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"A COMPARATIVE STUDY ON SURFACE RESPONSE OF CARBURIZED STEEL"

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ABSTRACT

Surface characteristics must be adjusted in modern materials while the foundation material's qualities remain unchanged. Hardness is especially important at times and must be increased to minimise wear on the surface of the material and hence damage of the surface. The current article examines carburized SAE 1020 steel for hardness and wear resistance. According to the findings, carburized samples had a higher resilience to surface wear. The hardness curve for non-carburized samples showed a displacement of about 800 nm, whereas the hardness curve for carburized samples showed a displacement of around 400 nm, indicating that the hardness of carburized samples has been significantly improved when compared to non-carburized samples

Key Words: *Hardness, Tribology, Carburization, Wear, Normal load, SAE 1020*

I. INTRODUCTION

Heat treatment is a process of heating and cooling operations; it is dependent on the time spent soaking a specimen or alloy in the solid state in order for it to acquire desired features." Steel heat treatment operations begin with the creation of martensite and end with the disintegration of austenite. The physical and mechanical qualities of any specific steel are determined by the quality of these converted products. Carburization results in residual changes for carbon content and carbide volume from surface to core as well as slow conversion of mechanical and wear characteristics. Heat treatment and carburization contribute to increased mechanical and wear resistance. Carburizing is the impingement of carbon onto the surface of low-carbon steels at temperatures ranging from 850 to 950°C, when austenite, with its carbon solubility, is the stable crystal structure. The high-carbon surface layer is hardened by quenching to generate martensite. A strong, low-carbon steel core was protected by a high-carbon martensitic shell with good fatigue and wear resistance. Surface carbon, on the other hand, is normally limited to 0.9 percent since too much carbon might result in production of austenite and brittle martensite. The initial stage in heat treating steel is to expose the specimen to a high temperature environment for a period of time in or above the critical range in order to generate austenite. Carburizing is a traditional and very inexpensive Case heat technique. A low steel, typically containing 0.20 percent carbon or less, is placed in air containing appropriate levels of carbon monoxide. Carburization is simply defined as the expansion of carbon to the exterior of low carbon steel at temperatures ranging from 850 to 950 degrees Celsius. However, surface carbon is frequently regulated to 0.9 percent because too much carbon material might result in retained austenite and weak martensite.

II. LITERATURE REVIEW

Steels are commonly employed in industrial production because of their superior manufacturing capability. However, their low surface hardness and strength restrict their performance and longevity in many applications,

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particularly in domains where surface hardness, fatigue resistance, and wear resistance are critical. Low-temperature nitriding or carburizing procedures were developed in the mid-1980s to enhance the surface characteristics of austenitic stainless steel by generating interstitially supersaturated austenite, often known as "S-phase" or "expanded austenite". The enlarged austenite layer has a high surface hardness (>HV1000), a high surface compressive residual stress (> -2 GPa), good surface wear, and corrosion resistance. Though studies on the mechanical characteristics of expanded austenite layer have been undertaken throughout the years, the majority of them have focused on the impact of expanded austenite layer on the overall properties of the treated sample. Li used carburizing through a 50 m thick 316L stainless steel foil to test the mechanical characteristics of the enlarged austenite layer and discovered that the maximum tensile stress was only 500MPa and the fracture strain was just 0.9 percent. In fact, substrate constraints have a significant impact on the mechanical characteristics of the enlarged austenite layer. Large amounts of C or N interstitial atoms, for example, in the surface carburized layer, might generate lattice expansion that is restricted by the substrate. Massive surface compressive residual stress ranging from -1.4 to -3.5 GPa is created in the expanding austenite layer as a result of the specimen's undisturbed substrate constraint. However, if the thickness of the substrate is insufficient to prevent surface layer deformation, fracture and pulverisation will occur. Stinville et al. studied the fracture behaviour of a plasma nitrided expanded austenite layer and discovered that the surface was extremely brittle, with cracks running perpendicular to the tensile direction.
According to a review of the existing literature, the carburizing process has a greater influence on improving the tribological response of steel substrates. The carburization procedure has aided in the improvement of the corrosion resistance of ferritic and ferritic-martensitic steel. The approach has enhanced the wear and hardness responses of several steel grades. Given the application limitations of the tested steels, carburization might impact the wear resistance of the substrate if the carbon potential is increased to 0.9.

III. EXPERIMENTATION

SAE 1020 steels were obtained and the test samples were set up by utilizing the machine activity. The percent arrangement of SAE 1020 steel by (wt %) is given as C-0.189, Si- 0.249, Mn-0.54, S-0.020, P-0.30, Cr- 1.317, Ni-1.589, Mo-0.280, Cu-0.249, Al-0.020 and Fe. The test sample for examination of mechanical and wear properties like hardness and wear are set up according to ASTM standard.

