International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

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

Research Article

Surface Integrity Enhancement of Inconel 718 by using Roller Burnishing process

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Accepted 10 July 2014, Available online 01 Aug2014, **Vol.4, No.4 (Aug 2014)**

Abstract

Burnishing is cold working process where hard roller are being pressed against irregular surface, so that surface finish and the micro hardness increases. In this study, single roller burnishing tool is modified to control the burnishing force. Speed, feed, and number of passes have been varied to examine the surface properties. Roughness data, Micro hardness have been compared before burnishing & after burnishing for Inconel 718 material. Roller Burnishing reduces Surface Roughness from 3.66 micron to 0.31 micron.

Keywords: *Roller Burnishing, Surface Roughness, Microhardness, Inconel 718*

1. Introduction

Surface integrity of manufactured component plays vital role to avoid friction losses, good corrosion resistant property and high fatigue life. Conventional machining process leaves surface irregularities, which causes additional cost of finishing operations. Burnishing is a plastic deformation process. In the burnishing process, the pressure generated by the rolls exceeds the yield point of the softer piece part surface at the point of contact, resulting a small plastic deformation of the surface structure of the piece part. All machined surfaces consist of a series of peaks and valleys of irregular height and spacing. The plastic deformation created by roller burnishing displaces the material from the peaks by means of cold work under pressure into the valleys. The result is a mirror-like finish with a tough, work hardened, wear and corrosion resistant surface.

2. Literature Review

P. S. Kamble *et al*. have used internal roller Burnishing tool to burnish the drilled holes. Speed, feed and number of passes have been varied by using Taguchi method to examine surface finish and micro hardness. ANOVA analysis is carried out to find out most significant burnishing process parameters among all. They have selected EN 8 material. They have found that the maximum micro hardness is achieved at lower feed rate and minimum number of passes. Surface roughness from 2.44 µm to 0.13 µm was achieved (P. S. Kamble *et al*, 2012). A. Stoic *et al*. investigated fine machining efficiency of 34CrMo4 steel using roller burnishing tool. Experimental results show that all smoothing outputs can be detected in all regimes. Roughness measured data before and after roller burnishing process have been compared (A. Stoić *et al*, 2010). The LPB is type of burnishing process, which can be tailored to suit the desired applications. LPB can be performed on conventional and CNC machine tools that results into deep, high magnitude, thermally and mechanically stable compression (Seemikeri C. Y., *et al* 2008). Binu C Yeldose *et al*. investigated comparison of effect of uncoated & Tin coated by reactive magnetron sputtering on EN31 rollers in burnishing with varying process parameters such as burnishing speed, feed, burnishing force, number of passes upon surface roughness of EN24 steel work material. It was observed that the performance of the Tin-coated roller is superior to uncoated rollers in burnishing operation. The burnishing speed, feed, depth of cut and number of passes are influencing parameters on the burnishing operation. The burnishing speed, burnishing force and number of passes are having almost equal importance on the performance of the roller in burnishing, particularly with reference to the surface finish of the components produced (Binu C. Yeldose *et al*, 2008).

3. Experimentation Work

3.1 Material selection

In this current research paper, an effort is being made to understand the improvement in the surface finish of burnished surfaces along with the influence of the process parameters in “INCONEL 718” material. INCONEL 718 is a high-strength & corrosion-resistant nickel chromium alloy used for components in liquid fueled rockets, casings and various formed sheet metal parts for aircraft and land-based gas turbine engines, and cryogenic tank.

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Table 1 Composition INCONEL-718

% Ni+Co	% Cr	% Fe	% Nb+Ta	% Mo	Ti	Al
50- 55	17-21	BAL	4.75 - 5.5	2.8 - 3.3	0.65 - 1.15	0.2 - 0.8

3.2 Burnishing Tool

The Roller Burnishing tool has been developed to control the pressure applied by roller on workpiece. Tool consist of cylinder connected to hand pump. At the nose end of cylinder, L-shaped frame is attached. Roller is supported by the frame. When oil pressure is supplies through cylinder, roller exerts burnishing force on Inconel 718 rod during burnishing operation. Burnishing force can be controlled by rotating knob connected with pressure gauge. Figure 1 shows the modified roller burnishing tool.

