaustenitizing treatment on abrasive wear resistance of carburized steel and found that double reaustenitizing treatment produced fine martensite with retained austenite that does not decreased the abrasive wear resistance of carburized steel.

4. CONCLUSIONS

1. The abrasive wear resistance of carburized SAE 8822H steel does not decrease with increasing carbon the amount of retained austenite up to 30% by volume.
2. Retained austenite network hardened and transformed to martensite thus increased the wear resistance and provided additional compressive stress.
3. The abrasive wear resistance of carburized components does not increased with increasing hardness value but increased with quantity of retained austenite. It shows that abrasive wear resistance rather depends on amount of retained austenite and some other factors like fines of martensite plates, spherical carbides, and carbon content in the martensite and retained austenite.
4. The surface carbon content (1.1 weight percent, alloy content Ni, Cr, Mo), austenitizing conditions (quenching from 860 °c to 140 °c in oil after carburizing) and double reaustenitizing had refined the case structure and increased the abrasive wear resistance.
5. The double reaustenitizing treatment is recommended for the production of carburized components where the high abrasive wear resistance is to be considered as the designing factor.

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