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Magnetic Abrasive Finishing of AISI52100

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Abstract- Quality of surface is an important factor to decide the performance of manufacture product. Magnetic abrasive finishing is a procedure in which work piece surface is smoothened by removing the material as micro-chips by abrasive particles in the presence of magnetic field in the finishing zone. To improve grinding efficiency of the magnetic abrasive finishing (MAF) technique. A test study is done to enhance the surface roughness nature of the AISI 52100 steel utilizing magnetic abrasive finishing system. In this project four pole electromagnet used. An electromagnet can produce magnetic flux density 0-0.2T at 0-100V DC power source. Taguchi Design of Experiments is connected to discover important parameters affecting the surface quality created. Important parameters affect on surface roughness have been examined. Mixture of iron particles (Fe particles of mesh no. 300, 320) and abrasive particles (SiC, Al_2O_3) having different mesh size. It has been observed that the increase in rotational speed, weight of abrasive in mixture and mesh number (iron particles and abrasive particles) improve the surface finish. The experimental result showed that the MAF process using silicon carbide (abrasive material) has better finishing potential as compare to alumina (abrasive material).

Index terms- **- Magnetic Abrasive Finishing of AISI 52100**

I. INTRODUCTION

A Magnetic abrasive finishing (MAF) process was first mentioned and patent by Harry P. Coats in 1938 Japanese did fundamental research related to external finishing and internal finishing of tubes during 1980's, other section. Magnetic abrasive finishing (MAF) can be defined as a process by which surface is finish by removing the material in the form of debris particles by magnetic abrasive particles in the presence of magnetic field in the finishing zone.

Mainly Two configuration of MAF process have been used:-
a. Flat work piece
b. Cylindrical work piece

Working Principle

In MAF, the working gap between the work piece and the magnet is filled with magnetic and abrasive particles (MAPs). MAPs can be used as unbounded or bonded. Bonded MAPs are prepared by ferromagnetic particles and abrasive particles unbounded MAPs are mixture of ferromagnetic particles and abrasive particles with a small amount of lubricant.

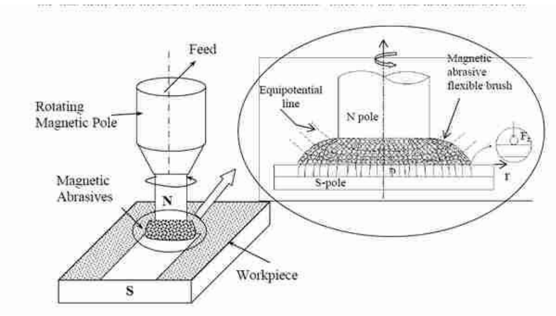


Fig 1: Working Principle [16]

The abrasives can be used such as alumina (Al_2O_3), silicon carbide (SiC), diamond and boron nitride. After the application of magnetic field, the magnetic and abrasive particles join each other along the lines of magnetic force and form a flexible magnetic abrasive brush (FMAB) between the work piece and the magnetic pole. This brush carries on like a multi-point cutting apparatus for finishing operation. At the point when the magnet turns, likewise grinding wheel like an adaptable crushing wheel and completing is carried out as per the powers following up on the abrasive particles.

Mechanism of MAF

The adaptable magnetic abrasive brush has different arbitrary bleeding edges and it acts like a multi-point cutting device. The thickness and quality of the brush might be actuated by changing the extent of the attractive field in the working zone. The rough particles trapped between the ferromagnetic particles and the work piece surface

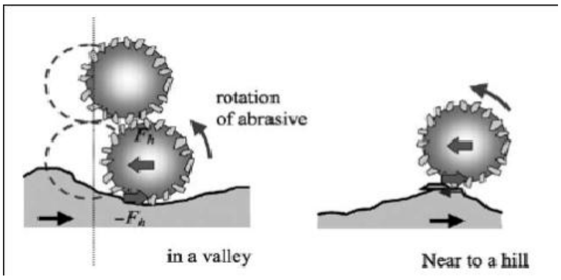


Fig.2. Mechanism of MAF

start micro spaces into the work piece surface. This results in the evacuation of material throughout the turn of the brush, and smoothening of micro-unevenness.

