Effect of Process Parameters on Surface Roughness and Surface Hardness in Roller Burnishing Process

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Abstract: ***The main aim of this study is to enhance the surface roughness and surface hardness of the of C20 carbon steel using the roller burnishing process. In globalization manufacturing processes the both physical and mechanical property are importance so we have studied and find best suitable parameter in minimize input parameter like force, feed, and Speed with using RSM method in Minitab16 and best result gain with burnishing tool which manufacture with new design which cover Lean manufacturing, J-I-T concept with easily assemble and disassemble for small and large scale industries and minimize tool manufacturing cost.***

Keywords: Roller burnishing, Surface roughness, Surface hardness, C-20, RSM

1. Introduction

In present in the era of globalization the performance of machine depend on accuracy, tolerance and surface finish of component. During achieve good accuracy with perfectly matching any parts without tolerance for require good surface finish. Finishing processes have always been important in manufacturing of all kinds of parts. A special attention is paid to surface quality from the view point of smoothness as physical and mechanical characteristics .During the resent years considerable attention is being paid to metal finishing operation to improve the surface characteristics of machined components. The various metal finishing processes can be broadly classified into ***two categories*** as follow.

1. Based on cutting action of Abrasives.
   As per example, Grinding, Lapping, Honing, Buffing, Polishing, Super finishing
2. Based on plastic deformation of the surface layer.
   As per example, Burnishing, Barrel Rolling, shot peeninig, shot blasting etc..

Due to low roughness obtained methods such as grinding, lapping, honing and polishing are commonly utilized for improving surface finish. Besides these methods there are other methods which improve surface characteristics through plastic deformation; these methods are referred to as burnishing.

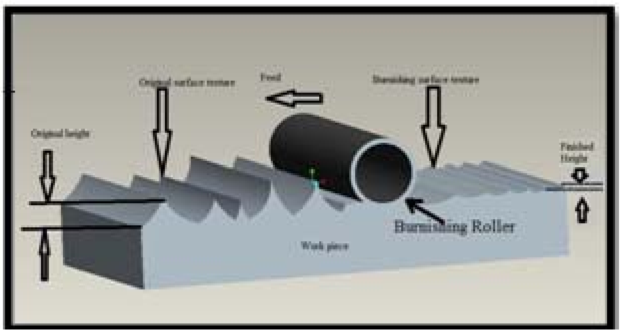
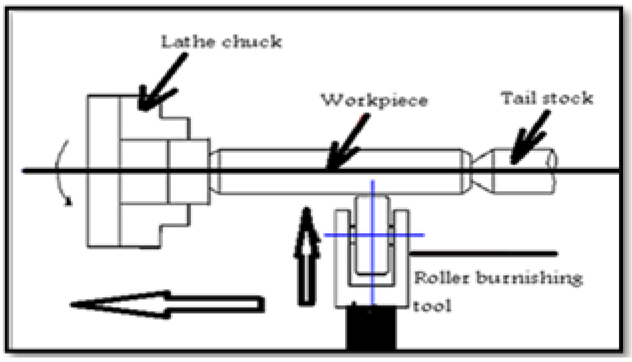


Figure: 1.1 The Roller burnishing process



Basic method of burnishing process

2. Literature Review

Khalid. S. Rababa et al [1] were carried out "Effect of Roller Burnishing on the Mechanical Behaviour and Surface Quality of O1 Alloy Steel'' enhance the mechanical properties and micro hardness of the surface of O1 steel using the roller burnishing process. Widely used methods of finishing treatment that create necessary parts with the given roughness usually do not provide optimum quality of the surface. Therefore, methods of Surface Plastic Deformation (SPD) are used. One of the most effective representatives is the roller burnishing. This can simply achieved by pressing a hard and highly polished ball or roller against the surface of metallic work pieces. In this paper the effect of diamond pressing process with a different pressing force (105, 140, 175, 210) N was studied and the results of the experiments are presented. The surface quality has been enhanced by 12.5% increased.

Malleswara Rao J. N. , Chenna Kesava Reddy A. , Rama Rao P [2] were carried out "Study Of Roller Burnishing Process On Aluminium Work Pieces Using Design Of Experiments'' In this paper his study surface roughness is the main response variable and the process parameters under consideration are spindle speed, tool feed and number of passes.Design of Experiments (Taguchi techniques) techniques enables designers to determine simultaneously the individual and interactive effects of many factors that could affect the output results in any design.

