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Effect of Nitro Carburizing and Post Oxidation on Micro Hardness and Wear Resistance of En-8 Steel

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ABSTRACT: *The Heat treatment operation is a process of heating and cooling in order to effect changes in their mechanical properties such as hardness, toughness and wear resistance of material. Review of literature suggested that mechanical properties like wear and fatigue strength can be enhanced by nitro carburizing heat treatment technique. There is always wide need for improvement in the properties of mechanical components. In the present work, effects of various input parameters using nitro-carburizing process on EN-8D steel is studied. EN-8D steel is the popular grade of through–hardening medium carbon steel, which is readily machianable in different conditions. EN-8D is suitable for the manufacture of part such as axels, shaft, gears, bolts and studs. Since the parts like gears, bolts etc. are prone to wear; there is a need for modification of surface characteristics of these materials. The aim of present research is to modify the surface properties of EN-8D steel and enhance the resistance against wear as well increment in fatigue strength.*

Keywords : *Nitrocarburizing, Post Oxidizing, EN-8D steel.*

I. INTRODUCTION

All Heat treatment operation is a process of heating and cooling in order to effect changes in their mechanical properties such as hardness, toughness and wear resistance of material. Heat treatment is also used to increase the strength of material, to achieve good hardened, tensile strength with sufficient ductility [1]. These process also help to the improve the machining effects, and make then versatile. Heat treatment is used increase the strength of material by altering the some certain manufacturability like welding and forging. The heat treatment modifies the microstructure and change properties of the work piece [2]. In the late 1950s, Imperial Chemical Industries (ICI), of the UK, developed an early version of salt bath nitrocarburizing. In the late 1970s, this process was acquired by Degussa of Germany and introduced as the Tufftride process. Other trade names for this process are Melonite and Tenifer. KC Jones became involved with salt bath nitrocarburizing in 1998. Salt bath ferritic nitrocarburizing is also known as liquid ferritic nitrocarburizing or liquid nitrocarburizing is also known by the trademarked names Tufftride and Tenifer. Nitrocarburizing is a thermochemical process and diffusion of nitrogen and carbon element in a metallic alloy is performed at elevated temperature. Nitrocarburizing process operates in temperature range 460^{o}C-560^{o}C [3]. Nitrocarburizing the treated layer can be divided into compound layer and diffusion layer.

The compound layer consist of (gamma) γ- Fe_4(C.N) and ε –Fe_{2}-$_{3}$(C,N). The surface layer of the sample after post oxidation consist of the also) γ- Fe_4(C.N) and ε–Fe_{2}-$_{3}$(C,N) but contain additionally Fe_2O_4(ferrite oxide) [Marusic et al 2006].The compound layer provides beneficial corrosion performance, while the diffusion zone is the outermost layer of a nitrided or nitrocarburized steel is 2–30 mm thick and consists of γ -phase or ε-phase, or a mixture there of depending on atmosphere and steel. Corrosion resistance and tribological properties (friction and wear) are mainly determined by the compound layer. Under the compound layer there is a"diffusion zone", which goes deeper into the steel, typically 0.1–0.5 mm. The diffusion layer contains nitrides and carbides. The diffusion layer mainly determined the Load bearing capacity, static and fatigue strength [4]. Nitrocarburizing is widely used to increase the fatigue strength, hardness, and corrosion- and wear- resistance of various engineering parts which are used for making dies, tools, automobile parts, and machine parts [5]. From the 1980s, a complex salt bath heat treatment, which is a Combination of nitrocarburizing and post-oxidation, was developed. It has been reported that additional processes of post-oxidation after nitrocarburizing have also been applied to further improve properties of the of steel components and tools [5].The purpose of surface modification treatment is to change the metal structure in a relatively thin surface layer i.e. by diffusion of an appropriate element. The following properties of the metal can be improved :resistance to wear ,chemical resistance, mechanical resistance and fire resistance [6]. Nitrocarburizing is the unique improvement in corrosion resistance and adhesive wear. This cannot be obtained by the carburizing and carbonitriding. Further the corrosion improvement by the post oxidation treatment. A very important advantage is that nitrocarburizing are low temperature method whereas carburizing and carbonitriding high temperature method [4].

