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EFFECT OF VARIOUS MICROSTRUCTURES OF PLAIN CARBON STEEL ON SLURRY EROSION A DISSERTATION

Umesh Kumar Hans[1] & Mr. Hari Prashad[2]

[*1]M.Tech. Scholar, School of Engineering & Technology, A unit of Ganga Technical Campus, Soldha, Bahadurgarh

[2]Mr. Hari Prashad, School of Engineering & Technology, A unit of Ganga Technical Campus, Soldha, Bahadurgarh

ABSTRACT

Since the advent of industrial revolution, steel has been primarily used for consolidation of infrastructure for the development of economy. However flow of materials in the form of slurry over the metallic structure has been the part and parcel of the development process. Erosion of metal surface due to cutting edges of the slurry particles has troubled the metallurgists and corrosion engineers over the last few decades. Erosion wear is a process of intensive degradation of metallic surface layers when solid particles impinge upon them. The resistance to erosion depends on working conditions and the parameters of the worn out material like toughness, hardness and microstructure. This project aims at findings the most suitable microstructure of plain carbon steel for erosion wear resistance. Plain carbon steels are generally used in conventional pipelines which may get damaged under the influence of high speed slurry impingement leading to the failure of pipelines.

Thus, it is very important to develop more erosion resistant material. So, the aim of ours present work is to come up with the steel that have best competency against slurry erosion In this work, three different samples of plain carbon steel with low, medium and high carbon percentage (weight) respectively are heat treated to obtain variety of microstructures and subsequently tested for slurry erosion with silica (SiO2) particles (210 - 317) microns with the speed of impact 3.66 m/sec. The concentration of silica erodent is 10% (weight). The test was conducted for 24 hours. Heat treated samples were also characterized for mechanical properties such as ductility, tensile strength, hardness and toughness. The experimental findings reveal quenched plain carbon steel having martensitic microstructure offering best resistance against slurry erosion

I. INTRODUCTION

The production efficiency and life span of machines is noticeably influenced by erosion wear resulting from solid particles, entrained in the flowing water. Erosive wear is an unwelcome variation of superficies and dimensions resulting from the interaction of the surface with the wearing medium. It results in the material loss from a solid surface owing to relative motion with a fluid containing solid particles.Development of microstructure and alloy that suited for slurry erosion has been a hot kick in industrial kitchen. Various permutations and combinations have been done to obtain a microstructure which is economical to produce and offers cutting edge over its class of metallic structure. Yet no significant and unanimously approved microstructure with fixed composition has taken up the stage.

My undergoing research is focused in two categories:

- Testing of steel to know its composition and obtain various microstructures through available heat treatment process to make a comparative study of micro structural resistance for slurry erosion
- Altering the composition of carbon to look for greener pasture in the terrain of corrosion engineering

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Steel classification

Plain carbon steels

Steel i.e. an alloy of iron, with carbon being the primary alloying element (2.1 % by weight) has been the part and parcel of everyone's life. Steels have been traditionally used in many applications such as piping, hydraulic transportation systems, turbine blades etc.

- Plain carbon steels
- Low alloy carbon steels
- High alloy carbon steels

Table1. . Designation and heat treatment cycle of all the steel samples Table3.2. Designation and heat treatment cycle of all the steel samples

Steel type	Designation	Heat treatment cycle
Low carbon annealed	LCS ann.	Austenitized at 950° C for 1 hour, followed by furnace cooling.
Low carbon normalized	LCS nor.	Austenitized at 950° C for 1 hour, followed by air cooling.
Low carbon water quenched	LCS quen.	Austenitized at 950° C for 1 hour, followed by water quenching.
Low carbon tempered	LCS temp.	Austenitized at 950° C for 1 hour, followed by water quenching and subsequently tempered at 600°C for 1 hr.
Medium carbon annealed	MCS ann.	Austenitized at 900° C for 1 hour, followed by furnace cooling.
Medium carbon normalized	MCS nor.	Austenitized at 900° C for 1 hour, followed by air cooling.
Medium carbon water quenched	MCS quen.	Austenitized at 900° C for 1 hour, followed by water quenching.
Medium carbon tempered	MCS temp.	Austenitized at 900° C for 1 hour, followed by water quenching and subsequently tempered at 600°C for 1 hr.
High carbon annealed	HCS ann.	Austenitized at 850° C for 1 hour, followed by furnace cooling
High carbon	HCS nor.	Austenitized at 850° C for 1 hour, followed by

II. PROCEDURE

Wear may well define the same as the physical harm to the surface that impairs the value or usual function of something. It can be either the damage of any surface or both the surfaces. Somehow, it results in the removal of material from the surface either in the form of stratum or wrecked out wear particles.Slurry erosion refers to the wear, or mass loss owing to the repeated hitting of hard, solid particles entrained in the liquid medium on the surfaces. The problem of slurry erosion has been a matter of grave concern for the industries which are likely to work under such kind of exposure. To get over the difficulties consequent to the slurry erosion, either the erosion should be identified in its very early phase or be entirely prevented in order to protect the system.