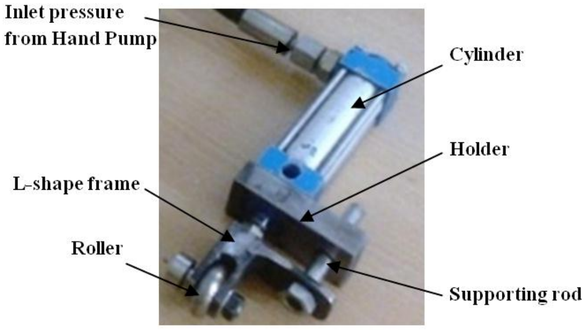


Fig.1 Burnishing Tool

Preliminary investigation is carried out to find optimum pressure applied by hand pump. It is found that 20kg/cm^2 gives good surface characteristics. For further trials 20kg/cm^2 is kept constant shown in table 4. Experiments are designed as per Taguchi's L9 array with speed, feed rate and number of passes are process parameters shown in table 3and 2 resp.

Table 2 Process Parameters for Burnishing

Levels / Parameters	1	2	3
Spindle Speed (r.p.m)	270	646	1000
Feed rate (mm/rev)	0.02	0.04	0.06
No. of passes	1	2	3

Table 3 Taguchi's L9 array for Burnishing Process

Trials	Spindle Speed(rpm)	No. of Passes	Feed rate (mm/rev)	Press.
1	270	1	0.02	C O N S T. = 20 kg/cm^2
2	270	2	0.04	
3	270	3	0.06	
4	646	1	0.04	
5	646	2	0.06	
6	646	3	0.02	
7	1000	1	0.06	
8	1000	2	0.02	
9	1000	3	0.04	

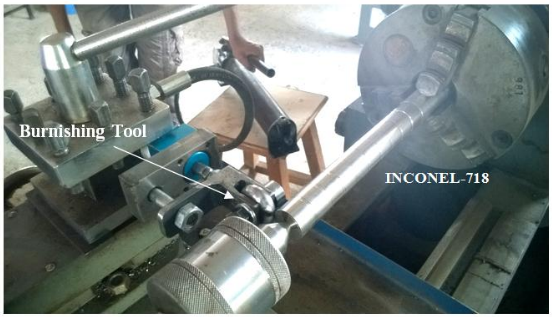


Fig. 2 Experimental set up for Roller Burnishing process

4. Result and discussion

4.1Effect on Surface Roughness

From the trials it is found that there is significant change in surface roughness due to the variation in spindle speed, feed and number of passes. Surface Roughness value by roughness measurement device before and after burnishing is shown in table 4.Comparison has been made with the help of graph plotted by roughness tester shown in fig. 3& 4.

Table 4 Observations for Surface roughness values

Trails	Roughness Value (in μm)	
	Before Burnishing	After Burnishing
1	1.70	0.87
2	3.66	1.08
3	2.57	0.53
4	1.58	0.46
5	2.7	0.48
6	1.73	0.31
7	2.10	0.51
8	1.09	0.31
9	2.78	0.52

Following are the testing reports of before and after Burnishing process. There is significant change in plastic deformation of higher picks after burnishing.

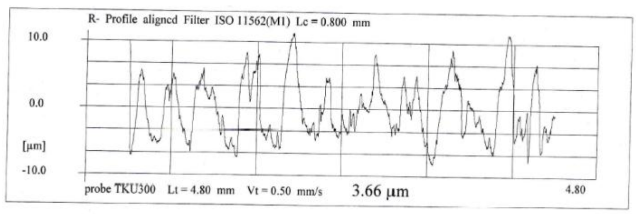


Fig.3 Roughness before Burnishing

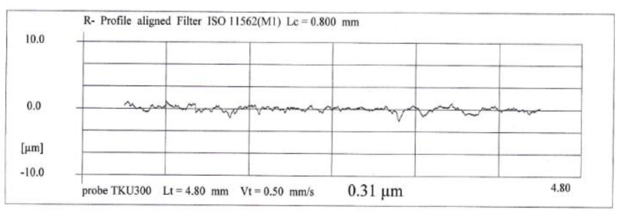


Fig.4 Roughness after Burnishing

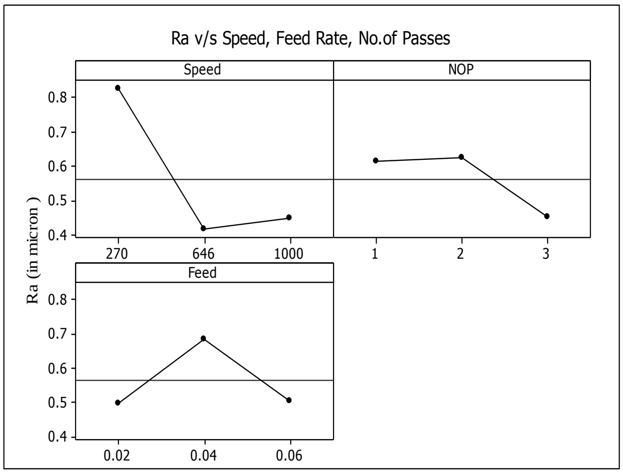


Fig. 5 Ra v/s Speed, Feed Rate and NOP

As the spindle speed, the surface roughness improved from 270 rpm to 646 rpm. If the three passes are made of burnishing tool along the surface to be applied then the improvement is observed at high spindle speed. The feed rate is also varied from 0.02 and 0.06,it is observed that the roughness is finest for 0.02 mm/rev and 0.06 mm/rev than 0.04 mm/rev feed rate.

