Effect of Process Parameters on Surface Roughness & Surface Hardness in Ball Burnishing Process

Ronak M. Lanukiya[1] Prof. J. D. Patel[2]
[2]Professor & Head of Dept.
[1,2]Department of Mechanical Engineering
[1,2]MEC, Basna, Mehsana, Gujarat,, India

Abstract— The main aim of this study is to enhance the surface roughness and surface hardness of the of C40 carbon steel using the BALL 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.

Key words: BALL Burnishing, Surface Roughness, Surface Hardness, C-40, RSM

I. 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.

A. *Based on cutting action of Abrasives*

As per example
Grinding, Lapping, Honing, Buffing, Polishing, Super finishing

B. *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.

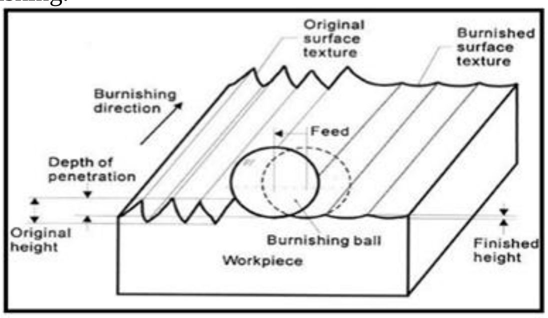
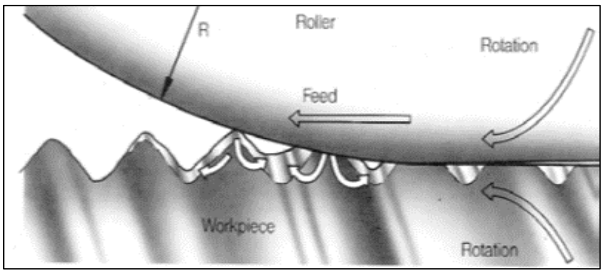


Fig. 1.1: The ball burnishing process



II. LITERATURE REVIEW

Malleswara Rao J. N. , Chenna Kesava Reddy A. , Rama Rao P et al(2011) [1] were carried out "effect of roller burnishing on surface hardness and surface roughness on mild steel specimens'' In this paper his study Roller burnishing tool is used for the experimental work of the present study on a specially fabricated mild steel specimen. In roller burnishing, a hard roller is pressed against a rotating cylindrical work piece and parallel to the axis of the work piece. Burnishing is essentially a cold forming process, in which the metal near a machined surface is displaced from protrusions to fill the depressions. In the present work, various experiments are conducted to investigate the effect of burnishing force and number of tool passes on surface hardness and surface roughness of mild steel specimens. The results show that improvements in the surface roughness and increases in surface hardness were achieved by the application of roller burnishing with mild steel specimens. The results are presented in this paper. Roller burnishing produces better and accurate surface finish on Aluminium work piece in minimum time. Roller burnishing is an economical process, where skilled operators are not required. This process can be effectively used in many fields such as Aerospace Industries, Automobiles Manufacturing sector, Production of Machine tools, Hydraulic cylinders, etc,and find effect with The surface hardness of mild steel specimens increases with increase in the burnishing force up to 42 kgf.

Aysun Sagbas et al(2011)[2] were carried out "Analysis and optimization of surface roughness in the ball burnishing process using response surface methodology and desirability function''Analysis and optimization of surface roughness in the ball burnishing process using response surface methodology and desirability function In this experimental study, the evaluations of the four variables burnishing force, number of passes, feed rate and burnishing speed were investigated by combining RSM and DFA. RSM with CCD was employed to evaluate the effects of burnishing parameters on the surface roughness of the 7178 aluminium alloy. The significant factors on the surface roughness were determined as burnishing force and number of passes. The predictive power of this model was tested with supplementary experimental surface roughness data and a good fit was observed. The average absolute error between experimental and predicted values was calculated as about 3.5% sufficiently low to confirm the high predictive power of model. After building the regression model, a numerical optimization technique using desirability function was employed to optimize the burnishing process. The experimental results at the optimum process parameter combination confirm the effectiveness of the response surface models for optimum burnishing parameters. RSM approach can help manufacturers to determine the appropriate burnishing conditions, in order to achieve specific surface roughness. RSM was found to be a useful approach and it should be recommended that this methodology be adopted to all optimization studies.