In MAF, normal force (Fn or Fy) is responsible for packing the ferromagnetic and abrasive particles forming a flexible magnetic abrasive brush which causes micro indentations into the work piece abrasive particles are held by iron particles combine with the magnetic field line. The magnitude is co relate of the magnetic field, FMAB strength varies. The cutting force (Fc or Fx) is responsible for micro chipping. The relative movement between the FMAB and the work piece is given by turning the magnet or work piece. Thus, the abrasive particles removal the material from the work piece as microchips bringing about the completed surface.

Advantages

1. Minimizes the micro-cracks and surface damage of work piece.
2. MAF is able to produce surface roughness of nanometer range with hardly any surface defects.
3. The flexible magnetic abrasive brush (tool) requires neither compensation nor dressing.

Applications

1. Non -ferromagnetic materials like stainless steel, brass and aluminum.
2. Ferromagnetic materials like steels.
3. Finishing of bearing.
4. Aerospace components.
5. Electronics components with micro meter or sub micrometer ranges.

II EXPERIMENTAL SETUP

Experimental set up consist following instruments:
1) Variac
2) Rectifier
3) Multi meter
4) Filler gauge
5) Milling machine.

As shown in Fig.3. The whole set up was mounted on a milling machine. An electromagnet tool was employed in the column of milling machine. This column can also be rotating both in clockwise and anticlockwise direction. Work piece made up of AISI 52100 was placed horizontally on machine set up.

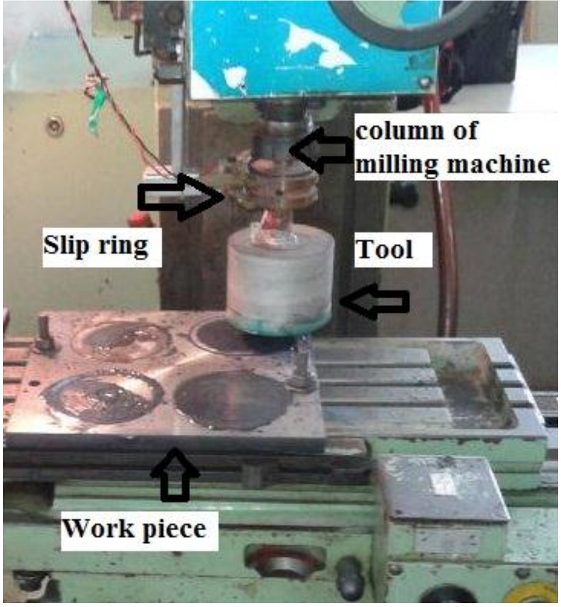


Fig.3: Experimental Setup

Details of electromagnet

- Four pole electromagnet, number of turns was 900 in each pole winding
- Maximum current rating 1.5A
- Field intensity 0.2T
- Mounted on milling machine
- Connected to DC power source (0-100V)
- Special arrangement of brass rings so that the magnetic poles received supply as they rotate four pole winding show in fig.4

Fig.4: Electromagnet winding

Table 1: Process Parameters and Levels

Sr.no	Process parameter	levels			
		1	2	3	4
1	Weight of abrasives (gm)	10	15	20	25
2	Voltage to the electromagnet (V)	25	40	55	70
3	Speed (r.p.m)	90	180	250	500
4	Mesh Number	300	320	-	-

An orthogonal array (OA) L16 for a, mixed level factor is used in the present investigation. Using mini-tab 17 software [13]

III EXPERIMENTATION

The Taguchi technique includes lessening the variety in a methodology through powerful plan of trials. The general destination of the strategy is to handle astounding item easily to the maker. The Taguchi system was produced by Dr. Genichi Taguchi of Japan who kept up that variety. Taguchi created a strategy for outlining tests to explore how distinctive parameters influence the mean and difference of a procedure execution trademark that characterizes how well the methodology is working .(Patel,2013)