Post-oxidation-it is an also improvement in corrosion resistance. Further post-oxidation in nitrate–nitrite salt bath at 350^{o}C for 10 min and then cooled in water to room temperature. Hence the improvement in corrosion resistance is obtained. And 1–2 mm thick Fe_3O_4layer is formed on top of the compound layer. The oxidation treatment gives the processed parts a black colour. The first gaseous process was developed by Lucas, England, and is called Nitrotec. It is based on the Nitemper process to which is added an oxidation treatment in air (Torsten Holm).The nascent nitrogen which comes from the dissociate: CNO^- : $4CNO^-$ -CO_3^{2-}+ $2CN^-$ + CO +2N .The nascent carbon which comes from the dissociate :CO :2CO – CO_2 +C (Gui-jiang.Li 2008).

N.Krishanraj et. al. (1998) studied that the usefulness of the ferritic nitrocarburizing treatment for improving the tribological properties of ferrous components is well established. The thin compound layer of beneficial epsilon carbonitride that develops at the surface lacks the ability to bear high Hertzian stresses [7]. Nitrocarbudzing in the austenite phase field of the Fe-N-C system overcomes this disadvantage since the formation of a hard zone of martensite-bainite below the compound layer provides the back-up to withstand point loads. Results of the Falex scuffing test indicate that the failure load increases on account of the thicker compound layer at the surface.

The review suggested that nitrocarburizing process has been successfully studied and implemented by various researchers. In the present work, effects of various input parameters using nitro-carburizing process on EN8 steel will be studied. EN8 steel is the popular grade of through–hardening medium carbon steel, which is readily machianable in any condition. Since the parts like gears, bolts etc. are prone to wear; there is a need for modification of surface characteristics of these materials.

II. SALT BATH NITRO CARBURIZING

In the present study some of the samples (60*10*10mm) were cut from EN-8D steel and nitrocarburizied. The nitrocarburizing was performed salt bath furnace. So that it could be hung at the end of an iron wire to facilitate loading into the furnace. Prior to submerging into salt bath.The sample was pre heated at different parameter and during the salt bath process. A reaction takes place between the salt bath and the specimens being treated so that nitrogen and carbon are absorbed by and diffuse into the surface of the specimens. After that the sample were cooled in water: then they were exposed to further post-oxidation at same temperature (350oC) and time 30 min. and then cooled in water to the room temperature. Nitrocarburizing process salt can be used (1). Primary Salt-base salt (Cyanide + cyanate + carbide) (2) Secondary Salt–regenerative. Post oxidation process salt can be used the NEUTROXY salt. The aim of present research is to modify the surface properties of EN 8 steel and to study the effects of input parameters like, Pre-heating temperature, pre-heating time, nitrocarburizing temperature on mechanical property like micro-hardness, wear resistance change of EN-8D steel after nitro-carburizing process. The input parameters and their levels are shown in Table 1.

Table 1 Parameter of interest and levels

Parameter	Unit	Level 1	Level 2	Level 3
pre heating temperature	^{o}C	250 ^{o}C	300 ^{o}C	350 ^{o}C
pre heating time	min.	10 min.	20 min.	30 min.
nitrocarburizing time	min	60 min.	120 min.	180 min.

III. TAGUCHI ORTHOGONAL ARRARY (OA)

The Taguchi orthogonal array is an experimental design which requires only a fraction of the full factorial combinations. The array is designed to vary as many factors as possible in a certain number of run compared to those dictated by full factorial design. The columns of the array are balanced and orthogonal. It means that in each pair of columns, all parameter combinations occur at same number of times. The orthogonal design allows estimating the effect of each parameter on the response independently. To select an appropriate orthogonal array for experiments, the total degree of freedom must be calculated. The degree of freedom is defined as the number of comparison between process parameter to determine the best level. For example, a two level process parameter counts for one degree of freedom. The degree of freedom associated with interaction between two process parameter is given by the product of degree of freedom for the two process parameter. The numbers of experiments are equal to number of rows in the orthogonal array and it must be equal or greater than the total degree of freedom. In this experiment, the assignment of parameters and interactions are carried out using 3×3 levels as L_9. This array has 6 degree of freedom and it can vary three process parameter. Therefore, nine experiments are required and the experimental layout for the study of performance parameter using Taguchi (L_9) orthogonal array. Table 2 shows the scheme of experiments to be conducted.

