

# Effect of Tempering Temperature & Applied Load on Various Wear Environment of Carburized Mild Steel

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**Abstract**— This work presents the effect of various wear environments like 20% soil & 80% sand and 40% soil & 60% sand on as received and carburized mild steel sample at different load like 75N, 200N & 375N and at different tempering temperature like 200°C, 250°C & 300°C. The mild steel sample was carburized at 950°C. The heat treatment after carburization has been acknowledge that at some instant it improving the various properties of mild steel. The mechanical properties and wear behaviour of mild steel samples carburized at temperature of 950°C and tempered at different tempering temperature of 200°C, 250°C & 300°C have been studied and it is observed that the sample with heat treatment improves the hardness, tensile strength and wear resistance of mild steel. For this experiment firstly the mild steel samples are carburized at temperature 950°C than soaking for two hour and then it is tempered at different temperature range of 200°C, 250°C & 300°C for 1h, 1.5h, 2h. After this the carburized and tempered mild steel samples are subjected for different kind of test such as abrasive wear test at different load like 75N, 200N & 375N, and tensile test. the result of these experiment shows that the carburized and tempered process greatly improve the mechanical and wear properties like hardness, tensile strength and wear resistance and these properties increases with increase in tempering temperature. The aim of these experiments is to examine the effects on mechanical and wear properties for mild steel samples which were carburized and tempered at different temperature and various wear environments.

**Key words:** Mechanical Properties, Carburizing, Tempering Temperature, Wear Rate

## I. INTRODUCTION

The service conditions of many steel components such as gears, cams, valves, agricultural equipment etc, make it necessary for them to possess both hard and wear resistant surfaces but tough and shock resistant cores [1]. A low carbon steel of approximately 0.1% carbon will be tough while a high carbon steel of about 0.9% or more will possess adequate hardness (and inherently low toughness) when suitably heat-treated. The combination of hard, wear resistant surface and tough core required in the aforementioned components involves the treatment of a shock-resistant steel so as to alter the nature of the surface in order to increase the hardness while the core remains more or less unaltered. There are two major processes through which such an alteration of the surface layers of steel components may be carried out, namely, (I) processes which impart surface hardness by changing the microstructure of the surface skin without changing the chemical composition of the surface. Such steel must not have a carbon content of less than 0.4% for them to be amenable to hardening (by any of flame, induction, laser, and electron beam hardening) (II) processes which impart surface hardness by changing the surface chemistry of the steel by diffusing carbon, nitrogen or both carbon and nitrogen into its surface. Steels for this process may have a

carbon content of about 0.1%. Examples of this latter process include carburizing, nitriding, cyaniding, diffusion coating, and hard surfacing. The method of carburizing was selected for this investigation because it has the advantages of ease of operation, adaptability and portability of the equipment required, ability to heat-treat component after this.

## II. METHODOLOGY

Preparation of test specimens. The test specimens for analysis were prepared as per ASTM standard and their description is given below Specimen for abrasive wear and hardness test Specimens of same dimensions are used for both the abrasive wear rate analysis and hardness testing.

Dimensions of the specimen are 75mm × 25mm × 5mm.



Fig. 2.1: Specimen for Abrasive Wear Rate Analysis & Hardness Testing

### A. Specimen for Tensile Test

A tensile test specimen as per ASTM standard is prepared for this purpose is based on the following equation.

- $L = 5.65\sqrt{A}$
- Where, L = Gauge length
- A = Cross sectional area

The dimensions of the specimen are: Effect of tempering temperature and applied load on various wear environment of carburized mild www.iosrjournals.org 64 | Page

- Thickness - 6mm
- Width - 25mm
- Gauge length - 100mm



Fig. 2.2: Specimen Tensile Test

### B. Carburization of Mild Steel Samples

It is proposed to compare the behaviour of low carbon steel for the as received specimen with heat treated specimen. The heat treatment process used in the current investigation is Carburization. The entire carburization process is explained below. Firstly, samples are placed on the thick bed of carburizer kept in a stainless steel container. The container is fully covered from all sides and the top of the container is

covered with a steel plate. The container was then introduced into the electrical box type furnace (Fig. 3.3.) maintained at the required carburization temperatures. The carburization temperatures used in present work are 950 °C. Specimens are subjected to different soak time of 2h. After carburization, the specimens are quenched in oil. This results in hardening of the specimen surface.