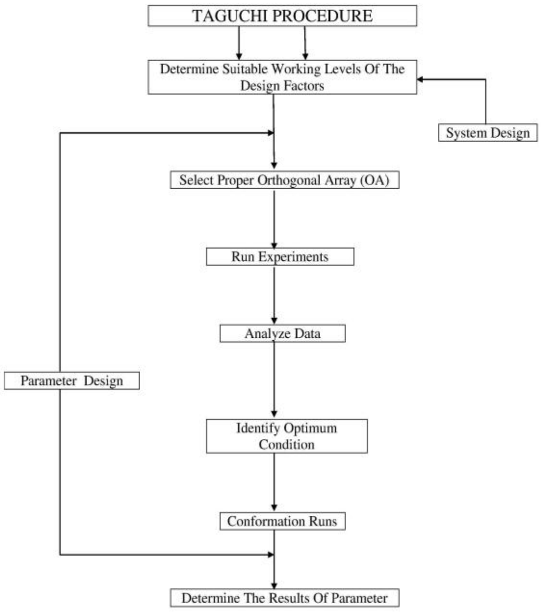


Fig 5: Flow Chart

Introduction of ANOVA (Analysis of variance)
This strategy was created by Sir Ronald fisher in the 1930s as a way to interpret the result from rural investigations. ANOVA is not a convoluted system and has a considerable measure of numerical excellence connected with it. ANOVA is a measurably based, objective choice making instrument for difference in average performance of group of items examined. The choice , instead of utilizing pure judgment, considers variety. ANOVA will be connected to experimental situations using orthogonal array set of information that has some structure. The experimental designs and subsequent analysis are intrinsically tied to one another.

Experimentation and analysis:

Materials used:
Silicon carbide (SiC) :- 300 and 320 mesh number (30%)
Aluminum Oxide (Al_2O_3):- 300 and 320 mesh number (30%)
Iron powder (Fe):- 300and 320 mesh number (70%)
Light oil (Viscosity- 25 m^2/sec)

Fixed parameters:
Abrasive mixture(i):- SiC + Fe (30% + 70%)
Abrasive Mixture (ii) :- Al_2O_3 + Fe (30% + 70%)
Working gap:- 1 mm
Process time:- 10 minute

L16 (4^3 2^1) Orthogonal array [6]

For Silicon Carbide

Table 2: Experimental Design And Result For Silicon Carbide

A	B	C	D	E	F	G	H
1	10	25	90	300	0.740	0.629	0.111
2	10	40	180	300	0.725	0.604	0.121
3	10	55	250	320	0.756	0.614	0.142
4	10	70	500	320	0.757	0.620	0.137
5	15	25	180	320	0.713	0.591	0.122
6	15	40	90	320	0.720	0.594	0.126
7	15	55	500	300	0.712	0.571	0.141
8	15	70	250	300	0.719	0.594	0.125
9	20	25	250	300	0.757	0.625	0.132
10	20	40	500	300	0.773	0.621	0.152
11	20	55	90	320	0.711	0.582	0.129
12	20	70	180	320	0.688	0.569	0.119

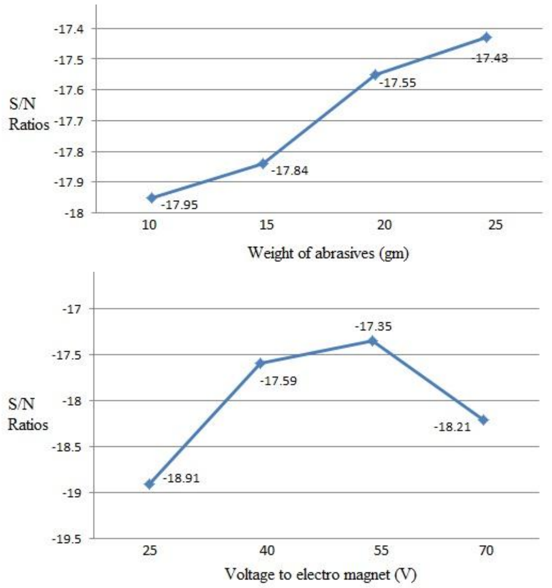
13	25	25	500	320	0.710	0.578	0.132
14	25	40	250	320	0.719	0.585	0.134
15	25	55	180	300	0.706	0.577	0.129
16	25	70	90	300	0.696	0.585	0.111