P. Zhang,J. Lindemann, W.J. Ding, C. Leyens [3] were carried out " Effect of roller burnishing on fatigue properties of the hot-rolled Mg–12Gd–3Y magnesium alloy'' and find the influence of RB on the high cycle fatigue properties of the Mg–
12Gd–3Yalloy was investigated because it is a substitute of aluminium so consider a fatigue property and find conclusions can be drawn: RB improved fatigue strength of the Mg–Gd–Y alloy significantly After RB, the fatigue strengths increased from
150 and 155 MPa, to 225 and 210MPa in the as-rolled alloy and the T5 heat-treated alloy.

3. Experimental Procedure

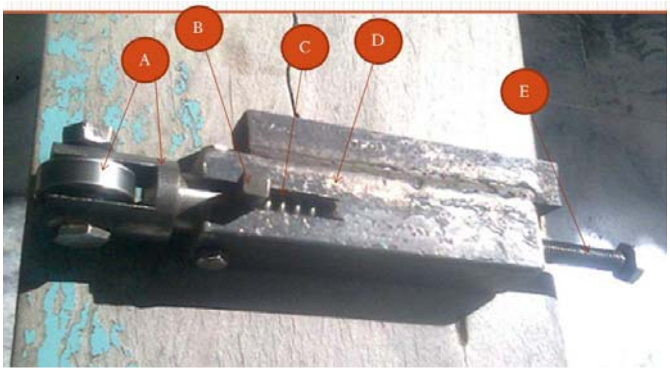
Since there is a dearth of literature on normal Roller burnishing process, a new Roller burnishing tool was introduced in this investigation which enables for single Roller burnishing process in site after turning without releasing the work piece. The main concern of this work is to examine the use of a Roller burnishing tool which will be used to improve surface characteristic such as surface roughness. The effect of burnishing parameter; namely; burnishing speed, feed, and burnishing force on surface roughness is comprehensively studied through this work. The process parameters are selected on the basis of literature review.

1. Work material : Carbon steel, 20(AISI1020) 70 HRB,3.2µm*
2. Dia, for material: ∅ 35 X 130 mm. Total 6 nos.pieces required (on each to 5 reading) for experiment freeform surface was about 77.8%.
3. Roller material : Ball bearing 6203Z
4. Burnishing force : 20-100 kgf
5. Burnishing feed : 0.05-0.17 mm/rev
6. Burnishing speed : 6.6-55 m/min (60-785 rpm)
7. Lubricant: No lub. only natural air *70 HRB,3.2µm achieve parameter after 1 or 2 mm d.o.c turning operation with 0.05 feed and 375 rpm speed using carbide cutting tool.

Setup of Conventional Lathe machine

The experimental work is conducted on Conventional (all central gear) machining. The main advantage of using such a machine is its flexibility. It enables the machining and burnishing operations to be accomplished easily in as sequential order. Any change in burnishing condition such as speed, feed, and force can be easily adjusted. Figure-3.1 shows the experimental set-up Conventional (all central gear) machining.

4. Burnishing Tool Design



Burnishing Tool Design
a) Ball bearing with holding arrangement b) Pin c) Calibrated Spring d) Tool holding arm/ body e) Screw

Setup several advantages, as follows:

1. The normal force is constant, the process is then consistent and easy to reproduce;
2. The Roller can rotate freely in sliding direction; this prevents any sliding contact with the work piece.
3. The tool can be installed on a regular lathe; burnishing can be thus carried out with the work piece in the same clamped position as for a previous operation.
4. The tool has a long life and it is easy to maintain.
5. In case of sudden increase in burnishing force, any damage to the burnishing tool or fixture arrangement can be avoided.
6. Burnishing force can be measured by measuring the deflection of pre- calibrated spring.
7. Also cover lean manufacturing and J-I- T concept.

5. Design of Experiment

5.1 CCD design

The scheme of carrying out experiments was selected and the experiments were conducted to investigate the effect of process parameters on the output parameters i.e. surface roughness and hardness. The experimental results are discussed subsequently in the following sections. The selected process variables were varied up to five levels and central composite rotatable design was adopted to design the experiments. Response Surface Methodology was used to develop second order regression equation relating response characteristics and process variables. The process variables and their ranges are given in Table.

In our project work we have used 3 factors each having same level.