Fig. 2.4: Electrical Furnace Box Type (Single & Double Door)

### C. Tempering of Carburized Samples

After the carburization process, the steel is often harder than needed and is too brittle for most practical use. Also, severe internal stresses are set up during the rapid cooling from the hardening temperature. To relieve the internal stresses and reduce brittleness, we should temper the steel after it is hardened. For this, the carburized steel samples are tempered at 200°C, 250°C, 300°C for 1hr, 1.5hr, 2hr and then allowed to cool in still air. Now the specimens are ready for testing. Abrasive wear test the test was conducted on a machine called Dry Abrasion Test Rig TR-50 (Company: DUCOM) as shown in the fig:



Fig. 2.3: Dry Abrasion Test Rig TR-50 (Door Close & Open).

### D. Machine Specification of Dry Abrasion Test Rig TR-5

- TYPE NO. – TR-50
- VOLTS – 30
- VA – 4000
- SL.NO – 140301S174
- YEAR – 2003

The sample is mounted perpendicularly on a stationary vice such that it's one of the face is forced to press against the

abrasive (mixture of soil and sand). The size of sand grain is from 212-300µm. The abrasive is made to flow from a nozzle against a rotary disc. The rotary disc has a rubber covering. The disc forces the abrasive mixture against the specimen to cause abrasive wear. The size of sand grain is from 212-300µm. In this machine, the test can be conducted with the following parameters (i) Speed (ii) Time or (iii) Load. In the present work, speed and time are kept constant while the load is varied. The loads used are 75N, 200N and 375N. Parameters that remained constant throughout all the experiments are:

### E. Parameter Taken Constant in Dry Sand Abrasive Wear Test

- Speed 100 rpm
- Time 2.25 min

For each sample, tests are conducted 20 times and the average value is taken as the observed value in each case. The machine has facility to fix the desired parameters, speed and time. The load is applied by placing the weights on a hook in cantilever. After each test, weight loss of the specimen is noted to determine the wear. The amount of wear is determined by weighing the specimen before and after the test using precision electronic weighing machine.

Specimen	Tempering temperature	Soaking time	Abrasive medium	Load applied	Sliding distance
As received specimen	NA	NA	20% soil mixture 40% soil mixture	75N, 200N and 375N	136.345m to 2726.9m
Heat treated	200°C	1h	20% soil mixture		
			40% soil mixture		
		1.5h	20% soil mixture		
			40% soil mixture		
		2h	20% soil mixture		
			40% soil mixture		
Heat treated	250°C	1h	20% soil mixture		
			40% soil mixture		
		1.5h	20% soil mixture		
			40% soil mixture		
		2h	20% soil mixture		
			40% soil mixture		
Heat treated	300°C	1h	20% soil mixture		
			40% soil mixture		
		1.5h	20% soil mixture		
			40% soil mixture		
		2h	20% soil mixture		
			40% soil mixture		

Table 1: Details Procedure of Abrasive Wear Test

### F. Wear Rate

It is defined as mass of wear per unit distance travelled. Wear rate = mass wear / sliding distance(s) Sliding distance (s) can be calculated as

$$\text{Sliding distance (s)} = V \times \text{time} = (2 \pi R N / 60) \times \text{time}$$

Where, R = radius of abrasive wheel (10.85cm)

$$N = \text{R.P.M (100)} \quad \pi = 3.14 \text{ (constant)} \quad \text{Time} = 2.25 \text{ minute} = 225 \text{ sec}$$

#### 1) Tensile Test

The tensile strength of the specimen is determined by using Universal testing machine. Specifications of Universal testing machine

- Sample Type: ASTM
- Model: AG-1/100kN
- P. No: 346-5211-11(frame)
- V: 3φ 200-230
- Hz: 50-60
- VA: 1.8k