Where,
A: Sr. number
B: Weight of abrasives (gm)
C: Voltage to electromagnet (V)
D: Speed of electromagnet (r.p.m)
E: Mesh number
F: Initial Ra value (µm)
G: After MAF Ra value (µm)
H: Delta Ra value (µm)

Larger is better:
S/N= -10*log [sum (1/y2)/n]

Table 3: Response Table S/N Ratios For Silicon Carbide

Level	Wt.of abrasive (gm)	Voltage(V)	Speed(R.P.M)	Mesh No.
1	-17.95	-18.91	-18.49	-17.94
2	-17.84	-17.59	-18.21	-17.73
3	-17.55	-17.35	-17.52	-
4	-17.43	-18.21	-18.12	-
Delta	0.45	0.86	1.37	0.22
Rank	3	2	1	4



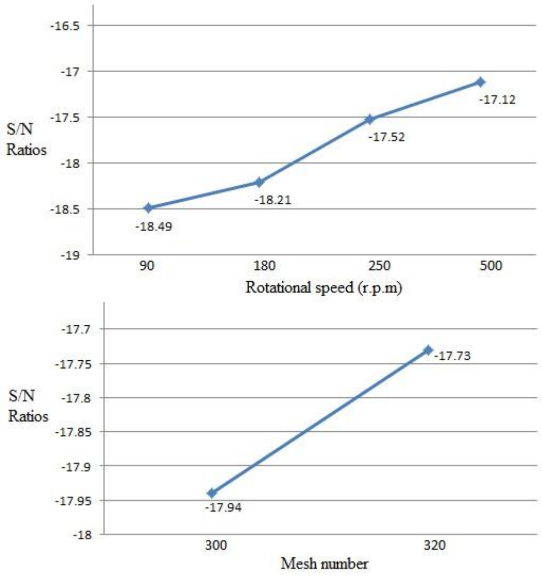


Fig 6: Main Effects Plot S/N Ratios For Silicon Carbide

Fig 6 shows that
1. Weight of abrasives: The graph shows that increase in S/N ratio by weight of abrasives from 10 to 25 gm.
2. Voltage to electromagnet: The voltage to electromagnet increase S/N ratio to a maximum of -17.35 at 55V after that then sudden decrease to -18.21 at 70V.
3. Speed: The rotational speed and S/N ratio show a comparatively uniform increase with a slit higher rate in the middle section.
4. Mesh number: Mesh number and S/N ratio directly proportional.

Table 4: Analysis of Variance For Silicon Carbide

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Wt.Of abrasive(gm)	3	0.002976	0.000992	4.75	0.063
Voltage(V)	3	0.001084	0.000361	1.73	0.276
Speed (R.P.M)	3	0.000805	0.000268	1.29	0.375
Mesh No.	1	0.000361	0.000361	1.73	0.246
Error	5	0.001044	0.000209		
Total	15	0.009270			

Table.4: shows that the weights of abrasives have most significant effect as the P-values being 0.063 and the three parameters of voltage to electromagnet, speed and mesh number have a somewhat similar significant range from 0.246 to 0.375.

Table .5: Model Summary For Silicon Carbide

S	R-seq	R-seq(adj)	R-seq(pred)
0.0144465	83.36%	50.07%	0.00%

Table.4.5: shows that the determination of coefficient (R^2) is 83.36% and adjusted R-seq is 50.07%.

Regression Equation:

Delta Ra value = 0.0722 + 0.000030A +0.000017B +0.000050C +0.000138D

Where:

A= Weight of abrasive (gm)
B=Voltage to electromagnet (V)
C=Speed (R.P.M)
D=Mesh number.

