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Effect Of Roller Burnishing Parameters On Surface Roughness And Hardness

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ABSTRACT

Roller burnishing is a process which produces a fine surface finish by the planetary rotation of hardened roils over a bored or turned metal surface. Roller burnishing involves plastic deformation of the surface of the work piece to improve surface structure. The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece. In the present study, the effect of process parameters on surface roughness in roller burnishing process has been studied. The experiments have been conducted based on design of experiments (DoE) to reduce the number of trails by varying burnishing speed, burnishing feed and number of passes. The surface roughness is decreases as the burnishing feed, speed and number of passes decreases.

Key words: Roller Burnishing, Design of Experiments, Surface Roughness, Hardness.

I. INTRODUCTION

Surface topography is of great importance in specifying the function of a surface. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality in the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece [1-3]. The function performance of a machined component such as fatigue strength, load bearing capacity, friction, etc. depends to a large extent on the surface as topography, hardness. Nowadays, about 50% of the energy supplied is lost in the friction of elements in relative motion.

Roughness values less than 0.1 mm are required for good aesthetic appearance, easy mould release, good corrosion resistance, and high fatigue strength. During recent years, however, considerable attention has been paid to the post-machining metal finishing operations such as burnishing which improves the surface characteristics by plastic deformation of the surface layers [4-6]. Besides producing a good surface finish, the burnishing process has additional advantages over other machining processes, such as securing increased hardness, corrosion resistance and fatigue life as a result of producing compressive residual stress [7-9].

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Since all machined surfaces consist of a series of peaks and valleys of irregular height and spacing, the plastic deformation created by roller burnishing is a displacement of the material in the peaks which cold flows under pressure into the valleys [10&11]. The result is a mirror-like finish with a tough, work hardened, wear and corrosion resistant surface.

The Fig1 shows the roller burnishing process. Roller burnishing tool is pressed against the work piece perpendicular to the axis of the work piece. The roller burnishing tool is fixed in the tool post and the work piece is held between lathe chuck and tail stock. The main aim of present paper is to study the effect of processes parameters, tool feed, tool speed and number of passes, on surface roughness.

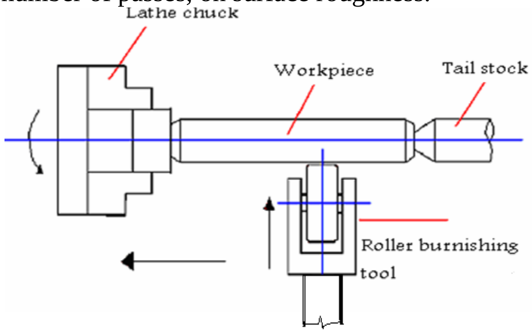

Figure1: Roller burnishing process

II. EXPERIMENTAL WORK

The material used for manufacturing roller is en 24 (Nickel Chromium Molybdenum Steel) with hardness value 40 HRC and maximum stress 850 – 1000 N/mm^2. The chemical composition of en24 steel is given in table1.

Table1: Tool material chemical composition (Wt %).

Si.No.	Chemical Composition (Weight %)	
1	Copper (C)	0.35 to 0.45
2	Manganese (Mn)	0.45 to 0.70
3	Silicon (Si)	0.10 to 0.35
4	Sulphur (S)	0.40
5	Phosphorous (P)	0.40
6	Chromium (Cr)	0.90 to 1.4
7	Nickel (Ni)	1.3 to 1.8
8	Molybdenum (Mo)	0.20 to 0.40

The shank is made of mild steel. The bush and stoppers are made of stainless steel. The entire assembly of roller burnishing tool is shown in fig2.

Figure2. Roller burnishing tool

Burnishing experiments are conducted on turned mild steel work piece, which is ductile and available commercially in the form of round bars. Work piece is turned to have 8 steps and grooves in between them. The length of each groove is taken as 3 mm between each step. In actual experiments, by applying different parameters on each step, this long work piece can be utilized as 8 different specimens. The length of each specimen is taken as 32 mm. the mild steel work piece after turning is shown in figure3.

Figure3: Work Piece after Turning Operation.

The three process parameters chosen are burnishing tool speed, burnishing tool feed and number of passes, which are generally considered as being the process parameters in controlling quality of the roller burnishing processes. The other parameters- force, depth cut are maintained constant at appropriate levels. The working range of the roller burnishing process parameters are fixed by conducting number of trial experiments. Table 2 gives the main parameters that affect the surface roughness and their working range. Because of wide range of process parameter, it has been decided to consider only 3 parameters, two levels, full factorial design matrix to optimize the experimental conditions. Eight (2^3) sets of coded conditions used to form the design matrix is shown in table 3. The -1 and +1 represents the lower and upper limits of the process parameter respectively for the convenience of processing and recording the experimental data.

