PARAMETRIC OPTIMIZATION OF BALL BURNISHING PROCESS FOR AA6061 MATERIAL

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ABSTRACT: These Experimental work with reducing of burnishing process parameters new design ball burnishing tool. The work piece material is Aluminum Alloy 6061 and ball material is of high chromium high carbon, four balls of Different diameter are used. The levels of input process parameters are selected on basis of one factor at a time analysis. The different input parameters are burnishing Speed, burnishing Ball diameter, and number of passes and the response parameter are surface roughness and hardness .The experiment is design with Full factorial method carried out with above Three factors and Four levels. The optimum set of parameter is determined One factor, interaction and predicted vs. Actual graph.

KEYWORDS:Ball burnishing, Surface roughness, Surface Hardness, No of passes,No of diameter,cutting speed,Design Expert,ANOVA

I. INTRODUCTION

In the present scenario of manufacturing good surface finish and dimensional accuracy plays an important role[1]. Surface finish is important not only as an indication of expert workmanship but it has effects on the life and function of the component. Ball burnishing processes are largely considered in industrial cases in order to restructure surface characteristics [2]. Ball burnishing is a chip less finishing method which employs a rolling tool pressed against the work piece in order to achieve plastic deformation.The process is relatively simple and can be easily performed on machine tools. Besides giving a good surface finish it also increases micro hardness, fatigue life and wear resistance of the components[5].

Burnishing is a cold working surface finishing process which is carried out on material surfaces to induce compressive residual stresses and enhance surface qualities[9]. A burnishing tool typically consists of a hardened sphere which is pressed onto/across the part being processed which results in plastic deformation of asperities into valleys[5]In burnishing process in which initial asperities are compressed beyond yield strength against load. The surface of the material is progressively compressed then plasticized as resultant stresses reach a steady maximum value and finally wiped a superfine finish[8].

II. LITERATURE SURVEY

1. **“Burnishing of Aerospace Alloy: A Theoretical and experimental Approach” Tao Zhang, NiloBugtai, Ioan D Marinescu**
   This paper concentrate on burnishing is well known as a very effective surface enhancement method for manufacturing. The current work focuses on obtaining predictable models of surface roughness and residual stresses based on experimental data. Smoother surfaces of aerospace material modified by ball burnishing have been achieved and significant influences of process parameters on both surface roughness and maximum residual stresses are established.
2. **"Study on the inner surface finishing of aluminium alloy 2014 by ball burnishing process" M.H. El-Axir, O.M. Othman , A.M. Abodiena**
   There are so many valves applicable in industry, one of them is ball valve because ball valve is mostly used in power plant to control and regulate the flow hydraulic plant. It is important to design the valve in such way that best efficiency can be achieved in plant by considering the flowing parameter such as pressure drop, velocity, and viscosity etc. CFD analysis improve the valve performance and valve life in industry at desire valve closing angle such as 0^o, 15^o, 30^o, 45^o, 60^o by changing the ball valve shape and checking the pressure drop at certain angle for getting best result
3. **"The effects of initial burnishing parameters on non-ferrous components" Adel Mahmood Hassan, Ayman Mohammad Maqableh**
   In This paper the ball diameter of the burnishing tool and the use of different lubricants on this process were studied. Two non-ferrous work piece materials, namely free machining brass and cast Al-Cu alloy, were used. 1. An increase in initial surface roughness will cause an increase in the surface roughness of the ball burnished work piece, but it has no effect on the surface hardness of these metallic work pieces. 2. An increase in the initial surface hardness will cause a decrease in the reduction of surface roughness, and in the total amount of the increase in surface hardness.