Carburization of SAE 1020 steel specimen
Steel test samples were created for mechanical and wear characteristics testing. It was subjected to the pack carburization treatment procedure. Mellow steel samples were placed in a gas carburizing heater with the help of a mild steel wire looped around it throughout the carburizing process. After that, it was placed in the gas carburizing heater, which maintained carburization temperatures of 9200C for a period of 6 hours. The carburized samples were then tempered for a certain temperature and time before being subjected to various mechanical and wear tests.

Fig. 1 Gas carburizing furnace

IV. RESULT & DISCUSSION

Microstructural analysis

SAE 1020 samples are examined for microstructure under various situations such as carburized samples, samples without carburisation, and worn out samples under various loads. The microstructure of the as-received and polished samples is depicted in Figs. 2(a) and 2(b). The SAE 1020 samples were ground with silicon carbide sheets ranging in grit size from 320 to 1500 before being diamond polished with 1 micron diamond paste. The photos show that the samples are well polished and have few, if any, fractures.

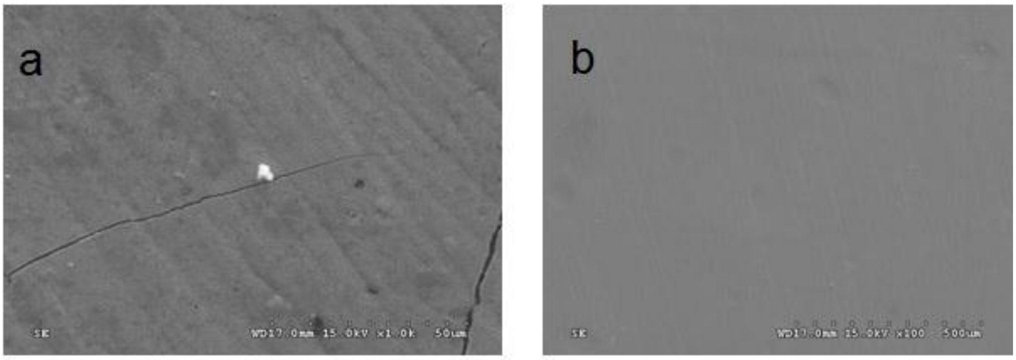

Fig. 2(a) and 2(b) Polished sample

The microstructure of SAE 1020 grade steel is analysed after it is carburized at 9200C for 6 hours. The analysis demonstrates a homogeneous distribution of carbon atoms in the matrix, which will undoubtedly aid in improving the tribological response of the samples under consideration.

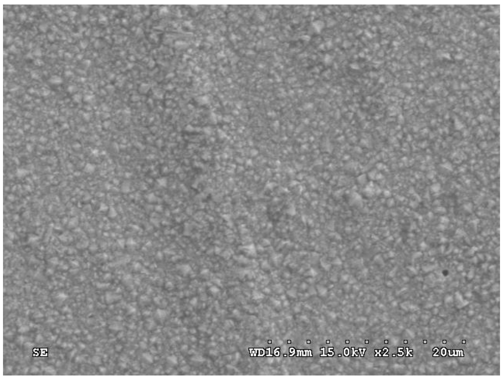

Fig. 3 Carburized sample

Steel samples of grade SAE 1020 are evaluated for wear resistance using a pin-on-disc tribometer, and the microstructure is investigated further. The analysis found that under a standard load of 10 N, the surface of the non-carburized samples had peeled off, making them
prone to poor tribological behaviour.

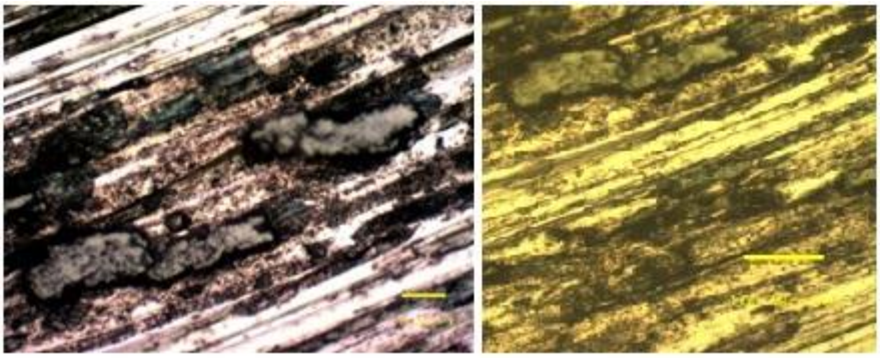

Fig. 4 Wear tested without carburisation (Load: 10N)

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The samples of grade SAE 1020 without carburisation are evaluated for wear resistance on a pin-on-disc tribometer with a normal applied stress of 30 N, and the microstructure is further investigated. The tribological response of the noncarburized substrate degraded more as the load increased, and the surface peeled off due to poor wear resistance.

