International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Evaluation of Surface Roughness of Burnished Dual-Phase Steels using Experimental and Finite Element Methods

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Accepted 10 September 2013, Available online 01 October 2013, **Vol.3, No.4 (October 2013)**

Abstract

Surface finish has vital influence on most of functional properties of a component like fatigue life, wear resistance, corrosion resistance etc. A good surface finish is essential in many applications e.g. in the mould dies, bio engineering and optical industries. This has given birth to processes like lapping, honing, burnishing etc. Burnishing is a fine finishing operation involving the cold working plastic deformation of surface layers to enhance the surface integrity and the functional utility of a component. It is a simple and economical process and can be effectively used in aerospace industries, automobile manufacturing industries, production of machine tools etc. The present study has been carried out to establish the effect of burnishing parameters viz. feed rate, speed, force, ball diameter and lubricant on surface roughness of high strength low alloy (HSLA) dual – phase steel specimens. The result indicates that burnishing parameters have significant effect on the surface roughness. The improvement in surface roughness is with good agreement with the available literature. In the present work, stresses at various points of surface irregularities and deformation of surface layer upto certain depth, were calculated by FEM. The surface roughness values of FEA were compared with the experimental values

Keywords: *HSLA, Dual phase, Burnishing, Hardness, Surface Roughness, Heat treatment, FEM*

1. Introduction

In present days, increased attention is being paid to surface integrity obtained. Cosmetic, functional performance and process control requirements impart high significance to the surface finish. Conventional processes have limitations on surface finish, which caused the evaluation of processes like grinding, lapping, honing, burnishing, polishing, etc. In recent years, however, much attention has been focused on processes, which improve the surface characteristics by plastic deformation. In manufacturing process, surfaces and their properties are as important as the bulk properties of the materials. Burnishing is such a process, which employs hard rollers and balls for the deformation. Besides improving the surface finish, burnishing secures increased hardness, wear resistance, corrosion resistance and fatigue life. The process can be automated to increase the production rate. Ball burnishing, a non-traditional finishing method that employs a hardened ball to plastically deform a surface, shows much promise. The work hardening is associated with the plastic deformation and compressive nature of the stresses imposed; improve the functional properties of the component.

D.S. Rao, *et al*, 2007 were conducted experimental work based on 3^4 factorial design to establish the effects of ball burnishing parameters on the surface hardness of HSLA dual phase steel specimens. Statistical analysis of the results shows that the speed feed, lubricant and ball diameter have significant effect on surface hardness.

Khalid. S, *et al*, 2011 have investigated the enhancement in the mechanical properties and micro hardness of the surface of O1 steel using the roller burnishing process and studied the effect of diamond pressing process with a different pressing force (105, 140, 175, 210)N. The major findings of this study are; the true stress of material has been increased of about 150 MPa, the surface quality has been enhanced by 12.5%, finally the U.T.S. has been increased by 166 Mpa

PrafullaChaudhari, *et al*, 2011 were summarized the ball-burnishing process of flat cylindrical surfaces performed on center lathe.

MalleswaraRao, *et al*, 2011 were investigated the effect of burnishing force and number of tool passes on surface hardness and surface roughness using roller burnishing tool on a specially fabricated mild steel specimen.. The results show that improvements in the surface roughness and increases in surface hardness were achieved by the application of roller burnishing with mild

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steel specimens. The results are presented in this paper. Roller burnishing produces better and accurate surface finish on Aluminum work piece in minimum time.

P Ravindrababu, *et al*, 2012 have investigated the effects of various burnishing parameters on the surface characteristics, surface microstructure, micro hardness in the case of EN Series steels (EN 8, EN 24 and EN 31), Aluminum alloy (AA6061) and Alpha-beta brass. The burnishing parameters considered for studies principally are burnishing speed, burnishing force, burnishing feed and number of passes. Taguchi technique is employed in the present investigation to identify the most influencing parameters on surface roughness. Effort is also made to identify the optimal burnishing parameters and the factors for scientific basis of such optimization.