4. **"Vertical Multi Roller Burnishing on Copper and Aluminium Metal" SThamizhmanii, RasoolMohideen, Sulaiman**
   In this paper, the experiments are useful in improving the quality of the burnished surface by selecting proper input parameters. The surface roughness has increased as the spindle rotation and feed rate for copper and aluminum. If the over lapping of the roller is maintained, and then it is possible to achieve lower surface roughness value. The burnishing is good process to improve the surface roughness for metals where grinding is not possible due to wheel loading effect in material like aluminum etc.
5. **"Optimization of Surface Roughness Index for a Roller Burnishing Process Using Graph Theory and Matrix Method" Pascale Ballanda, Laurent Tabourota, Fabien Degrea, Vincent Moreaub**
   This paper proposes a finite element modelling of the ball burnishing process. Diameter of ball is 3.2mm. Representative Position of work piece dimension is 6mm*2mm*2mm. Hear the Friction coefficient μ is set zero. In this work, the mechanics of the burnishing process using a ball. The mechanism of formation and flow of the ridge appears to have a central role in the treatment of a surface by burnishing. The numerical models of roller burnishing that are based on the assumption of equivalence between burnishing (rolling contact) and indentation phase (normal contact) are inadequate to provide an accurate estimation of the geometrical and mechanical characteristics of a roller-burnished surface. Thanks to this model, the effect of the burnishing process on the material is analyzed. A ridge phenomenon that affects the mechanics of the process is demonstrated, allowing for improved modelling of the burnishing process
6. **"Design and Fabrication of Multi Ball Burnishing for Post Machining Finishing Process" Ravi butola,JitendraKumar,DrQasimMurtazar**
   In this Design and Fabrication of Multi Ball Burnishing for Post Machining Finishing Process Using No of balls in the burnishing ool are 16,Radius of each ball is 5.5mm feed of milling table is 38mm/min . The surface roughness with fabrication burnishingtool was found 0.005136μm
7. **"Effect of Burnishing Process on Behaviour of Engineering Materials" Prof.Ghodake A. P., Prof.Rakhade R.D., Prof.Maheshwari A.S**
   Burnishing force and number of burnishing tool passes are the important parameters to improve the ductility of materials. Burnishing process greatly affects the frictional coefficient and improves wear resistance of materials. Different methods can be used effectively for obtaining optimum parameters for burnishing process. Depth of penetration, feed rate, and burnishing speed are also play an important role to improve material properties. Tribological aspects like appropriate lubricants for obtaining better surface quality are selected. Optimum burnishing parameters gives the lowest value for surface roughness and thus surface finish improved. Hardness is improved by burnishing process by selecting optimum process parameters.

III. Experimental Setup

3.1 Machine tool

The Experiments will be carried out on HMT TL 20 Lathe machine tool and the work piece material AA6061

Fig 1: HMT TL 20 Lathe Machine

Component	Amount (%)
Magnesium 0.8	1.2
Silicon 0.4	0.8
Iron max	0.7
Copper 0.15	0.4
Zinc max	0.25
Titanium max	0.15
Chromium 0.4	0.35

Table 3.1: Chemical composition of AA6061 material

3.2 Hardness Tester

The hardness of all the machined work pieces was measured using a Dial gauge operated brinel hardness tester machine.

Fig 2: Dial gauge operated brinel hardness tester machine

3.3 Input and Output Parameters

Input Parameters	Output Parameters
No. of ball diameter	Surface roughness
No. of passes	Surface hardness
Speed	

Table 3.3: I/O Parameters

3.4 Factor with level Value

Factors	Level 1	Level 2	Level 3
No. of ball dia	6 mm	8 mm	10 mm
Speed	1400	1800	2200
No. of passes	3	4	5

Table 3.4: Factor with level value

Hear fix as feed-1mm/rev and depth of cut is taking as 1mm. So total numbers of trial runs required for each material are:

$N = (\text{No. of Levels})^{(\text{No. of Factors})}$

Where,

N = Total number of trials,

F = Number of factors and

L = Number of levels.

So it will be $N = 3^3 = 27$

3.5 Design Of Experiment

The technique of defining and investigating all possible conditions in an experiment involving multiple factors is known as the design of experiments. Design of experiments refers to the process of planning, designing and analysing the experiment so that valid and objective conclusions can be drawn effectively and efficiently. In order to draw statistically sound conclusions from the experiment, it is necessary to integrate simple and powerful statistical methods into the experimental design methodology.

