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Wear Analysis Of 42crmo4 Steel At Different Hardness.

[1]Rajnish Kumar, [2]Dr. Amol Lokhande, [3]Dr. Vishal Sulakhae
[1] **Student,** [2] **Professor,** [3] **HOD Mechanical Engineering,**
[1]Mechanical Engineering Department School of Engineering & Technology, Sandip University, Mahiravani, Nashik, Maharashtra, India.

***Abstract*:** 42CrMo4 steels are widely used in automotive, aerospace applications and machine tools where wear resistance needs to be maintained throughout its lifetime. It is possible to change the initial microstructure and hardness of these steels with various heat treatments and improve their mechanical properties. For this purpose, the effect of hardness on wear characteristics of 42CrMo4 quality steel was investigated in this study. After various hardening process the samples were made with different hardness values obtained in 42CrMo4 steel. Hardness measurements and the wear tests were performed with microhardness tester and wear testing machine, respectively. The microstructural features developed by the applied heat treatments were examined with an optical microscope, and the wear characteristics were studied in terms of friction coefficient, wear volume loss, and worn surfaces of samples.

***Index Terms* - 42CrMo4 Steel, heat treatment, microstructure, hardness, wear, metallurgy.**

1. Introduction

Wear is a significant material failure mechanism that reduces the surface quality and cause deterioration of machining tolerance of parts working in contact. 42CrMo4 is a quality steels with high toughness and strength properties and are widely preferred in applications involving contact deformation such as machine parts. Heat treatment is an effective method of obtaining the optimum microstructure component of the steel to increase its mechanical properties to the desired level. The wear behavior of a material varies mainly depending on the mechanical features of the worn surface, such as hardness and toughness, in a tribological system. It is essential to identify how wear characteristics differs according to the basic steel microstructures when designing wear-resistant steel components.

Hardness provides wear resistance by reducing the depth of wear, and toughness by limiting delamination in the worn area. Hardness is a structure- sensitive property that is lowest in ferrite structures formed from the austenite phase during slow cooling and highest in martensite structures transformed with rapid cooling. Advanced strength, toughness and hardness mechanical properties for a steel alloy can be achieved by the tempered martensite microstructure**.**

Fast cooling results the hard carbides to precipitated in the martensitic matrix to have wear improving characteristics, and by altering the tempering temperature amount of precipitation can be controlled and a considerable effect on wear resistance is observed.

Moderate cooling transformation phase of pearlite consists of a layered arrangement of ferrite and cementite, and the distribution of iron-carbide in it also affects the wear resistance. Perlite clusters dispersed in a ductile ferrite matrix strengthen the structure and reduce the rate of material loss during wear.

M.M. Khruschov has done abrasive wear tests on technically pure metals, heat treated steels, cold work hardened materials, hard wear resistant materials and minerals against fixed abrasive grains are discussed [1]. SAHA, G investigates steels for mining wear applications involving abrasive and impact-abrasive conditions [2]. Jaswin, M The effect of cryogenic treatment on the microstructure and wear resistance of X45Cr9Si3 and X53Cr22Mn9Ni4N valve steels is investigated by conducting an optical and scanning electron microscopy (SEM) study and reciprocating wear test[3]. WU, H. Y studied The effects of the initial spheroidizing microstructures on the microstructure and mechanical properties of the quenched and tempered steel were studied in detail[5].

The purpose of this study is to characterize the wear behaviour of 42CrMo4 steel as a response of different hardness obtained after heat treatment. To examine the wear performance of the steel after heat treatments, test is conducted on wear testing machine. Elemental analysis of the wear zone, and hardness testing are included to reveal the steel's wear behavior.

2. Literature review of Heat treatment

The classical alloy for heat treatment is, of course medium and high carbon steel. From the time of its discovery, steel has been regularly subjected to heat treatment of one form or another. The histories of the swordsmiths and cutlers' trades make it very clear that precise method of hardening of steel, by plunging the solid red-hot steel into water (thus producing 'martensite'), and its toughening, by tempering the quench-hardened steel at a moderate temperature, have been known empirically and used for thousands of years.

Even the antique literary book, "The Odyssey of Homer" finds description such as **"Just as a smith plunges into cold water some great axe-head or edge and it hisses angrily-for that is the treatment, and the strength of iron lies in its temper…"**.