F. Gharbi et al(2010) [3] and all developed newly ball burnishing tool was designed and tested for surface finishing of large flat surfaces in a shortest possible time. Optimization and analysis of the burnishing process were carried on AISI 1010 steel hot-rolled plates using the Taguchi technique and response surface methodology (RSM) to identify the effect of burnishing parameters (i.e., burnishing speed, burnishing force, and feed rate) on surface roughness, surface hardness, and microstructure of burnished surfaces. The optimal burnishing parameters were found after conducting the Taguchi's L25 matrix experiments and obtaining the response models for the surface roughness and the hardness. It was found that the burnishing force has the most influential effect on the surface roughness and hardness, followed by the burnishing speed, and least influence by the feed rate. In addition, micro structural examinations of the burnished surface indicate that burnishing force more than 400 N causes flaking of the burnished surfaces. The optimal burnishing parameters for the steel plates were a combination of a burnishing speed of 51.7 m/min., a burnishing force of 400 N, and a feed rate of 0.18 mm/rev. Using these parameters, the mean surface roughness has been improved from 2.48 to 1.75 Ra, while the hardness increases from 59 to 65.5 HRC.

M.L. Neema and P. C. Pandey et al(2009) [4] have employed ball peening under controlled conditions on a turned surface peening parameters viz. peening frequency, ball diameter, force, feed, and number of tool passes have been varied to study the changes in properties in respect to Surface roughness and hardness by using experimental design technique known as response surface methodology, due to Box and Wilson (1951), has been employed to plan the experimental programmed. Also have been found that peening results improves the surface finish, hardness and low coefficient of sliding friction with higher load carrying capacity

BALL 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.

III. EXPERIMENTAL PROCEDURE

Since there is a dearth of literature on normal BALL burnishing process, a new BALL burnishing tool was introduced in this investigation, which enables for single BALL burnishing process in site after turning without releasing the work piece. The main concern of this work is to examine the use of a BALL 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 40(AISI1040) 70 HRB,3.2μm*
2) Dia, for material: □ 35 X 130 mm. Total 6 nos.pieces required (on each to 5 reading) for experiment.
3) Ball 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.

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- shows the experimental set-up Conventional (all central gear) machining.

A. *Setup several advantages, as follows:*

1) The normal force is constant, the process is then consistent and easy to reproduce;
2) 2. The ball 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.

IV. DESIGN OF EXPERIMENT

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

A. *Output Parameters*

- Surface roughness
- Surface hardness

Fig. : Burnished work piece

Fig. : Experimental set up with the Ball burnishing equipment

Sr. No	Burnishing Force (X1)Kgf.		Burnishing Feed (X2)mm/rev		Burnishing Speed (X3)m/min		Response	
Std. Order	Coded	Real	Coded	Real	Coded	Real	S.R (µm)	S.H (HRC)
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	-1.68179	6.6	0.63	92.02
14	0	60	0	0.11	+1.68179	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

Table 3.1: Experimental result

V. 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.

A. Analysis and Discussion of Results for Surface Roughness

SURFACE ROUGHNESS(µm):
=1.1480 -0.0156 FORCE+5.0819 FEED -0.0102

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)

B. 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%

ANALYSIS AND DISCUSSION OF RESULTS FOR SURFACE HARDNESS

SURFACE HARDNESS(HRB):

=85.677 + 0.155 FORCE--80.819 FEED +0.211 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)