In the context of DOE in manufacturing, one may come across two types of process variables or factors: qualitative and quantitative factors. A factor may take different levels, depending on the nature of the factor- quantitative or qualitative. A qualitative factor generally requires more levels when compared to a quantitative factor we are taking full factorial method.

IV. Result And Analysis

4.1 Output

Run order	no of dia	no of pass	RPM	surface roughness	surface hardness
1	10	4	1800	0.45	115
2	10	4	2200	1.52	111
3	10	5	1800	0.367	111
4	8	4	1800	0.94	120
5	8	3	1800	0.909	121
6	10	5	1400	0.468	113
7	10	3	1800	1.284	113
8	8	3	1400	0.722	120
9	12	5	1400	2.875	116
10	10	4	1400	0.397	115
11	8	5	2200	0.96	117
12	8	5	1400	0.714	118
13	12	5	2200	1.445	115
14	12	4	1800	1.648	114
15	12	3	1800	2.955	114
16	12	4	2200	2.016	115
17	10	5	2200	0.496	113
18	8	4	2200	1.017	117
19	8	5	1800	0.785	118
20	12	4	1400	2.405	114
21	10	3	1400	1.452	111
22	12	5	1800	2.774	113
23	8	3	2200	1.257	119
24	10	3	2200	1.198	114
25	12	3	2200	2.098	113
26	8	4	1400	1.213	118
27	12	3	1400	2.557	115
			Initial value	2.318	81

Table 4.1: Output

4.2 ANOVA Table for Surface Roughness

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	23	10.99	0.48	16.57	<0.0001
A-no of dia	2	11.9881	5.99405	46.36	<0.0001
C-no of pass	2	0.7813	0.39066	3.02	0.105
B-RPM	2	0.0416	0.02078	0.16	0.854
A*C	4	0.8592	0.21481	1.66	0.251
A*B	4	1.2361	0.30901	2.39	0.137
B*C	4	0.6810	0.17025	1.32	0.342
Total	26	16.6215			

Table 4.2: Analysis of Variance

The Model F-value of 16.57 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise. Values of "Prob> F" less than 0.0500 indicate model terms are significant. In this case A, B, C, AC are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

4.3 Final Equation in terms of codded factor

Surface roughness=
+2.11-0.52*A[1]-0.34*A[2]=0.081*A[3]-0.16*B[1] +0.044*B[2]+0.098*C[1]+0.049* C[2] -0.088* A[1]B[1]+0.060* A[2]B[1]+0.035* A[3]B[1]+0.054* A[1]B[2]-0.023* A[2]B[2] -0.090* A[3]B[2]+0.14* A[1]C[1]+0.13* A[2]C[1]-0.066* A[3]C[1] -4.583E-003* A[1]C[2]+0.034* A[2]C[2]+0.051* A[3]C[2]+0.075* B[1]C[1]+0.023* B[2]C[1]-1.778E-003*B[1]C[2]+0.043* B[2]C[2]

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.
The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the center of the design space.

4.4 Surface Roughness Graph

Hear as on graph when we increase tool diameter surface roughness value is also increase
On based on second graph speed increase surface roughness increase
On based on third graph no of passes increase surface roughness value decrease.

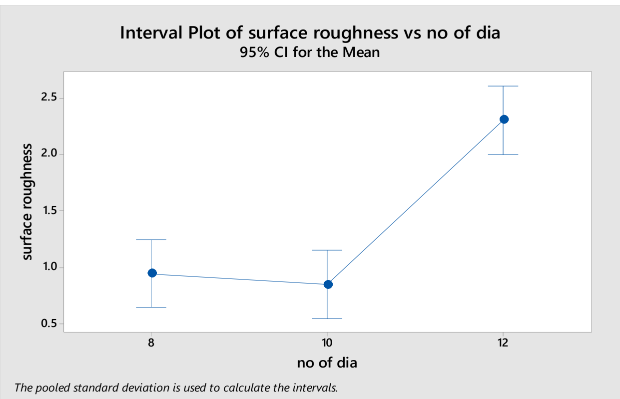

Fig 3(a)