P. S. Kamble, *et al*, 2012 were used the internal roller burnishing tool to burnish the drilled hole. Speed, feed, and number of passes have been varied using Taguchi method to examine the surface finish and micro hardness. ANOVAs analysis is carried out. Surface finish from 2.44 micron to 0.13micron is achieved.

2. Experimental Work

2.1 Material Composition

Commercial micro-alloyed steel was selected as the starting material. The as- received steel was in the form of 20mm thick hot rolled plate in the tempered condition. The chemical composition of steel was ascertained with the help of Baird optical emission spectrometer.

2.2 Heat treatment

Dual-phase microstructures were prepared by intermediate quenching (IQ). The IQ-treatment consisted of double quench operation. The specimens were first soaked at 920 ± 2 ° C for 30 minutes and were quenched in 9% iced-brine solution (-7° C). These were then held at inter critical temperatures (ICT) of 730° to 780° C for 60 minutes and were finally quenched in oil (25 ± 2 ° C).

2.3 Micro structural characterization

Several stereological measurements were carried out to estimate the volume fraction of ferrite and martensite in the developed microstructures using manual point counting technique and automatic areal analysis using a LECO image analyzer.

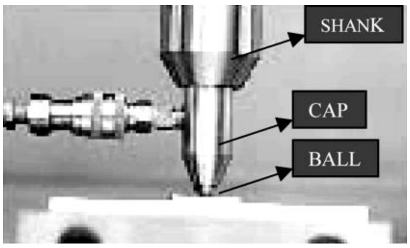

Figure 1: Ball burnishing tool assembly.

The experimental work was conducted on Kirloskar Turn master lathe shown in figure 1.The terminology used in the process is shown in figure 2. The use of lathe for pre-machining and burnishing operations enabled a wide range of parameter settings to be easily obtained and adjusted.

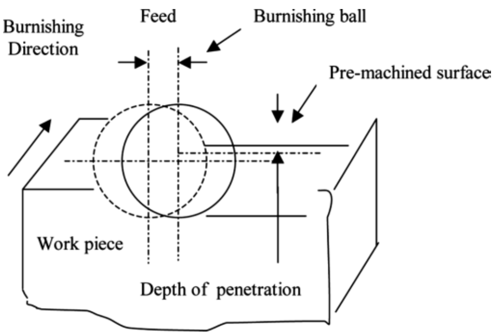

Figure 2: Schematic illustration of terminologies.

2.4 Burnishing Parameters

The following are the values of the burnishing parameters used in the present investigations based on the availability.

1 Ball diameter in mm ------------------- 8, 10, 12.5, 13.5, 14.5, 16.5, 18.4 and 20.2

2 Speed in m/min ----------------------- 5.65, 11.3, 17.0, 22.62, 28.27, 34.0

3 Feed in mm/rev --------------------- 0.024, 0.034, 0.043, 0.054, 0.065, 0.074, 0.085, 0.095, 0.098.

4 Burnishing tool motion -----------------------Left to right

5 Lubricants -----------------------------Grease (Lithium soap grease with sulphur as additive)

Burnishing force in kgf -----------5, 10, 15, 20, 25, 30, 35, 40.

Table 1: Experimental values of the Surface roughness (μm) of dual-phase steel specimens burnished at various forces using Grease as lubricant (feed=0.085mm/rev, speed=22.62m/min and ball diameter=16.5mm)

Burnishing Force (N)	Inter Critical Temperatures (°C)					
	730	740	750	760	770	780
49	1.425	1.434	1.43	1.421	1.428	1.431
98	1.42	1.431	1.425	1.417	1.42	1.427
147	1.413	1.426	1.42	1.41	1.415	1.423
196	1.41	1.423	1.417	1.408	1.41	1.419
245	1.405	1.418	1.413	1.404	1.408	1.414
294	1.409	1.423	1.416	1.407	1.411	1.418
343	1.415	1.427	1.421	1.413	1.417	1.423
392	1.421	1.43	1.426	1.418	1.423	1.428

Cylindrical dual phase steel specimens were pre-machined to 18 mm diameter using high speed steel (HSS) tool. These specimens were cut to appropriate length of 200 mm and each was divided into 10 segments. Each segment was taken a length of 20 mm by making grooves in between each segment with the intent of exposing to different set of conditions during the experiment. The pre-machined surface roughness obtained was 2.644 µm to 3.0 µm without removing the specimens, the surfaces were burnished by ball burnishing tool.