For Aluminum Oxide

Table 6: Experimental Design And Result For Silicon Carbide

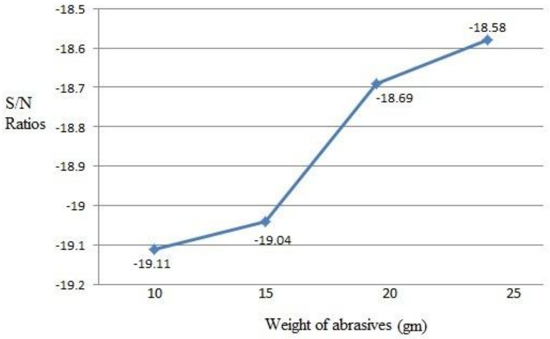
A	B	C	D	E	F	G	H
1	10	25	90	300	0.747	0.649	0.098
2	10	40	180	300	0.731	0.628	0.103
3	10	55	250	320	0.758	0.629	0.129
4	10	70	500	320	0.764	0.641	0.123
5	15	25	180	320	0.714	0.611	0.103
6	15	40	90	320	0.726	0.619	0.107
7	15	55	500	300	0.718	0.601	0.117
8	15	70	250	300	0.736	0.621	0.115
9	20	25	250	300	0.768	0.651	0.117
10	20	40	500	300	0.773	0.642	0.131
11	20	55	90	320	0.710	0.599	0.111
12	20	70	180	320	0.696	0.591	0.105
13	25	25	500	320	0.716	0.601	0.115
14	25	40	250	320	0.724	0.598	0.126
15	25	55	180	300	0.727	0.609	0.118
16	25	70	90	300	0.695	0.590	0.105

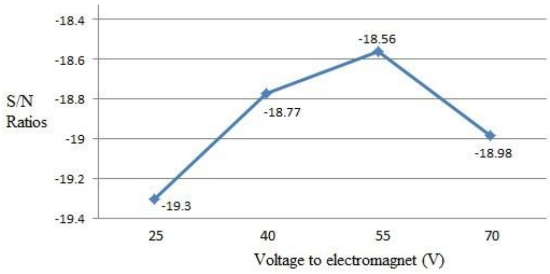
Where,
A: Sr. number
B: Weight of abrasives (gm)
C: Voltage to electromagnet (V)
D: Speed of electromagnet (r.p.m)
E: Mesh number
F: Initial Ra value (µm)
G: After MAF Ra value (µm)
H: Delta Ra value (µm)

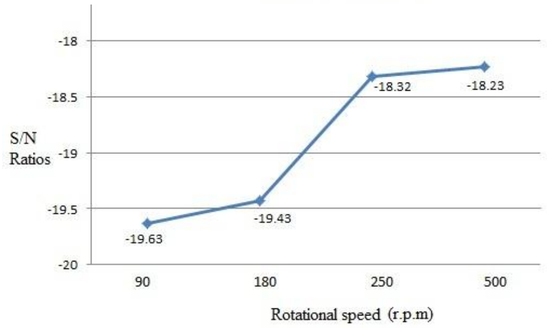
Larger is better:
S/N= -10*log [sum $(1/y^2)$/n]

Table.7: Response Table S/N Ratios For Alumina

Level	Weight of abrasive(gm)	Voltage(V)	Speed(R.P.M)	Mesh number
1	-19.11	-19.30	-19.63	-18.97
2	-19.04	-18.77	-19.43	-18.83
3	-18.69	-18.56	-18.32	
4	-18.58	-18.98	-18.23	
Delta	0.42	0.74	1.39	0.14
Rank	3	2	1	4







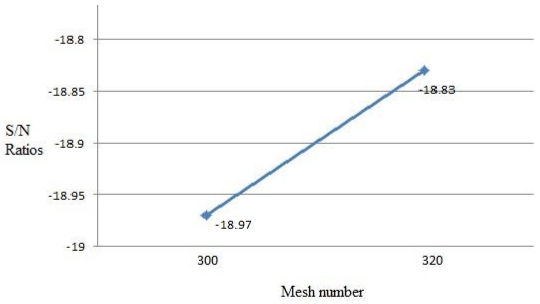


Figure 7: Main Effects Plot S/N Ratios For Alumina

Fig.4.7 gives comparative study of four variable parameters that are (1)weight of abrasives(gm) (2)voltage to electromagnet(V) (3) speed (r.p.m) (4) mesh number with respect to signal to noise ratio(S/N).