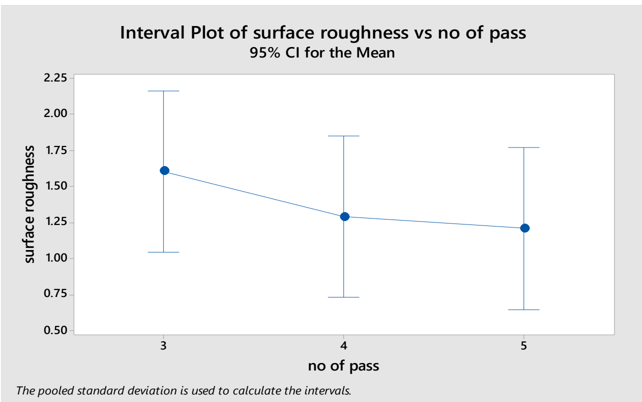

Fig 3(b)

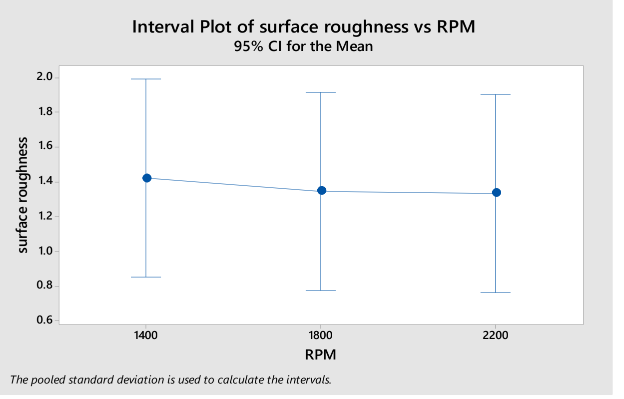

Fig 3(c): One Factor graph for Surface

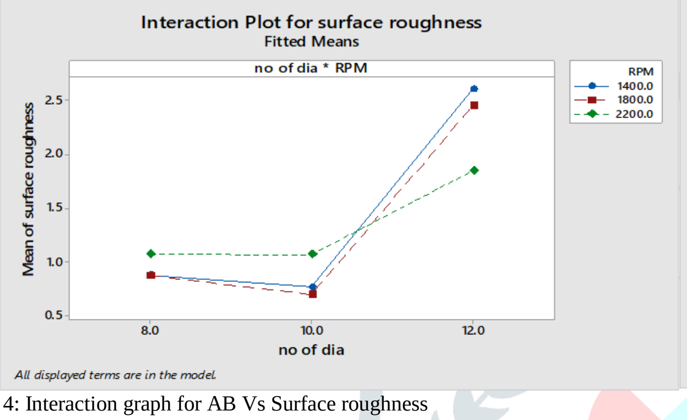

Fig 4: Interaction graph for AB Vs Surface roughness

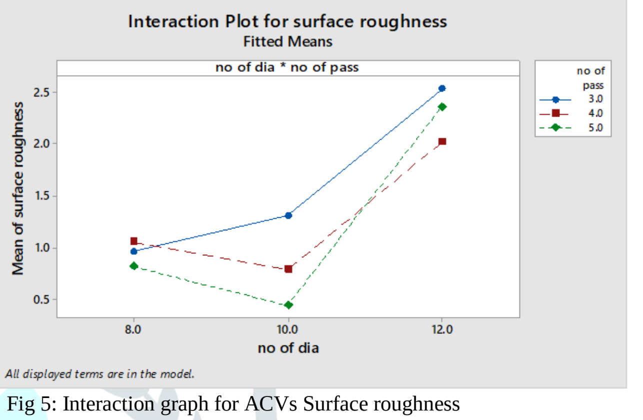

Fig 5: Interaction graph for ACVs Surface roughness

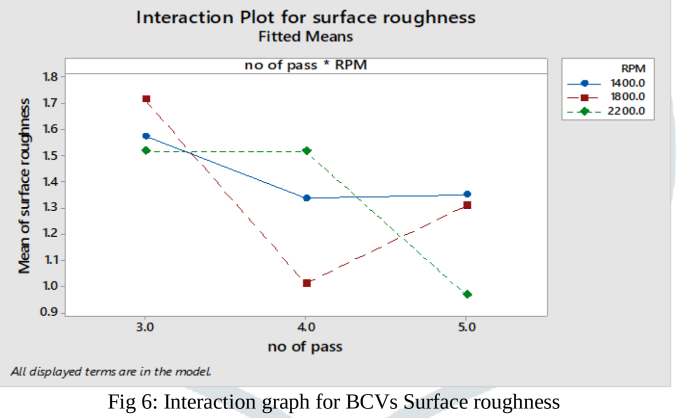

Fig 6: Interaction graph for BCVs Surface roughness

According to fig 4, Hear for minimum no of dia using good surface roughness and when increase ball diameter surface roughness value is increase as usual seed is minimum surface roughness value is minimum but when speed increase surface roughness value increase for 1400RPM and 6 no of dia surface roughness value is minimum and for 2200 RPM surface roughness maximum.

According to fig 5, Hear minimum dia getting good surface roughness mean surface roughness value is decrease as diameter decrease as usual no of passes increase surface roughness value is also decrease for no of passes not much affected mean at some amount of no of dia surface roughness values increase but minimum no of dia 6 mm and 5 no of passes getting good surface roughness and for 6 mm dia and 5 no of passes maximum surface roughness

According to fig 6, Hear for minimum speed applied getting good surface roughness and when increase no of passes surface roughness value is decrease as usual seed is minimum surface roughness value is minimum but when speed increase surface roughness value increase for 1400RPM and 5 no of passes surface roughness value is minimum and for 2200 RPM and 5 no of passes surface roughness maximum