4.2Effect on Microhardness

Before burnishing microhardness was 539Hv. Surface Microhardness values after burnishing are tabulated in table 5. Microhardness is measured on vicker hardness tester.

Table 5: Observations for Micro Hardness

Patches	Microhardness (Hv)
1	588
2	587
3	587
4	587
5	554
6	567
7	560
8	558
9	548

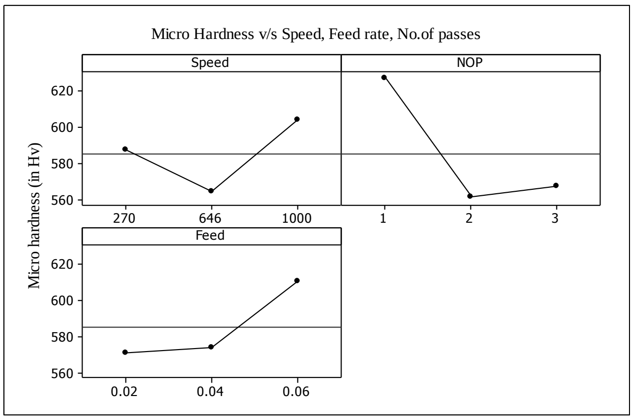
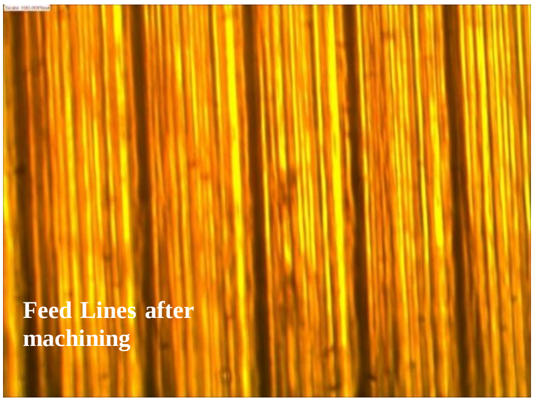


Fig. 6 Micro Hardness v/s Speed, Feed Rate and No. of passes

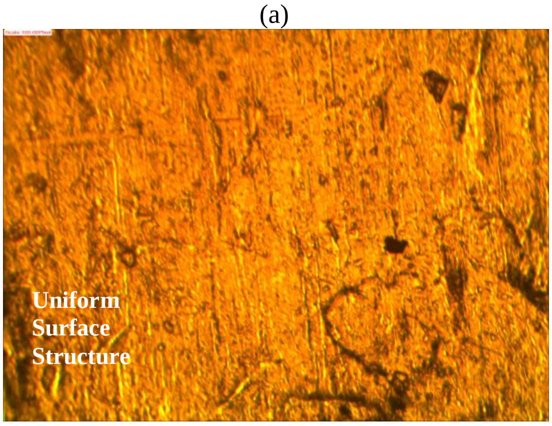
For 1000 rpm spindle speed, the Micro Hardness observed is optimum. The feed rate was varied from 0.02 to 0.06 mm/rev and it is observed that the Micro Hardness improves as the feed rate increases. Number of passes also plays significant role in improving Micro Hardness. For single pass of Burnishing tool along the surface of component, it is found that the Micro Hardness improvement is maximum than 2 or 3 passes of tool shown in figure 6.

4.3 Surface Pattern

The surface pattern is captured using microscope shown in figure7. Figure 7(a) shows the feed lines are marked due to machining on Inconel 718. These are nothing but irregularities present over the surface of component. After burnishing process uniform surface is obtained.



(a)



(b)

Fig.7 Microscopic images of surface (a) before and (b) after Burnishing

Conclusions

1. From this comparative study, it is found that spindle speed, feed rate and number of passes along with considerable pressure causes to change in Surface Finish and Micro Hardness.
2. Roller Burnishing reduces Surface Roughness from **3.66** micron to **0.31** micron. Optimum burnishing results obtained at the speed, feed rate and no of passes are **646** rpm**, 0.06** mm/rev and **2** respectively
3. Micro Hardness is also improved from **539**Hv to **588** Hv.

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