C. Regression table for surface hardness using Minitab software

Term	Coef	SE	T	P
Constant	85.67	2.812	30.4	0.0
FORCE(kgf.)	0.155	0.041	3.74	0.0
FEED(mm/rev)	-	28.12	-	0.0
SPEED(M/MIN)	0.211	0.045	4.67	0.0
FORCE(kgf.)*FORCE(k	-	0.000	-	0.0
FEED(mm/rev)*FEED(m	298.5	93.76	3.18	0.0
SPEED(M/MIN)*SPEED	0.001	0.000	4.21	0.0
FORCE(kgf.)*FEED(mm	0.850	0.248	3.41	0.0
FORCE(kgf.)*SPEED(M	-	0.000	-	0.0
FEED(mm/rev)*SPEED(	-	0.288	-	0.0

S = 0.422295 PRESS = 8.81431

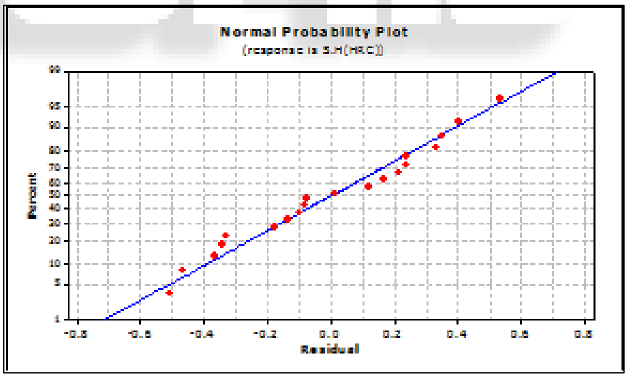
R-Sq = 97.67% R-Sq(pred) = 88.48% R-Sq(adj) = 95.57%

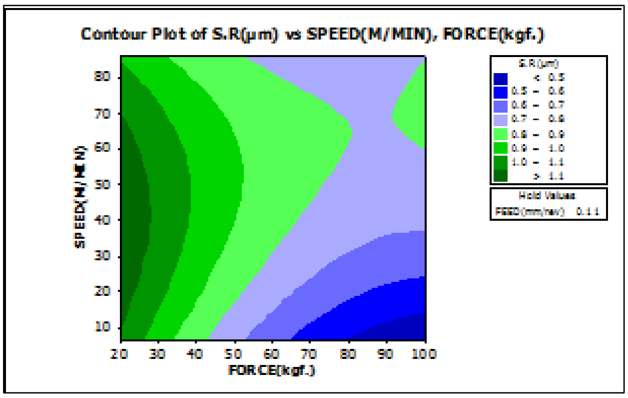
D. Validation Result

Sr. No.	Force	Feed	Speed	Predictive		Exp.		%Error	
	X1 (kgf.)	X2 (mm/rev)	X3 (m/min)	S.R (µm)	S.H (HRB)	S.R (µm)	S.H (HRB)	S.R (µm)	S.H (HRC)
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

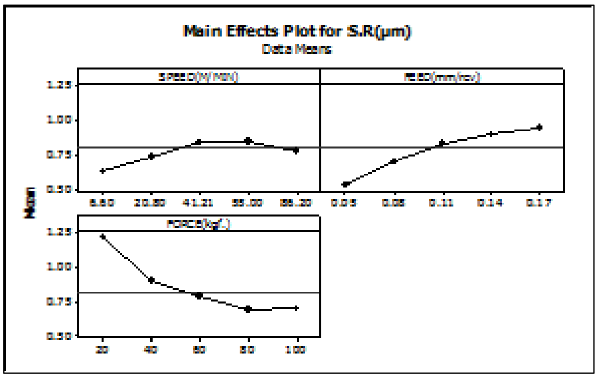
Predictive data are come on mathematical model
Experiment data are come on experimental

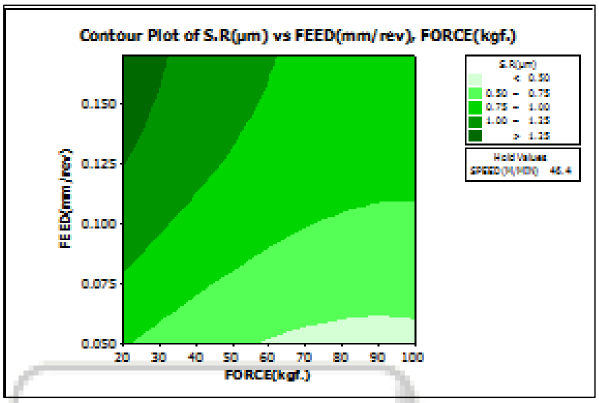
E. Normal Probability Plot for S.R (µm)