4.5ANOVA Table for Surface Hardness

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	23	250.69	10.9	6.52	0.0008
A- no of dia	2	138.0	692.5	31.71	<0.0001
C- no of pass	2	33.5	16.75	10.85	0.461
B- RPM	2	6.00	3.00	1.85	0.461
A*C	4	37.61	6.27	3.98	0.469
A*B	4	18.44	3.00	0.94	0.489
B*C	4	3.50	0.87	0.98	0.470
Total	26	296.5			

Table 4.5: Analysis of Variance

The Model F-value of 6.52 implies the model is significant. There is only a 0.08% chance that an F-value this large could occur due to noise. Values of "Prob> F" less than 0.0500 indicate model terms are significant. In this case A, C, AC are significant model terms. Values greater than 0.1000 indicate the model terms are not

4.6 Final Equation in terms of coded factor

Surface hardness=
+115.75+0.92* A[1]+2.81* A[2]-2.64* A[3]+0.50* B[1]+0.000* B[2]+0.92*C[1]+0.42* C[2]+0.50* A[1]B[1]+0.94* A[2]B[1]-0.28* A[3]B[1]+0.000* A[1]B[2]-0.22* A[2]B[2]+0.56* A[3]B[2] +1.75* A[1]C[1]-0.81* A[2]C[1]-0.36* A[3]C[1]+0.58* A[1]C[2]+0.36* A[2]C[2]-0.53* A[3]C[2]+0.083* B[1]C[1]+0.083* B[2]C[1]+0.083* B[1]C[2]+0.33* B[2]C[2]

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels of the factors are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

The equation in terms of actual factors can be used to make predictions about the response for given levels of each factor. Here, the levels should be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the centre of the design space

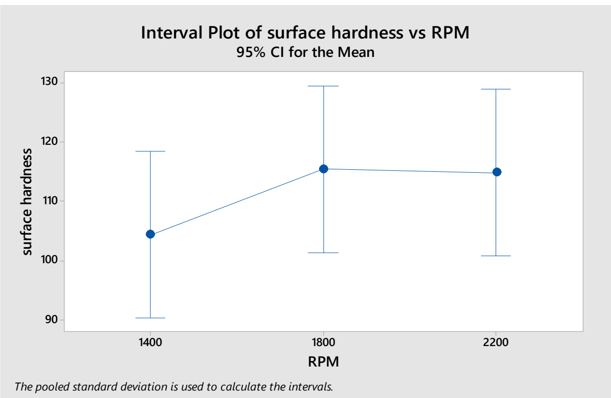

Fig 7(a)