Average surface roughness (Ra) tests were performed using a MITUTOYO roughness tester. The surface roughness values for various surface roughness values for various feed, speed and ball diameter were found to be optimum at 0.085mm/rev, 22.62m/min and 16.5mm respectively. Using these optimum values burnishing process was performed with various burnishing forces with grease as lubricant, surface roughness values are tabulated in table 1. The Modulus of elasticity values at various Intercritical Temperatures were found by performing tensile test

2.5. Finite Element Analysis of burnishing proces

In the present work, stresses at various points of surface irregularities and surface layer upto certain depth, were calculated by FEM. The problem was treated as two-dimensional using constant strain triangles.

The analysis process has been simulated using commercial available FEA package ANSYS-13. In FEA the burnishing process was modeled as 2D and the surface roughness was considered as a triangular asperity with included angle of 90°. The height of the triangular asperity was considered as the surface roughness before burnishing. The surface roughness values obtained through FEA are compared with experimental values and tabulated in table 2.

Table 2: Comparison of Experimental and Finite Element values Surface roughness (µm) for heat treated HSLA dp steels specimens

Intercritical Temperatu re in (°C)	Experiment al Values (µm)	FEM Values (µm)	Percentage Variation
730	1.405	1.334	7.5
740	1.418	1.361	5.8
750	1.413	1.380	3.3
760	1.404	1.399	1.4
770	1.408	1.429	1.2
780	1.414	1.460	4.6

3. Result and discussion

3.1. The effect of burnishing force on surface roughness:

It is observed that the surface roughness decreases with the increase of the applied force up to the maximum value of 245N, after which the surface roughness increases with further increase of the force. The results are shown in figure 3. This behavior can be explained that when increasing the force beyond the mentioned optimum value, the bulge of metal in front of the tool becomes large and the region of the plastic deformation widens which damages the already burnished surface, i.e. increase the surface roughness.

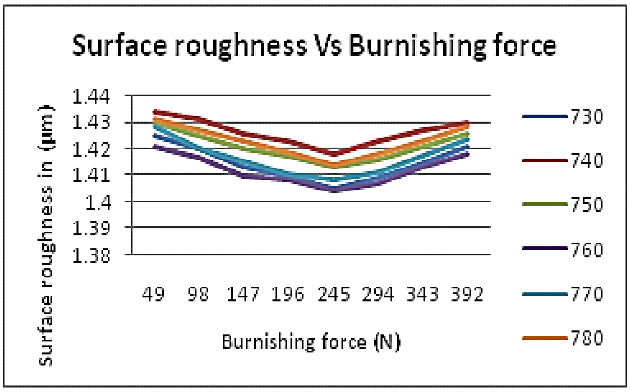

Figure 3: Variation of Surface roughness with burnishing force with Grease as lubricant

Surface roughness is also found to be imperative. When the burnishing force is increased up to 245N, the surface roughness is found to be decreased. Again when the force is increased above 245N, the surface roughness is increased i.e. material get deteriorated.Surface roughness values estimated by using FEM are shown in figure 4 to 6.

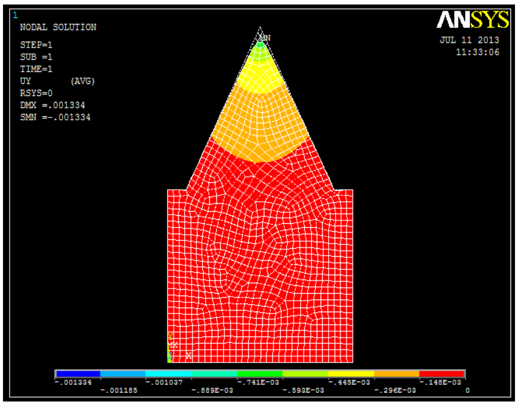

Figure 4: Deformation diagram for 730^{0}C heat treated HSLA dp steel for optimum force of 25kgf