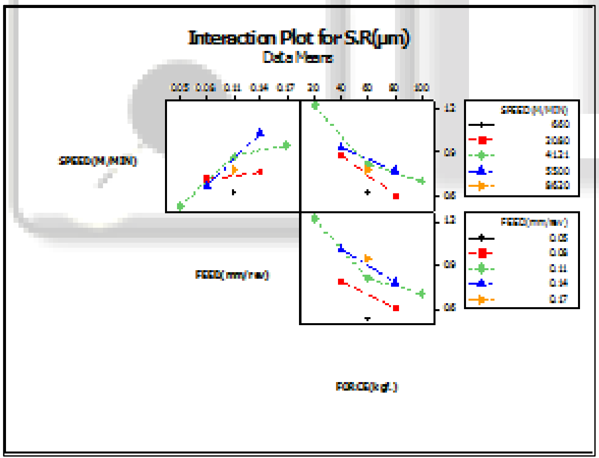


F. Main effect Plot for S.R (μm)

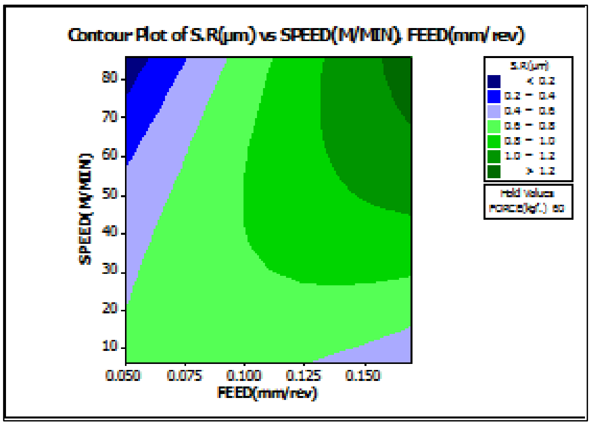




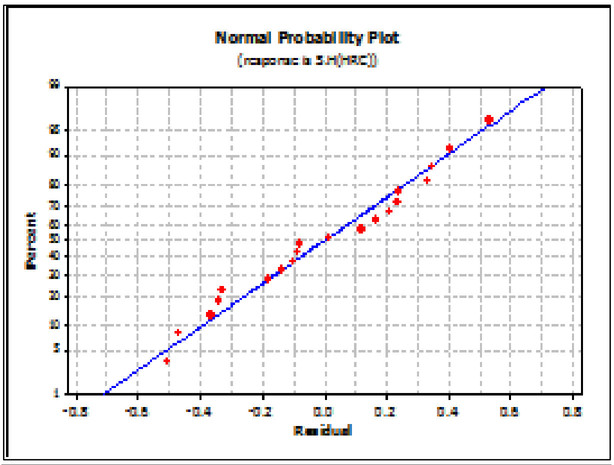
G. Interaction Plot for S.R (μm)