Factor A: Burnishing force.
Factor B: Burnishing Feed
Factor C: Burnishing Speed

Output Parameters

- Surface roughness
- Surface hardness

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Table 3.1: Experimental result

Sr. No	*Burnishing Force (X1)Kgf.*		*Burnishing Feed (X2)mm/rev*		*Burnishing Speed (X3)m/min*		*Response*	
Std.Ord	Coded	Real	Coded	Real	Coded	Real	S.R	S.H
1	-1	40	-1	0.08	-1	20.8	0.84	88.67
2	+1	80	-1	0.08	-1	20.8	0.59	91.90
3	-1	40	+1	0.14	-1	20.8	0.91	87.95
4	+1	80	+1	0.14	-1	20.8	0.62	92.76
5	-1	40	-1	0.08	+1	55	0.74	90.70
6	+1	80	-1	0.08	+1	55	0.61	90.20
7	-1	40	+1	0.14	+1	55	1.12	86
8	+1	80	+1	0.14	+1	55	0.94	88
9	-1.68179	20	0	0.11	0	41.21	1.22	85.10
10	+1.68179	100	0	0.11	0	41.21	0.70	90.80
11	0	60	-1.68179	0.05	0	41.21	0.53	92.50
12	0	60	+1.68179	0.17	0	41.21	0.95	88.02
13	0	60	0	0.11	-	6.6	0.63	92.02
14	0	60	0	0.11	+1.681	86.2	0.78	88.78
15	0	60	0	0.11	0	41.21	0.87	89.70
16	0	60	0	0.11	0	41.21	0.81	88.66
17	0	60	0	0.11	0	41.21	0.85	89.33
18	0	60	0	0.11	0	41.21	0.80	89.50
19	0	60	0	0.11	0	41.21	0.86	88.70
20	0	60	0	0.11	0	41.21	0.85	89.03

6. Experimental Results

The response parameters i.e. surface roughness (Ra µm) and surface hardness (HRB) burnished specimen measured. With model-TR 110 TIME group instrument and its specification shown in. and SMS machine measure hardness on 100 kgf. load with 1/16" diamond probe as per respectively and chosen value of specimen after 3 observation and its observation are listed in Table 5.1.The initial (without burnished) average roughness and hardness of specimen as 3.2 µm and 70 HRB.

6.1 Analysis and Discussion of Results For Surface Roughness

Surface =1.1480 -0.0156 FORCE+5.0819 FEED -0.0102 **Roughness (µm):** SPEED (M/MIN)+ 0.0001 FORCE*FORCE- 28.7182 FEED*FEED -0.0001 SPEED (M/MIN)*SPEED (M/MIN) -0.0188 FORCE*FEED+0.0001 FORCE*SPEED (M/MIN)+ 0.1466 FEED*SPEED (M/MIN)

Regression table for surface roughness using Minitab software. The analysis was done using uncoded units.

Estimated Regression Coefficients for S.R(µm)

Term	Coef	SE Coef	T	P
Constant	1.1480	0.19405	5.916	0.000
FORCE(kgf.)	-0.0156	0.00285	-5.463	0.000
FEED(mm/rev)	5.0819	1.94060	2.619	0.026
SPEED(M/MIN)	-0.0102	0.00311	-3.271	0.008
FORCE(kgf.)*FORCE(kgf.)	0.0001	0.00001	5.006	0.001
FEED(mm/rev)*FEED(mm/rev)	-28.7182	6.47020	-4.439	0.001
SPEED(M/MIN)*SPEED(M/MIN)	-0.0001	0.00001	-6.597	0.000
FORCE(kgf.)*FEED(mm/rev)	-0.0188	0.01717	-1.092	0.300
FORCE(kgf.)*SPEED(M/MIN)	0.0001	0.00003	2.544	0.029
FEED(mm/rev)*SPEED(M/MIN)	0.1466	0.01990	7.368	0.000

S = 0.0291391 PRESS = 0.0444338, R-Sq = 98.52% R-Sq(pred) = 92.26% R-Sq(adj) = 97.19%

6.2 Analysis and Discussion of Results for Surface Hardness

Analysis And Discussion Of Results For Surface Hardness
Surface=85.677 + 0.155 FORCE--80.819 FEED +0.211 Hardness(HRB): SPEED(M/MIN)- 0.001 FORCE*FORCE+ 298.585 FEED*FEED +0.001 SPEED(M/MIN)*SPEED(M/MIN) +0.850 FORCE*FEED-0.002 FORCE*SPEED(M/MIN)- 1.735 FEED*SPEED(M/MIN)