The experiments will be conducted on the work piece based on this matrix and after performing these experiments the work piece is test for surface hardness (HRC) and surface roughness (R_a) values by Rockwell hardness tester and Mitutoyo surface tester.

Table 2: Important roller burnishing processes parameters and their limits.

S. No	parameters	Notation	Units	Levels	
				Max (+)	(-)
1	Spindle speed	N	Rpm	975	415
2	feed	f	mm/rev	0.055	0.036
3	Number of passes	n		3	1

Table3. 2^3 full factorial design matrix

S.No	N	f	n
1	-	-	-
2	-	-	+
3	-	+	-
4	-	+	+
5	+	-	-
6	+	-	+
7	+	+	-
8	+	+	+

III. RESULTS AND DISCUSSIONS

The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece. To optimize the input parameters of the roller burnishing process surface roughness is compared before and after burnishing process. The results are shown in the Table 4.

S.No.	Average surface roughness		
	R_a(µm)	R_q(µm)	R_z(µm)
Before Burnishing	1.61	1.68	8.72
After Burnishing 1	0.52	0.73	4.00
2	0.84	1.06	5.51
3	0.92	1.18	5.46
4	0.85	1.09	5.24
5	1.14	1.38	6.00
6	1.12	1.36	5.68
7	1.09	1.32	5.86
8	1.04	1.25	5.34

The variation of surface roughness with various input parameters combinations is shown in the graphs below.

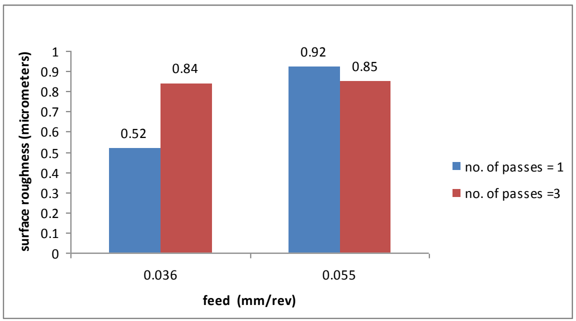

Figure 4. Effect Surface roughness due to feed at 415 rpm

In Fig 4 the effect of surface roughness due to feed at low speed and is shown in the graph. The graph says that at low feed as the no. of passes increases the surface roughness is increasing and at high feed reverse case is occurred as the no. of passes increases surface roughness is decreasing. This is because as low feed is given the tool passes over the work piece slowly by which a uniform pressure is applied on the workpiece which increases the surface roughness with increase in no. of passes. And when high feed is given the tool passes over the work piece is fast which leads to non-uniform application of pressure on the work piece which obviously decreases the surface roughness with increase in no. of passes.

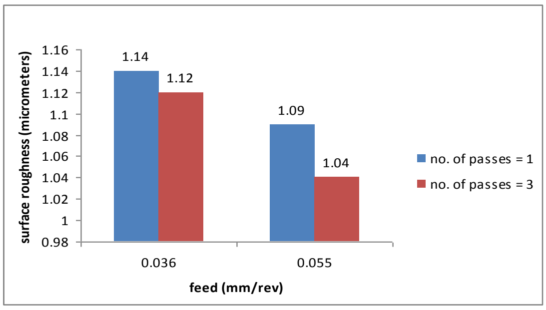

Figure5. Effect of surface roughness due to feed at 975 rpm.

In Fig5 the effect of surface roughness due to feed at high speed is shown in the graph. From the graph it is observed that at both high speed and low feed and at high speed and high feed as the no. of passes increases the surface roughness is decreasing. This is because as low feed is given the tool passes over the work piece slowly but the workpiece is rotating fastly which leads to the reduction in surface roughness. And when high feed is given the tool passes over the work piece is fast which leads to non-uniform application of pressure on the work piece which obviously decreases the surface roughness with increase in no. of passes.