Application

- To improve the mechanical properties of a material that include hardness, tensile strength, shock resistance, ductility, and resistance to corrosion.
- To improve machinability and reduce brittleness.
- For the relief of the internal stresses of the metal-induced during hot or cold working.
- To change the grain size or refine it.
- To increase the magnetic and electric properties.
- To increase the resistance to corrosion as well as resistance to wear.
- To improve the hardness of the surface of the material.
- To improve the limit of fatigue of medium and small-sized parts like gears, shafts etc.
- To give an appearance that is clean, bright, and pleasing to the hardened surface.
- To obtain a tough core though case hardening.
- Heat treating improves the hardening properties of steel to allow it to cut other metals.
- To promote the uniformity of a structure.

3. Experimental setup

The chemical composition of 42CrMo4 steel is given below. 42CrMo4 grade steels in the form of cylindrical rods were processed to dimensions of Ø10x16.5 mm and then hardening and tempering is done to obtain different hardness on the specimen.

Chemical composition of 42CrMo4 steel

Element	C	Si	Mn	Ni	Cr	Mo	V	Cu	P	S
Max. %	0.45	0.40	0.80	-	1.20	0.30	-	-	0.020	0.020
Min. %	0.38	0.15	0.50	-	0.90	0.15	-	-	0.035	0.035

In the study, the specimen is hardened, quenched, and tempered with different cycles to obtain different hardness values due to change in microstructure, samples are characterized with the values of hardness as below
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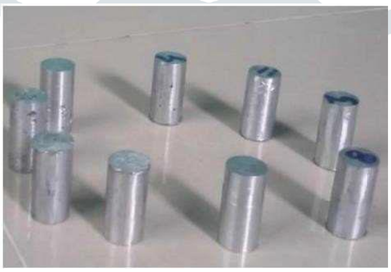
Sample	1 (untreated)	2	3	4	5
Hardness (HRC)	23	30	38	43	51
Tempering temp. (°C)	650	580	500	380	250

The hardness variation of the heat-treated samples is investigated by Rockwell Hardness Tester on 'C' scale. The surface hardness should be reported in HRC. The readings should be taken preferably in the centre of the diameter. Sufficient distance between two indentations should be maintained so that it does not overlap each other. Three readings should be taken on the surface and the average value must be reported.
The test specimen for each hardness is clamped on wear test machine on by one, with a vertical load of 15Kg. each specimen is kept sliding of 3000m at 715 RPM on wear test machine.
Results obtained after the experiment are as below


4. Result and analysis

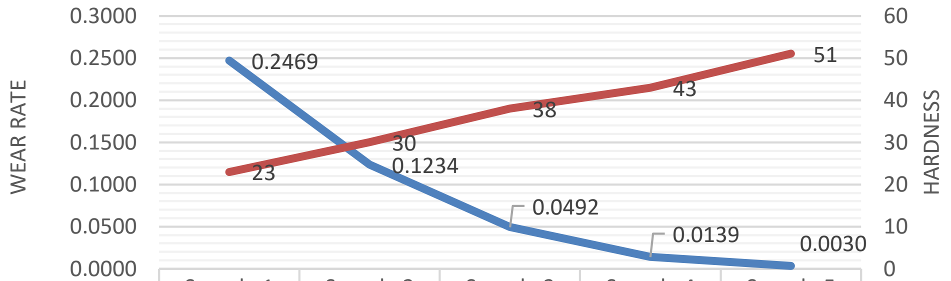
Sliding distance: - 3000m

	Material Hardness (HRC)	Sample Dia. & Length (mm)	Load (Kg)	RPM	Initial weight. (gm)	Final weight (gm)	Change in weight (gm)	Wear Rate/10^-4 (mm^3/m)
Sample 1	23	Ø10x16.5	15	716	10.2902	4.4987	5.7915	0.2469
Sample 2	30	Ø10x16.5	15	716	10.1401	7.2458	2.8943	0.1234
Sample 3	38	Ø10x16.5	15	716	10.3119	9.1572	1.1547	0.0492
Sample 4	43	Ø10x16.5	15	716	10.3795	10.0536	0.3259	0.0139
Sample 5	51	Ø10x16.5	15	716	10.2241	10.1528	0.0713	0.0030

42CrMo4 Steel samples are used in Quench & Tempered condition. The samples were tempered are different temperatures to achieve the hardness as per experimental results. Increase in tempering temperature results in lowering the hardness.

Wear resistance of each material is different even if the hardness is similar. Wear properties depend on hardness, alloying elements in material.
heat treatment and microstructure of the steel. Chromium and molybdenum are carbide forming elements which enhances the material wear properties in 42Crmo4. From experimental we can see that higher hardness (low tempered) shows wear resistance highest among other samples with Low hardness (high tempered**).** The carbides are coherent with martensite structure when the tempering is low. As we increase the tempering temperature the carbides precipitates separately from martensitic boundary and shifts in the matrix of ferrite and pearlite [11].