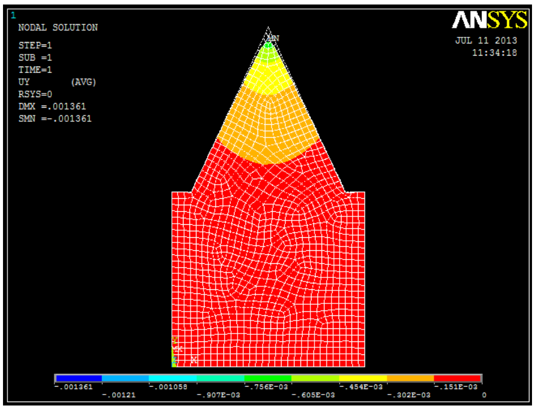

Figure 5: Deformation diagram for 740^{0}C heat treated HSLA dp steel for optimum force of 25kgf

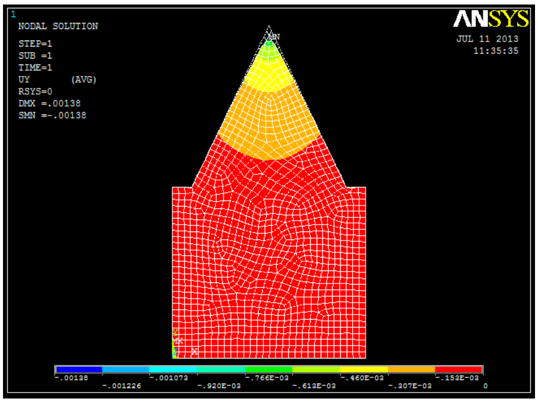

Figure 6: Deformation diagram for 750^{0}C heat treated HSLA dp steel for optimum force of 25kgf

There was a close match between the surface roughness values estimated analytically by using FEM and those obtained from the parametric experimental investigations. This would be yet promising and useful information for the Mechanical Engineers engaged with such type of projects and related practices.

4. Conclusions

- To produce optimum surface roughness, a feed of approximately 0.085 mm/rev, speed of 22.62 m/min, test load of 245N and grease as lubricant were found suitable. An improvement of nearly **47%** in surface finish was noticed.
- There is a close match between experimental and an analytical method of surface roughness with a minimal variation of less than **10%** was found.

Acknowledgements

1. The authors would like to thank Mrs.D.Sujana and D.Hemanth for supporting the experimental work on ball burnishing.
2. The authors acknowledge gratefully the contribution of Sri Srujan Manohar, Sri G. V. V. S. N. Murthy and Sri T. Naveen Kumar, Faculty of Mechanical Engineering, G. V. P. College of Engineering.

References

D. Srinivasa Rao, H. Suresh Hebbar, M. komaraiahand U. N. Kempaiah,(2007), Surface Hardness of High-Strength Low Alloy Steels (HSLA) Dual-Phase Steels by Ball Burnishing using Factorial Design, *Materials and Manufacturing Process*, Vol.22, pp.1-

Khalid. S. Rababa and Mayas Mohammad Al-mahasne, (2011), Effect of Roller Burnishing on the Mechanical Behavior and Surface Quality of O1 Alloy Steel, *Research Journal of Applied Sciences, Engineering and Technology,* Vol.3(3), pp.227-23

PrafullaChaudhari, GK Awari and SS Khandare,(2011), Investigation on Micro and Macro Properties of Ball Burnished Components, *VSRD-Technical and Nontechnical Journal,* Vol. 2 (3), pp.137-14

MalleswaraRao J. N., ChennaKesava Reddy A. Rama Rao P. V,(2011), The effect of roller burnishing on surface hardness and surface roughness on mild steel specimens, *International journal of applied engineering research,* Vol.1, No

P Ravindrababu, K Ankamma, T Siva prasad, AVS Raju and N Eswaraprasad,(2012), Optimization of burnishing parameters and determination of select surface characteristics in engineering materials, *Indian Academy of Sciences*, Vol. 37, Part 4, pp. 503–520

P. S. Kamble, V. S. Jadhav,(2012), Experimental study of Roller burnishing process on plain carrier of planetary type gear box, *International Journal of Modern Engineering Research (IJMER),* Vol.2, pp-3379-3383