IV. INFLUENCE OF OPTIMAL PROCESS PARAMETERS OF MICROHARDNESS ANALYSIS OF EN-8D STEEL

Microhardness tests for nitro carburizing EN-8D steel were conducted by vicker micro hardness machine at Giani Zail Singh Campus CET Bathinda Punjab. For determining the optimum result of microhardness results of the nitrocarburizing process experiments are studied by using the signal-to-noise ratio. These are based on the results of the S/N and main effect plot,optimal process parameters for.Taguchi method suggests the equation for calculating the S/N ratio for smaller-the-better characteristicsis where the value of output parameter for the i^{th} test in that trial. Similar procedure has been adopted Table 3 shows the result table for mean and s/n ratio of microhardness obtained for different parameters levels. From the main effects plots for mean and s/n ratio (Fig.1) highest s/n ratio is obtained at level 1 for pre- heating temperature, pre-heating time and nitrocarburizing time respectively. Therefore, the optimal combination of process parameter is found to be pre heating temperature. Pre heating temperature is the most significant factor according to the ranking. Table 3 shows the table for mean and s/n ratio of micro hardness obtained for different levels.

From the main effects plots for mean and s/n ratio (Fig. 2) highest s/n ratio obtained at level 1 for nitrocarburizing time, Level 2 for pre-heating time and level 3 for pre heating tempeature respectively. Therefore, the optimal combination of process parameter is found to be nitrocarburizing temperature. Nirocarburizing temperature is the most significant factor according to the ranking. Table 4 shows there table for mean and s/n ratio of wear obtained for different level.

Table 2. Scheme of experiments to be conducted

Sr No.	Pre heating temp	Pre heating time	Nitrocarburizing time
1	250°C	10 min	60 min
2	250°C	20 min	120 min
3	250°C	30 min	180 min
4	300°C	10 min	120 min
5	300°C	20 min	180 min
6	300°C	30 min	60 min
7	350°C	10 min	180 min
8	350°C	20 min	60 min
9	350°C	30 min	120 min

Table 3. Experimental result for microhardness

Sr No.	Pre heating temp	Preheatin g time	Nitro carburizing time	MicroHardness 1	Micro Hardness 2	Micro Hardness 3	SNRA1	MEAN1
1	250°C	10 min	60 min	102.9	145.5	166.9	42.2667	138.100
2	250°C	20 min	120 min	102.1	132.8	166.1	41.9993	133.333
3	250°C	30 min	180 min	127.5	120.3	143.5	42.2384	130.433
4	300°C	10 min	120 min	178.5	97.5	98.8	40.9881	125.000
5	300°C	20 min	180 min	109.8	99.5	130.0	40.9129	113.100
6	300°C	30 min	60 min	102.4	78.6	101.1	39.2728	94.100
7	350°C	10 min	180 min	98.8	102.3	134.6	40.7367	111.900
8	350°C	20 min	60 min	62.4	98.7	87.9	37.8790	83.000
9	350°C	30 min	120 min	70.8	98.8	120.6	39.0810	96.733