During the experimental study it is found that the wear resistant property of material improves with increase in hardness of the material, also the wear rate of the material is inversely proportional to hardness of the material.



	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Wear Rate/10^-4 (mm3/m)	0.2469	0.1234	0.0492	0.0139	0.0030
Material Hardness (HRC)	23	30	38	43	51

WEAR RATE VS HARDNESS RELATION

5. CONCLUSION

In this study, the wear rate reduces to minimal level for the hardened 42CrMo4, this is due to carbon infusion and the retention into the martensite structure. Martensite structure being hard and brittle in nature offers high wear resistance. The hardened jobs are mainly used for the areas where sliding contacts are present to offer high degree of wear resistance and longer life. Parts such as gear, chisel in power drilling tools, linkage arms, Brake drum, liners and pins in excavators are hardened and used for application for elongated life.

REFERENCES

1. KHRUSCHOV, M.M. Principles of abrasive wear. *Wear*. 1974, vol. 28, pp. 69-88.
2. SAHA, G., VALTONEN, K., SAASTAMOINEN, A., PEURA, P., KUOKKALA, V.T. Impact-abrasive and abrasive wear behavior of low carbon steels with a range of hardness-toughness properties. *Wear*. 2020, vol. 450–451, p. 203263.
3. Jaswin, M. Arockia, D. Mohan Lal, and A. Rajadurai, "Effect of cryogenic treatment on the microstructure and wear resistance of X45Cr9Si3 and X53Cr22Mn9Ni4N valve steels,"*Tribology Transactions*, vol. 54, no. 3, pp. 341–350, 2011.
4. ZAMBRANO, O. A., GÓMEZ, J. A., CORONADO, J. J., RODRÍGUEZ, S. A. The sliding wear behaviour of steels with the same hardness. *Wear*. 2018, vol. 418–419, pp. 201–207.
5. WU, H. Y., HAN, D. X., DU, Y., GAO, X. H., DU, L. X. Effect of initial spheroidizing microstructure after quenching and tempering on wear and contact fatigue properties of GCr15 bearing steel. *Mater. Today Commun*. 2022, vol. 30, p. 103152.
6. LI, C., DENG, X., HUANG, L., JIA, Y., WANG, Z. Effect of temperature on microstructure, properties and sliding wear behavior of low alloy wear-resistant martensitic steel. *Wear*. 2020, vol. 442–443, p. 203125.
7. J. Jones Praveen, M. Vinosh, A. Bovas Herbert Bejaxhin, and G. Paulraj, "Embedded effect of ZrB2-Si3N4 on tribological behaviour of Al 8011 metal matrix composite," *Materials Today Proceedings*, 2021.
8. S. J. Kim, K. S. Kim, and H. Jang, "Optimization of manufacturing parameters for a brake lining using Taguchi method," *Journal of Materials Processing Technology*, vol. 136, no. 1-3, pp. 202–208, 2003.
9. S. Hao, J. Xie, A. Wang, W. Wang, and J. Li, "Effect of consolidation parameters and heat treatment on microstructures and mechanical properties of SiCp/2024 Al composites," *Science and Engineering of Composite Materials*, vol. 22, no. 6, pp. 673–684, 2015.
10. A. Bovas Herbert Bejaxhin, G. Paulraj, G. Paulraj, G. Jayaprakash, V. Vijayan, and A. BovAs Herbert BejAxhin, "Measurement of roughness on hardened D-3 steel and wear of coated tool inserts," *Transactions of the Institute of Measurement and Control*, vol. 43, no. 3, pp. 528–536, 2021.
11. Xin Yao 1, Jie Huang 1,2, Yanxin Qiao 1,* , Mingyue Sun 2,*, Bing Wang 2 and Bin Xu 2 Precipitation Behavior of Carbides and Its Effect on the Microstructure and Mechanical Properties of 15CrNi3MoV Steel
12. A study on Carbon Fiber Based Polymer Rein Force composites; PK Chidambaram, DA Lokhande, DM Ramachandran… - REST Journal on Emerging trends in Modelling …, 2021
13. Sharma, Mohit, Shanglin Gao, Edith Mäder, Himani Sharma, Leong Yew Wei, and Jayashree Bijwe. "Carbon fiber surfaces and composite interphases." Composites Science and Technology 102 (2014): 35-50.