1. Weight of abrasives: The graph shows that increase in S/N ratio by weight of abrasives from 10 to 25 gm

2. Voltage to electromagnet: The voltage to electromagnet increase S/N ratio to a maximum of -18.56 at 55V after that then sudden decrease to -18.98 at 70V.

3. Speed: The rotational speed and S/N ratio show a comparatively uniform increase with a slit higher rate in the middle section.

4. Mesh number: Mesh number and S/N ratio directly proportional.

Table.8: Analysis of Variance for alumina

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Weight of abrasive(gm)	3	0.002950	0.000983	3.86	0.070
Voltage(V)	3	0.000950	0.000317	1.24	0.387
Speed(R.P.M)	3	0.000500	0.000167	0.65	0.614
Mesh number	1	0.000625	0.000625	2.45	0.178
Error	5	0.001275	0.000255		
Total	15	0.006300			

Table.8: shows that the weights of abrasives have most significant effect as the P-values being 0.070 and the three parameters of voltage to electromagnet, speed and mesh number have a somewhat similar significant range from 0.178 to 0.614.

Table.9: Model Summary for alumina

S	R-sq	R-sq (adi)	R-sq(pred)
0.0159687	79.76 %	39.29 %	0.00 %

Table.9: shows that the determinations of coefficient (R^2) are 79.76% and adjusted R-seq is 39.29%.

Regression Equation

Delta Ra value = 0.09000 + 0.00200A + 0.00200B + 0.00600C + 0.000001D

Where,
A= Weight of abrasive (gm)
B=Voltage to electromagnet (V)
C=Speed (R.P.M)
D=Mesh number

Impact of Process Parameters On Surface Finishing

- In light of the above results, rotational speed and weight of abrasives are discovered to be the hugest parameter emulated by working voltage. Nonetheless, the impacts of grain mesh number and rotational speed in surface finish increment with expansion in mesh number of abrasives.
- It might be closed from the results and examination that abrasive weight and rotational speed of electromagnet are the parameters which altogether impact the material removal, change in surface roughness quality, and percent change in surface finish.
- Delta Ra is more for higher rotational speed (r.p.m), With increment in rate weight of abrasives the normal power for every unit volume of Maps reduces as the rate of ferromagnetic particles decreases, However in the meantime number of cutting edges expands because of expansion in rate weight of abrasives for a given mesh number.

IV CONCLUSIONS AND FUTURE SCOPE

Conclusions

1. The insertion of a magnetic tool with magnetic abrasive finishing the removal of material from the peaks of the surface asperities by the magnetic abrasive intermediate between the tool and target surface. This accomplishes an easily completed surface with less material removal than the utilization of magnetic abrasive only.
2. It can be concluded from the results and discussion that abrasive weight and rotational speed of electromagnet are the parameters which significantly influence the material removal, change in surface

roughness value, and percent improvement in surface finish.

3. There were two abrasive materials (Silicon carbide and Alumina) used in this project. Comparing both abrasive materials with respect to surface finish achieved, silicon carbide has batter characteristic than alumina.
4. It has been observed that the increase in rotational speed, weight of abrasive in mixture and mesh number (iron particles and abrasive particles) improve the surface finish.

Future Scope

- In the present work, plane work pieces were considered for study. The work can be extended to cylindrical and work piece of contoured shapes.
- The effect of feed rate on surface roughness improvement can be studied.
- Using abrasive gel with iron particles mixture.
- In the present work, minimum rotational speeds were considered for study. The extended to maximum rotational speed.

V REFERENCES

[1] Junmo Kanga, Andrew Georgea, Hitomi Yamaguchia, “High-Speed Internal Finishing Of Capillary Tubes By Magnetic Abrasive Finishing’’ Procedia CIRP 1 (2012) 414 41.