Regression table for surface hardness using Minitab software

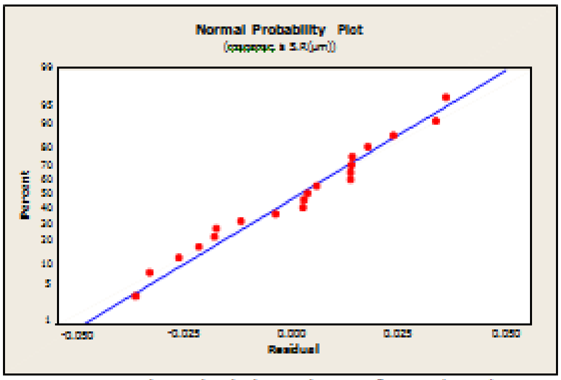
Term	Coef	SE Coef	T	P
Constant	85.677	2.8122	30.466	0.000
FORCE(kgf.)	0.155	0.0414	3.743	0.004
FEED(mm/rev)	-80.819	28.1239	-2.874	0.017
SPEED(M/MIN)	0.211	0.0451	4.674	0.001
FORCE(kgf.)*FORCE(kgf.)	-0.001	0.0002	-3.659	0.004
FEED(mm/rev)*FEED(mm/rev)	298.585	93.7685	3.184	0.010
SPEED(M/MIN)*SPEED(M/MIN)	0.001	0.0002	4.219	0.002
FORCE(kgf.)*FEED(mm/rev)	0.850	0.2488	3.416	0.007
FORCE(kgf.)*SPEED(M/MIN)	-0.002	0.0004	-5.276	0.000
FEED(mm/rev)*SPEED(M/MIN)	-1.735	0.2884	-6.016	0.000

S = 0.422295, PRESS = 8.81431, R-Sq = 97.67% R-Sq(pred) = 88.48% R-Sq(adj) = 95.57%

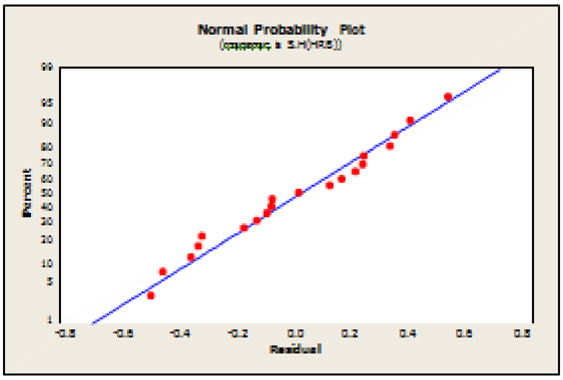
7. Validation Result

Sr. No	Force X1 (kgf.)	Feed X2 (mm/rev)	Speed X3 (m/min)	Predictive S.R (µm)	Predictive S.H (HRB)	Exp. S.R (µm)	Exp. S.H (HRB)	%Error S.R (µm)	%Error S.H (HRB)
1	75	0.12	13.73	0.75	92	0.71	91.5	5	1
2	70	0.05	86.2	0.27	97.38	0.26	97.70	3	0.3
3	100	0.17	6.6	0.46	98.68	0.48	98.80	4	0.2
4	90	0.05	13.73	0.71	91.48	0.74	90.05	5	1.6

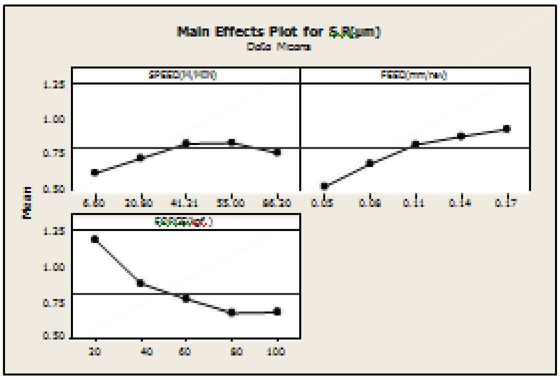
Predictive data are come on mathematical model
Experiment data are come on experimental



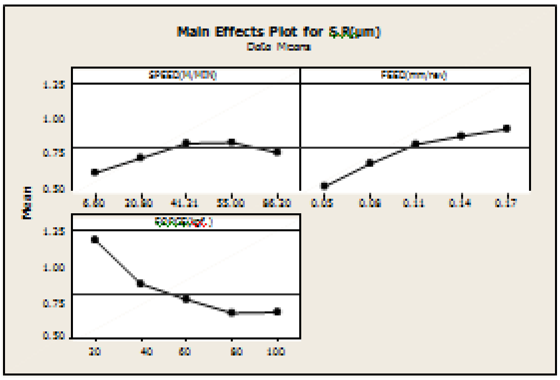
Normal probability Plots of S.R (µm)