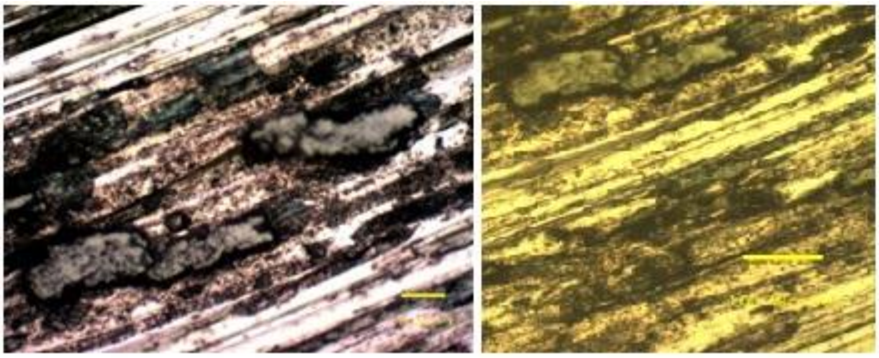

Fig. 5 Wear tested carburisation (Load: 10N)

The infusion of carbon atoms on the surface of SAE 1020 substrates clearly increased the tribological behaviour or wear resistance of the samples, as shown in fig. 5. Carbon atom diffusion helps to change the surface properties of the substrate, enhancing its wear resistance. It is also clear from the optical microscope picture that the wearing out of the surface layer is reduced for the same sample and applied load when carburized samples are compared to non carburized samples.

The infusion of carbon atoms on the surface of SAE 1020 substrates clearly strengthened the tribological behaviour or wear resistance of the samples, as shown in fig. 5. Carbon atom diffusion helps to change the surface properties of the substrate, enhancing its wear resistance. It is also clear from the optical microscope picture that the wearing out of the surface layer is reduced for the same sample and applied load when carburized samples are compared to non carburized samples. However, increasing the applied load may worsen the condition because it may have an adverse effect on the tribological characteristics of the substrate; however, when compared to non-carburized substrates exposed to the same load, carburized substrates exhibit significantly better tribological response.

Hardness results

Because the indentation depth (and hence volume) is significantly less than in traditional indentation measurements, the nanoindentation technique is often used to determine the mechanical characteristics of a tiny amount of material. The load-displacement curve is continually recorded throughout loading and unloading in this approach; the hardness HN is derived from the loading section of the load-displacement curve, while the Young's modulus E is retrieved from the unloading part. Nanoindentation is ideal for investigating the mechanical characteristics of films produced on a substrate. However, accurate assessment of such parameters is challenging due to the inherent substrate influence and surface roughness. A shallower indentation would diminish the substrate impact while amplifying the roughness effect, and vice versa. As a result, a compromise must be struck, and the appropriateness of the choice is represented in the quality of the load-displacement curves.

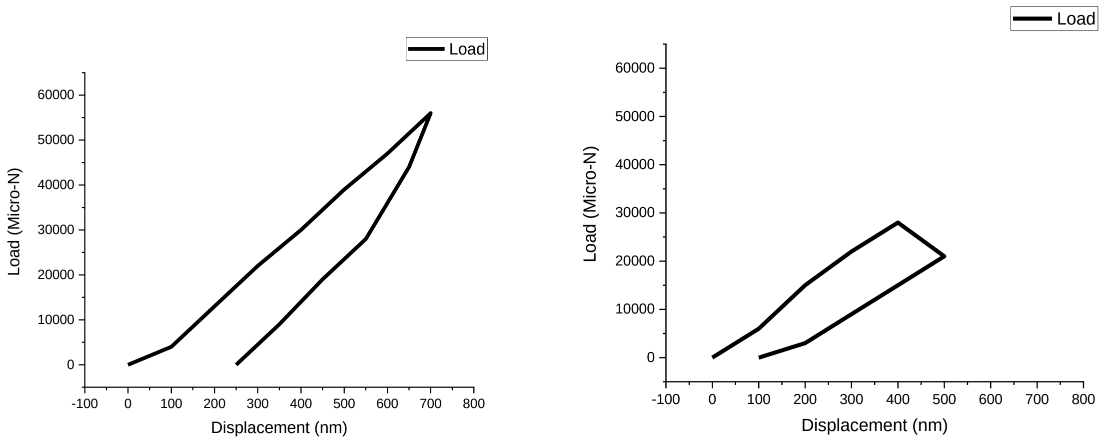

Fig. 8-9 Hardness results of non-carburized and carburized samples

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V. Conclusion

Carburization had a significant influence on the mechanical characteristics of carburized SAE 1020 grade steel in the current studies. Carburisation had a higher influence on the surface morphology of the substrates studied. The displacement of the hardness curve for non-carburized samples was approximately 800 nm, while the displacement for carburized samples was around 400 nm, indicating that the hardness of carburized samples has improved significantly when compared to non-carburized samples. Optical pictures of the wear tracks show that carburisation of the samples greatly improved the wear resistance of the SAE 1020 samples.

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