- Frame capacity: 100kN
- Frame weight: 800kg



Fig. 2.5: Universal Testing Machine (AUT) Results & Discussion

Effect of sliding distance on the various wear environment of carburized mild steel at load 75N and different (OGRAPH) tempering temperature:

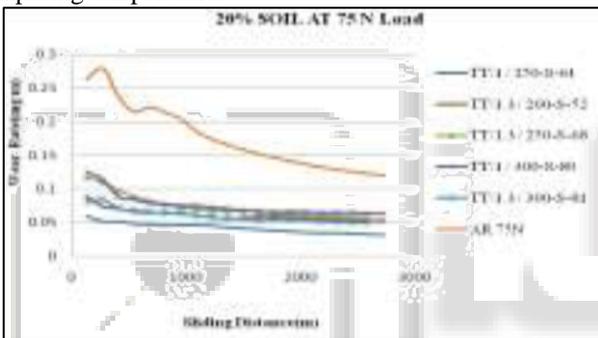


Fig. 3: Wear Rate Vs Sliding Distance For 20% Soil Mixture at 75N Load

Effect of sliding distance on various wear environment like 20% soil & 80% sand of carburized mild steel at constant tempering temperature of 200°C at different load:-

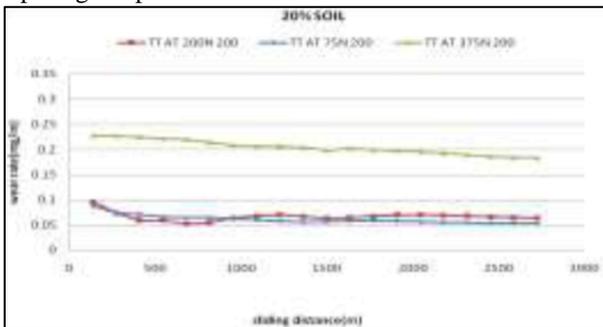


Fig. 4: Effect of Different Load on Wear Rate of Mild Steel Carburized at 950°C and Tested at 200°C

Effect of sliding distance on various wear environment like 20% soil & 80% sand of carburized mild steel at constant tempering temperature of 300°C at different load:

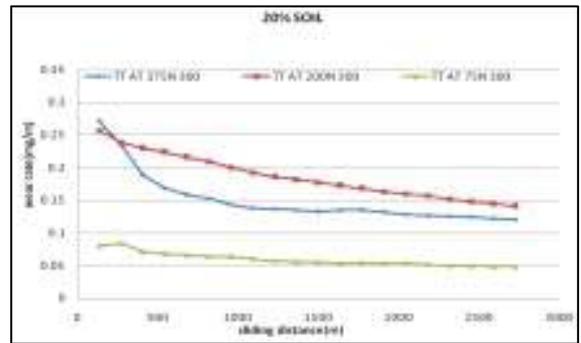


Fig. 5: Effect of Different Load on Wear Rate of Mild Steel Carburized At 950°C & Tested At 300°C

### III. CONCLUSION

In this experimental work the different kind of mild steel samples were carburized at 950°C and various wear environment such as mixture of 20% soil & 40% soil and tempered under the different tempering temperatures like 200°C, and 300°C and then tested for various kind of test like abrasive wear test, tensile strength test. The result abrasive wear test for as received mild steel simple and the mild steel sample carburized at 950°C and tempered at 200°C, &300°C and various wear environment for different loads 75N, 200N .From these results we found that the wear rate due to abrasion is highest for the mild steel tempered at temperature of 200°C for 20% soil and it is lowest at temperature of 300°C for 40% soil. From the graph (fig.) it is clear that the wear rate curve decreases gradually with increase in the tempering temperature. This result is expected because as the tempering temperature increases, the hardness of carburized mild steel also increases and therefore abrasive wear rate decreases. Tensile strength of heat treated mild steel varies linearly with hardness and tempering temperature. The tensile strength is highest for the mild steel tempered at temperature of 300°C and lowest for as received sample of mild steel. The results show that the tempering greatly improved the tensile strength of mild steel from the graph.

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