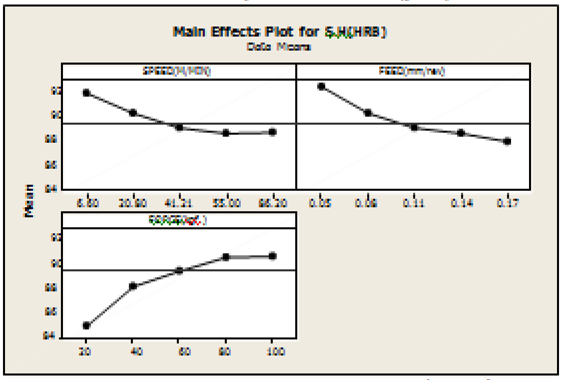
Normal probability of S.H (HRB)



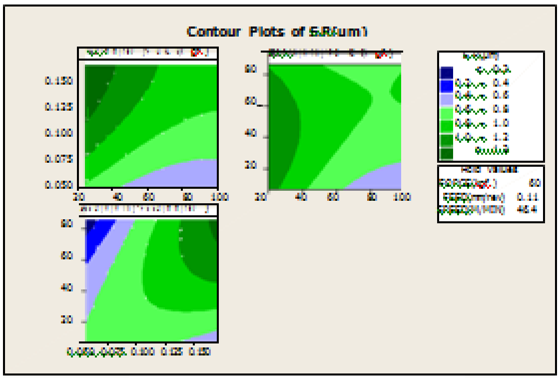
Main effect plot for S.R (µm)



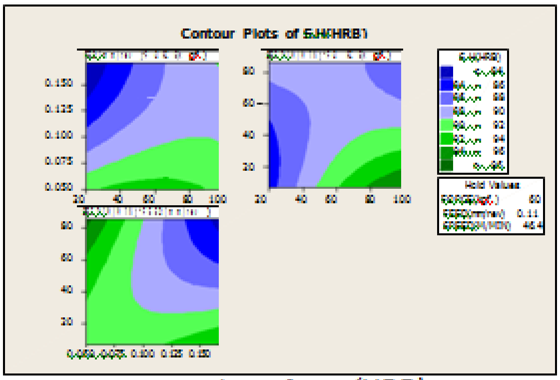
Main effect plot for S.R (µm)



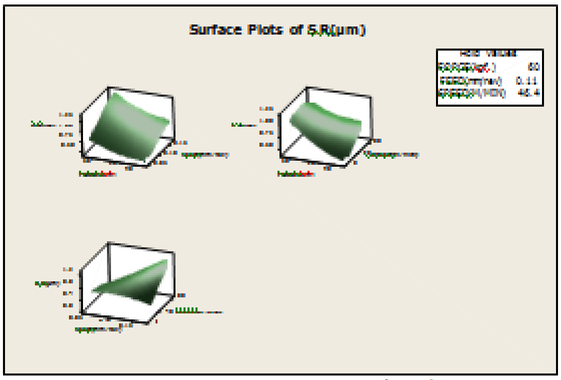
Main effect plot for S.H(HRB)



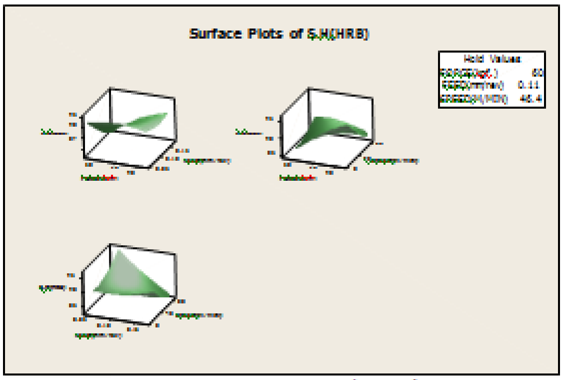
Counter Plots of S.R (µm)



Counter Plots of S.H. (HRB)



Surface Plots of S.R (µm)



Surface Plots of S.H(HRB)

8. Conclusion

In this process both force and speed are affected and feed also affected but less affecting than other both parameter.

a. Burnishing speed
   In this parameter when speed low S.R is low and S.H high and then increase both are decrease and after than speed increase S.R is low
b. Burnishing force
   On high force in both parameter S.R decrease and S.H increase and low force S.R is increase and S.H as decrease.
c. Burnishing feed
   Increase of feed in both parameter S.R increase and S.H decrease

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