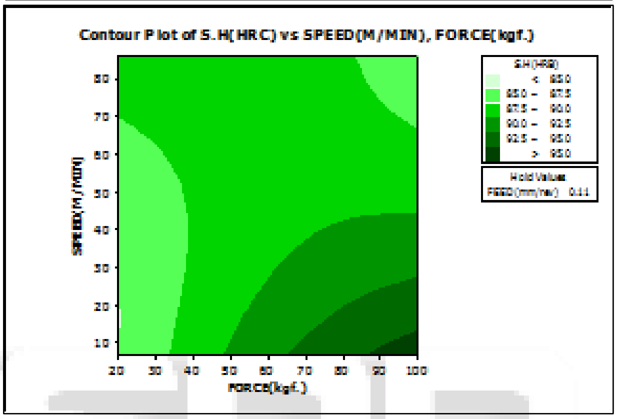


H. Contour Plot of S.R(μm)



I. Normal Probability Plot for S.H





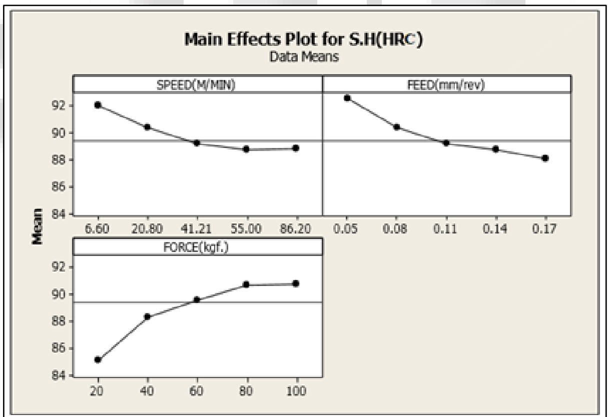
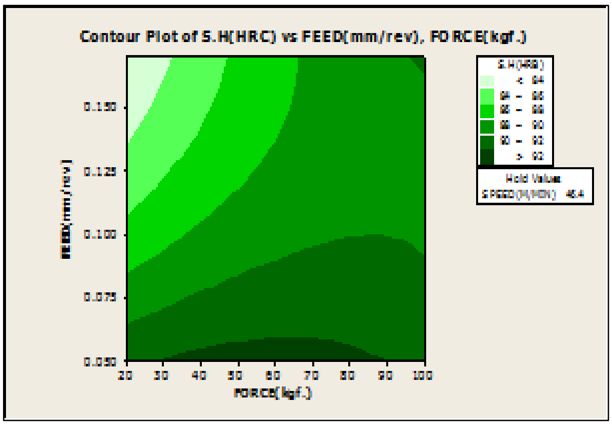
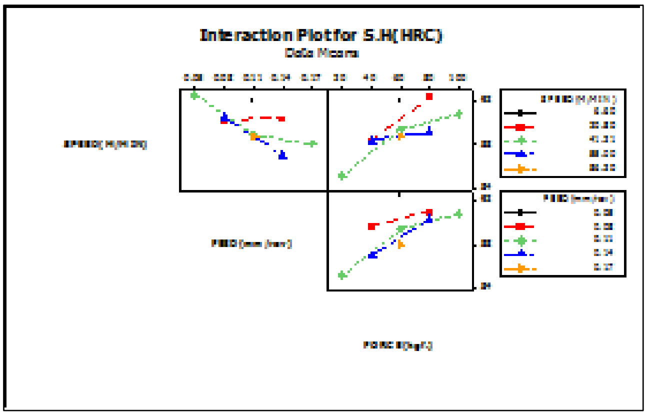


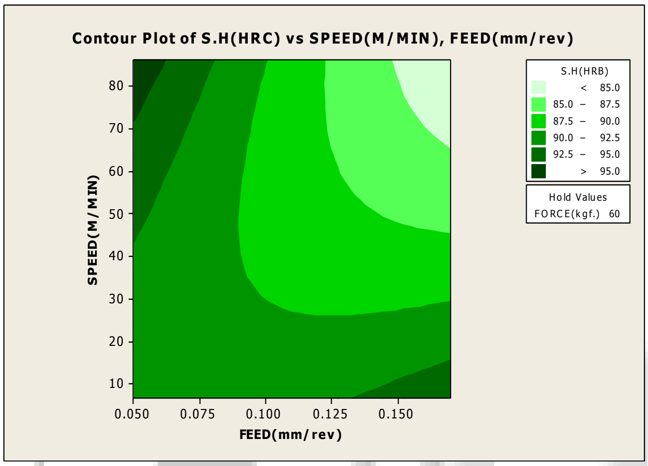
Figure: 6.7 Main effect plot for S.H (HRC)



J. Interaction Plot For S.H



K. Contour Plot of S.H



VI. CONCLUSION

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

Increase of feed in both parameter S.R increase and S.H decrease

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