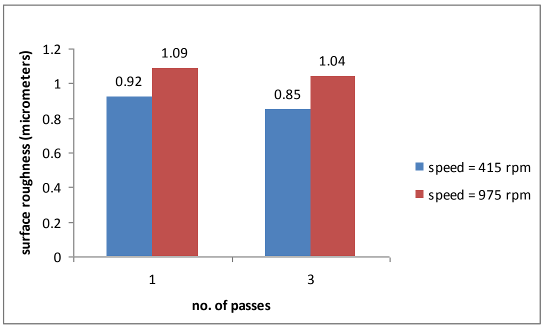

Figure6. Effect of surface roughness due to no. of passes at 0.055 mm/rev.

In Fig6 the effect of surface roughness due to no. of passes at high feed is shown in the graph. From the graph it is observed that in both cases i.e. at high feed with minimum no. of passes and with maximum no. of passes as the speed increases the surface roughness is increasing. This is because at high feed the tool passes over the work piece fastly independent of speed the surface roughness is increases.

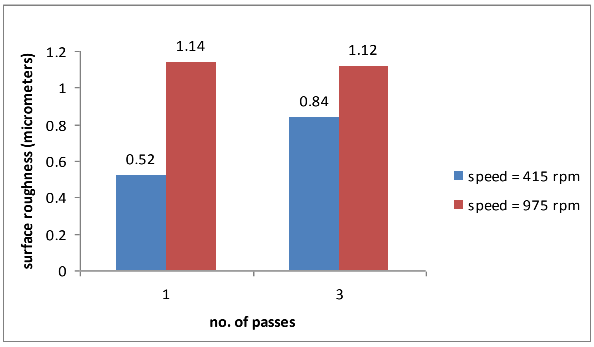

Figure7. Effect of surface roughness due to no. of passes at 0.036 mm/rev

In Fig7 the effect of surface roughness due to no. of passes at low feed is shown in the graph. From the graph it is observed that at low feed in both cases i.e.,at minimum no.of passes and maximum no. of passes as the speed increases there is maximum increase in surface roughness value. This is because at low feed the tool passes over the work piece slowly by which uniform pressure is applied on the work piece which leads to maximum increase in surface roughness value.

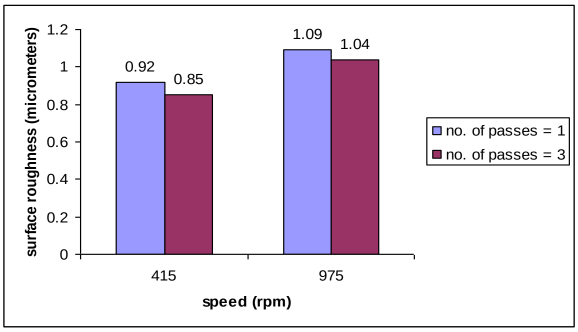

Figure8. Effect of surface roughness due to speed at 0.055 mm/rev

In Fig8 the effect of surface roughness due to speed at high feed is shown in the graph. From the graph it is observed that at high feed and in both cases i.e., at low speed and high speed as the no.of passes increases there is minimum decrease in surface roughness value.This is due to at high feed as the tool passes over the work piece fastly by which minimum pressure is applied on the work piece which leads to minimum decrease in surface roughness value.

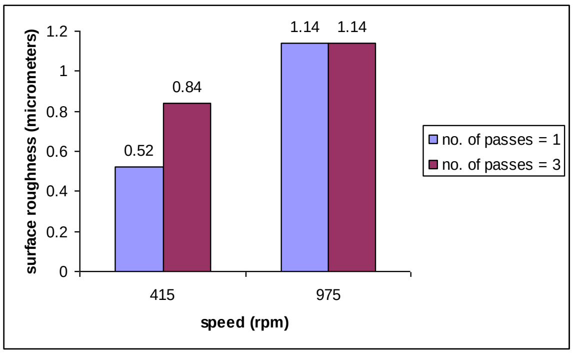

Figure9. Effect of surface roughness due to speed at 0.036 mm/rev

In Fig9 the effect of surface roughness due to speed at low feed is shown in the graph. From the graph it is observed that at low feed and speed as the no. of passes increases the surface roughness increase and at the high speed as the no. of passes increases the surface roughness remains constant. This is due to at low feed the tool passes over the work piece slowly, at low speed the contact between tool and work piece is maximum which increases surface roughness.

IV. CONCLUSIONS

The designed roller burnishing tool was successfully used for burnishing operation. Surface roughness is redused after roller burnishing irrespect of procees parameters. The best surface finish was obtained at 415 rpm burnishing speed, 0.036 mm/rev burnishing feed, and one pass of burnishing tool. The roller burnishing processes reduce the suface rufness by 33%. compared to turned surface.

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