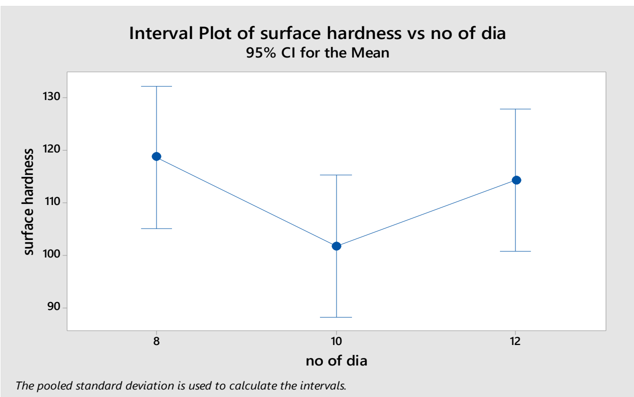

Fig 7(b)

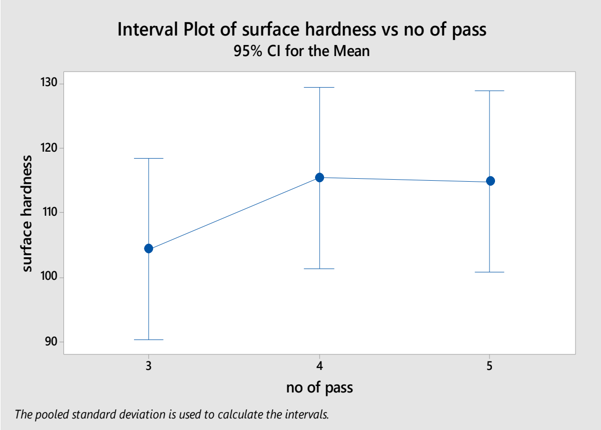

Fig 7(c): One factor for Surface Hardness

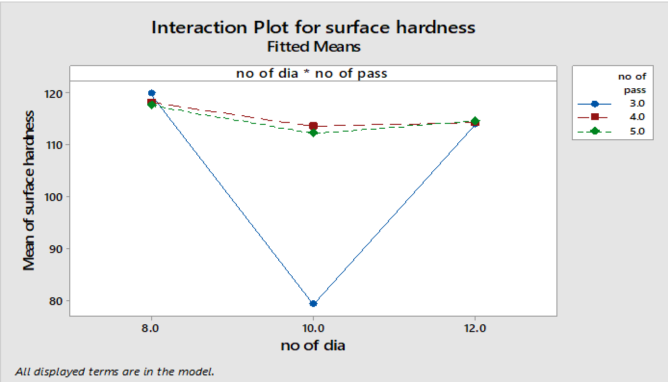

Fig 8: Interaction graph on AC Vs Surface Hardness

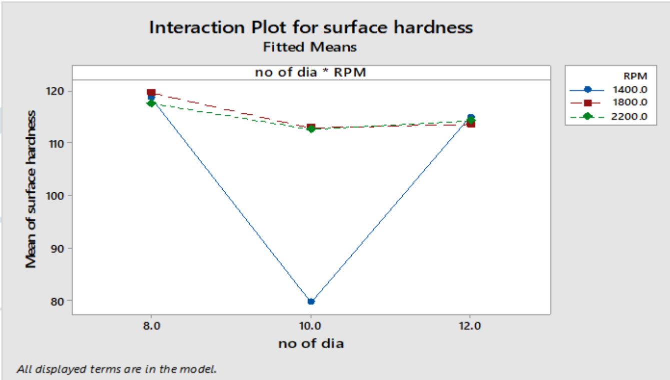

Fig 9: Interaction graph on ABVs Surface Hardness

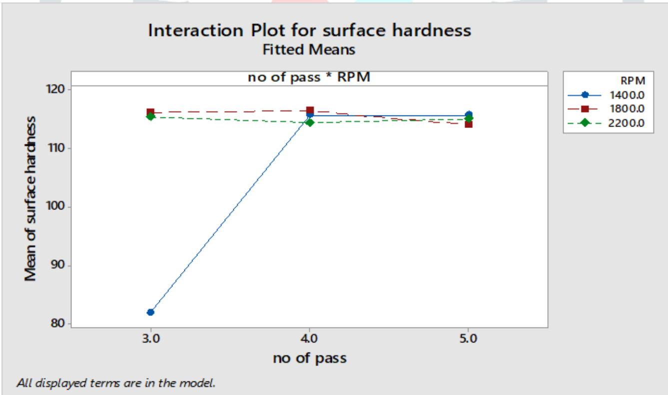

Fig 10: Interaction graph on BC Vs Surface Hardness

According to fig 7, Hear as on graph when we increase tool diameter surface hardness value is also decreaseon based on second graph speed increase surface hardness decrease on based on third graph no of passes increase surface hardness value decrease. In first graph tool diameter 10mm at that diameter surface hardness value is minimum.

According to fig 8, as per result for 8mm diameter and 4 no of passes hardness value is maximum for 5 no of passes and 10 mm diameter surface roughness value is minimum find

According to fig 9,hear for minimum no of dia using good surface hardness and when increase ball diameter surface roughness value is decrease as usual seed is minimum surface hardness value is maximum but when speed increase surface hardness value decrease for 1400RPM and 6 no of dia surface hardness value is maximum and for 2200 RPM and 10 mm of dia surface hardness minimum.

According to fig 10, hear for minimum speed applied getting good surface hardness and when increase no of passes surface hardness value is decrease as usual seed is minimum surface hardness value is maximum but when speed increase surface hardness value decrease. For 1400RPM and 3 no of passes surface hardness value is maximum and for 2200 RPM and 5 no of passes surface roughness minimum.

V. CONCLUSION

For Surface Roughness, Increase tool diameter surface roughness value is also increase. Speed increase surface roughness increase. No of passes increase surface roughness value decrease. For minimum no of diameter using good surface roughness and when increase ball diameter surface roughness value is increase Speed is minimum surface roughness value is minimum but when speed increase surface roughness value increase for 1400RPM and 6 no of diameter surface roughness value is minimum. Minimum diameter getting good surface roughness mean surface roughness value is decrease as diameter decrease.