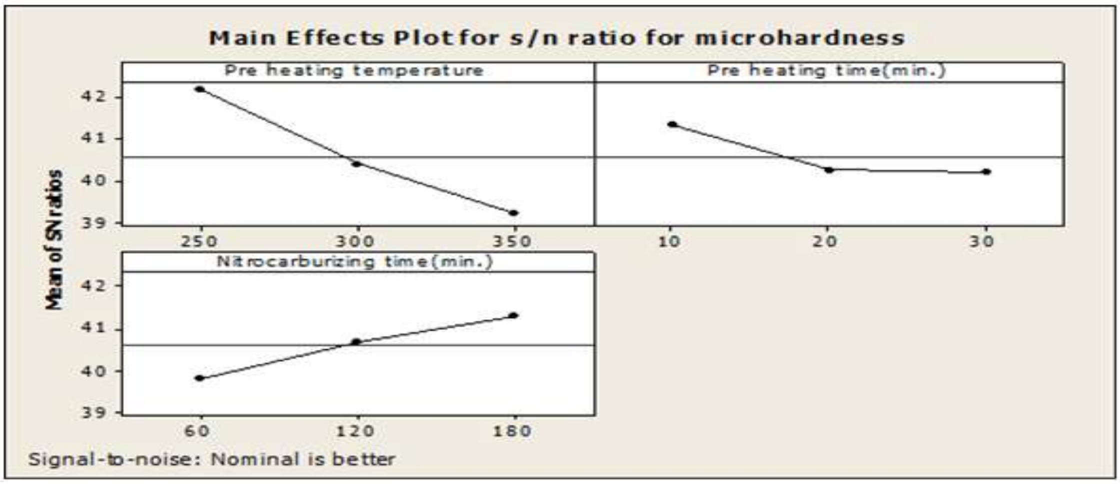

Fig. 1 Main effect plot for s/n ratio for microhardness

Table 4 Experimental result of wear

Sr No.	Pre heating temp	Pre heating time	Nitrocarburizing time	weight loss	SNRA1	MEAN1
1	250°C	10 min	60 min	1.087	3.5671	1.087
2	250°C	20 min	120 min	0.152	16.3661	0.152
3	250°C	30 min	180 min	0.745	2.5569	0.745
4	300°C	10 min	120 min	0.798	1.9599	0.798
5	300°C	20 min	180 min	1.026	-0.2229	1.026
6	300°C	30 min	60 min	1.019	-0.1635	1.019
7	350°C	10 min	180 min	1.064	-0.5386	1.064
8	350°C	20 min	60 min	1.052	-0.4403	1.052
9	350°C	30 min	120 min	1.004	-0.0347	1.004

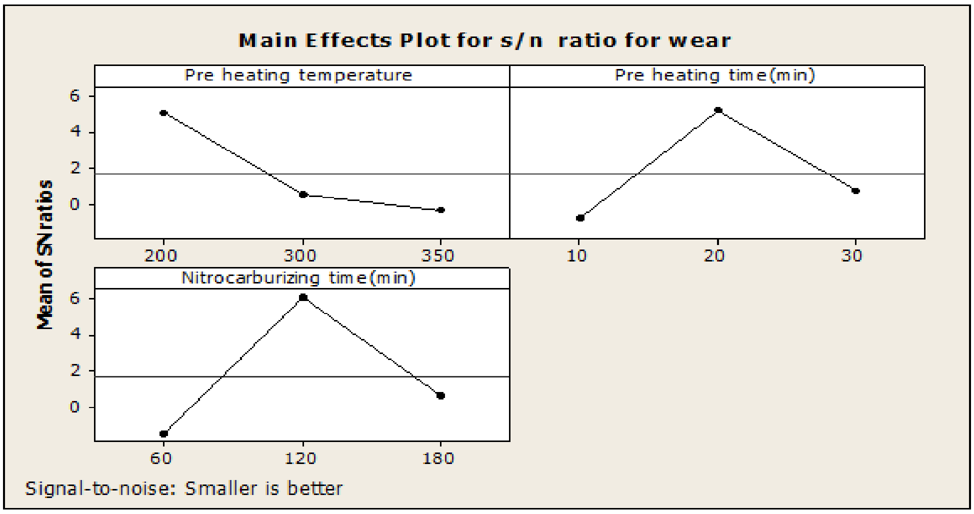

Fig. 2 Main effects plot for s/n ratio for wear

V. CONCLUSION

1. A Micro-hardness is a significant parameter when it comes to heat treatments. Micro-hardness results reveal that there is a significant increase in micro-hardness with the increase in nitro carburizing time and temperature. As the S/N ratios graphs reveal that pre-heating temperature has a level-1. Temperature is a critical parameter, which always assists increase in hardness. Maximum values of S/N ratio for micro hardness is 42.2667.

2. Wear resistance test is also a useful test, since nitro carburizing diffusion layer helps in increase in wear resistance. It has been found that an increase in wear resistance has been reported with increase in Nitro-carburizing temperature and time. Both these parameters increased the surface hardness, and with the increase in hardness, wear resistance increased significantly. Maximum value of S/N ratio for wear 1.064.

REFERENCES

[1]. Mithlesh Sharma et al, study of effect on mechanical properties of Ss 304 at different ranges of carburization temperature, 2013 ISSN 2319-7080

[2]. V.K.Murugan et al.,Effect of tempering behaviours heat treated medium carbon (C35Mn75) steal.vol.2,april2013 ISSN:2319-8753.

[3]. Huang, R., et al., Surface modification of 2205 duplex stainless steel by low temperature salt bath nitrocarburizing at 430°C. Applied Surface Science, 2013. 271: p. 93-97.

[4]. Torsten Holm, L.S. Nitriding and Nitrocarburizing. FURNACE ATMOSPHERES. 3.

[5]. Pre heating of materials.refer to or www.boc.co.nz

[6]. Zhang, J.W., et al., Effect of nitrocarburizing and post-oxidation on fatigue behavior of 35CrMo alloy steel in very high cycle fatigue regime. International Journal of Fatigue, 2011. 33(7): p. 880-886.

[7]. Marušić, K., et al., Modification of carbon steel surface by the Tenifer® process of nitrocarburizing and post-oxidation. Surface and Coatings Technology, 2006. 201(6): p. 3415-3421.

[8]. N.Krishnaraj etal., Scuffing resistence of salt bath nitrocarburizing medium carbon steel,wear 210 (197)237-244.