2.1 Heat Treatment

As received cast steel bars are heated by means of conventional heat treatment techniques. These techniques include annealing, normalising, water quenching. Two samples of each class of plain carbon steel were water quenched out of which one sample was tempered. The heat treatment process commences with the selection of austenitization temperature for all the samples by means of an iron- carbon equilibrium diagram [29] which is about 20 – 30 degrees above the A3 line. Then the samples were placed in the furnace and heated to the selected austenitization temperature and remain there for some time interval (soaking time) required for homogenization. The soaking time was decided according to the thickness of the samples, which is 1 hour.The furnace used in the heat treatment comprises high alumina refractory tube incorporated with the Kanthal wire. The furnace is also employed with a high sensitive temperature regulator, to maintain the required temperature.

Table .2 steel of dimension

Steel type	C	Si	Mn	P	S	Cr	Ni	Al	Cu	C eq.
Low C steel	0.18	0.19	0.56	0.11	0.03	-	0.01	-	-	0.29
Medium C steel	0.38	0.19	0.46	0.08	0.06	0.03	0.02	-	0.06	0.47
High C steel	0.51	0.35	0.27	0.02	0.03	0.89	0.26	-	0.12	0.77

2,2 Slurry Erosion Test

The remaining grip section of the fractured tensile specimen was cut out and used in as a sample for the slurry erosion test. Samples measuring approximately 15 × 5 × 5 mm were cut out of the grip section by means of a diamond cutter machine due to accuracy associated with it and then polished up to the series of emery papers on all the surfaces. Silica sand (210 -312 microns) was used to prepare the sand- water slurry used in the test. Sand of the required and uniform size was prepared by the use of sieve shaker machine which is displayed in figure 3.6 (a). Slurry used for the erosion test is 10 % by concentration, i.e. 1 kg of sand with 10 liters tap water of pH value 7.

III. FUTURE SCOPE

In low carbon steel, the maximum erosion rate corresponds to the annealed condition which exhibits the coarse grain microstructure Due to the impact of solid particles on the surface of the specimen, causes the plastic deformation of the material and their subsequent fracture from the surface In annealed condition, the plastic deformation is severe due to less resistance to plastic deformation by coarse grain microstructure which results in higher material loss. As the grain structure is refined by normalizing, the resistance for plastic deformation increases due to the fine distribution of partite which results in decreased weight loss during erosion. Resistance to plastic deformation increase to the great extent by the formation of martensite which exhibits the least weight loss during erosion. Weight loss is subsequently increased by the formation of ferrite and the fine spheroid cemented during tempering. Tempered microstructure exhibits the higher resistance for plastic deformation in comparison to that of annealed and normalised condition due to the fine distribution of cemented in ferrite grains which results in less amount of weight loss in tempered condition than that of annealed and normalized condition

Sample designation	UTS (MPa)	% Elongation	Toughness (Joules)	Hardness (VHN)
LCS ann	429	34	125	135
LCS nor	452	31	123	175
LCS quen	778	5.8	89	265
LCS temp	517	23.5	122	185
MCS ann	338	32.7	121	165
MCS nor	349	30	117	197
MCS quen	834	4.9	81	383
MCS temp	380	25.4	118	182
HCS ann	620	25.2	115	188
HCS nor	662	24.3	109	210
HCS quen	905	4	76	472
HCS temp	654	24	112	205

IV. CONCLUSION

The slurry erosion of the steels is greatly influenced by their microstructures i.e. the types of phases, their fraction, their size and distribution.The minimum slurry erosion rate is observed in high carbon quenched steels i.e. 0.786951 grams.The erosion resistance of the plain carbon steels can be improved by increasing their hardness and strength (UTS). The cutting and pouching mechanism is responsible for the loss of material during slurry erosion

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