No of passes increase surface roughness value is also decrease. Mean at some amount of no of diameter surface roughness values increase but minimum no of dia 6 mm and 5 no of passes getting good surface roughness and for 6 mm dia and 5 no of passes Hear speed and no of passes interaction with surface roughness graph is generated. Hear for minimum speed applied getting good surface roughness and when increase no of passes surface roughness value is decrease As usual seed is minimum surface roughness value is minimum but when speed increase surface roughness value increase For 1400RPM and 5 no of passes surface roughness value is minimum and for 2200 RPM and 5 no of passes surface roughness maximum

For Surface Hardness, Increase tool diameter surface hardness value is also decrease. Speed increase surface hardness decrease No of passes increase surface hardness value decrease. Hear tool diameter and speed interaction vs surface hardness graph is generated. Minimum no of diameter using good surface hardness and when increase ball diameter surface roughness value is decrease Minimum surface hardness value is maximum but when speed increase surface hardness value decrease. For 1400RPM and 6 no of diameter surface hardness value is maximum and for 2200 rpm and 10 mm of diameter surface hardness minimum. No of passes increase but hardness value is decrease. For 8mm diameter and 4 no of passes hardness value is maximum. For 5 no of passes and 10 mm diameter surface roughness value is minimum find. For minimum speed applied getting good surface hardness and when increase no of passes surface hardness value is decrease. Speed is minimum surface hardness value is maximum but when speed increase surface hardness value decrease.For 1400 rpm and 3 no of passes surface hardness value is maximum and for 2200 rpm and 5 no of passes surface roughness minimum.

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