[2] Biing-Hwa Yana, Geeng-Wei Changa, Tsung-Jen Chenga, Rong-Tzong Hsub, “Electrolytic Magnetic Abrasive Finishing’’ Journal of Machine Tools & Manufacture 43 (2003) 13551366.

[3] Hitomi Yamaguchia, Anil K. Srivastavab, Michael A. Tana, “Magnetic Abrasive Finishing Of Cutting Tools For Machining Of Titanium Alloys’’ Journal of Manufacturing Technology 61 (2012) 311314.

[4] Harish Kumar, Sehijpal Singh, Pardeep Kumar, “Magnetic Abrasive Finishing- A Review” Journal Of Engineering Research & Technology (IJERT)Vol. 2 Issue 3, March 2013.

[5] Girma B, Joshi SS, Raghuram MV, Balasubramaniam R (2006), “An Experimental Analysis Of Magnetic Abrasives Finishing Of Plane Surfaces” Machine Sci Technology,10 (3), 32334.

[6]Murat Sarıkaya a, Abdulkadir Güllü, “Taguchi Design And Response Surface Methodology Based Analysis Of Machining Parameters In CNC Turning Under MQL” Journal of Cleaner Production 65 (2014) 604e616.

[7] V.K. Jain, Prashant Kumar, P.K. Behera, S.C. Jayswal, “Effect Of Working Gap And Circumferential Speed On The Performance Of Magnetic Abrasive Finishing Process” Wear 250 (2001) 384–390.

[8] Dhirendra K. Singh a,1, V.K. Jain a, V. Raghurama, R. Komanduri b,2, “Analysis Of Surface Texture Generated By A Flexible Magnetic Abrasive Brush” Wear 259 (2005) 1254–1261.

[9] Rahul S. Mulik, Pulak M. Pandey, “Ultrasonic Assisted Magnetic Abrasive Finishing Of Hardened AISI 52100 Steel Using Unbonded Sic Abrasives” Int. Journal of Refractory Metals and Hard Materials 29 (2011) 68–77.

[10] Dhirendra K. Singh1, V.K. Jain, V. Raghuram, “Parametric Study Of Magnetic Abrasive Finishing Process,” Journal of Materials Processing Technology 149 (2004) 22–29.

[11] Mahdi Dargahi a,c, Hossein Kazemian b, Mohammad Soltanieh c, Morteza Hosseinpour d, Sohrab Rohani b, “High Temperature Synthesis Of Sapo-34: Applying An L9 Taguchi Orthogonal Design To Investigate The Effects Of Experimental Parameters” Powder Technology 217 (2012) 223–230.

[12] Krishankant, Jatin Taneja, Mohit Bector, Rajesh Kumar, “Application Of Taguchi Method For Optimizing Turning Process By The Effects Of Machining Parameters” International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-1, October 2012.

[13] Ridhdhish J Patel [M-Tech(CIM)], “Improvement Of Surface Roughness Using Magnetic Abrasive Finishing” Institute of technology, Nirma University, Ahmedabad(2013).

[14] http://en.wikipedia.org/wiki/Magnetic_field-assisted_finishing

[15] Girma B, Joshi SS, Raghuram MV, Balasubramaniam R (2006) An experimental analysis of magnetic abrasives finishing of plane surfaces. MachineSci Technol, 10 (3), 323340.

[16] Gorana VK, Jain VK, Lal GK (2004) Experimental Investigation into cutting forces and active grain density during

abrasive flow machining. Int J of Machine Tools and Manufacture, 44, 201211.

[17] Grover GK, Nigam SP (2001) Mechanical vibrations. Nemchand and Bros, Roorkee, India. Guo YB, Liu CR (2002) Mechanical Properties of Hardened “AISI52100 Steel in hard machining processes” J of Manufact Science Engineering(ASME), 124, 1-9.

[18] Phillip j.ross, “Taguchi Techniques for Quality Engineering” (second edition).