PARAMETRIC ANALYSIS ON MAGNETIC ABRASIVE MACHINING

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INTRODUCTION

- **HISTORY OF MAF:** Initially developed as a machining process in the US in the 1930s,with the first patent in the 1940s. University research in the Soviet Union, Bulgaria, Germany, Poland, and US began in the 1960s with practical usage appearing by the 1980s and 1990s. The growth of the semiconductor, aerospace, and optics industries have resulted in the continued development of better methods for attaining high form accuracy and surface integrity.

PROJECT BACKGROUND:

- The quality of the surface has great influence on functional properties of the major engineering parts, wear resistance, power loss due to friction, fatigue life, etc. Therefore, modern manufacturing industries demand high quality surfaces and also high efficiency of finishing process to meet present demand of the market.
- Traditional machining consists of only one process can't satisfy the current demand of high quality products with high efficiency.

- Therefore, an advanced abrasion based hybrid machining process Will be developed that constitutes advanced abrasion based machining process with non abrasive process to meet the demand of finishing industries.

OBJECTIVE:

- To achieve higher surface finish as compare to other finishing processes.
- Development of this hybrid process setup on available machine as attachment and its optimization will help in improvement of quality and reduction of cost of finishing industries. Modern grinding industries involved in high quality surface finishing will be benefited.

SCOPE OF PROJECT:

- In future our project is used for following:

1. In Technical colleges (Like Diploma, B.E, B-Tech etc.) for performing a practical for surface finishing of workpiece.
2. In Industries(small scale industries & large scale industries) for surface finishing of product.

LITERATURE REVIEW

1. K.B.Judal et al.[1]

- **Input Parameter:**

  Workpiece speed : 250-750rpm

  Working gap : 1mm

  Electrode gap: 2mm

  Frequency of vibration: 2 Hz, 4 Hz, 6 Hz

  Abrasive particle : Silicon Carbide (grit size 10 μm)

- **Material :**Stainless steel (AISI304)

- **Conclusion :**To achieve higher surface finish within short time. Increasing both the frequency of vibration and rotational speed of workpiece the material removal increases and surface roughness decreases.

2. K.B.Judal et al.[2]

- **Input parameter :**

  Ferromagnetic particles: steel grit(grit size 180µm)

  Excitation current: 0.5,1.0,1.5,2.0,2.5A

  Work piece speed: 150,250,420,710 rpm

  Working gap: 1mm

  Amplitude of vibration: 2mm

  Frequency of vibration: 2,3,4,5 Hz

- **Material :** Stainless steel-magnetic (AISI-420)
- **Abrasive :** Silicon carbide (grit size 10 µm)
- **Conclusion :**The surface roughness decreases with increase in electrolytic current. Due to higher magnetic permeability of AISI-420 stainless steel, MAM has greater contribution in total MR.

3. Jeong-Du Kim et al. [3]

- **Input Parameter:**

  Ferromagnetic particles: steel grit(grit size 180µm)

  Excitation current: 0.5,1.0,1.5,2.0A

  Magnetic flux density: 0-0.3T

  Working gap: 1mm

- **Material:** SM45C
- **Abrasive :** Silicon carbide
- **Conclusion :** For the highest finishing efficiency, an optimal magnetic flux density exists and it was 0.06 T for an electrode gap of 1 mm.

4. Ik Tae Im1 et al. [4]

- **Input Parameter:**

  Magnet: permanent magnet

  Workpiece speed: 800rpm

  Magnetic flux density: 0.52T

  Frequency of vibration: 12Hz

  Abrasive particle: mixture of Iron and Diamond

- **Material :** STS 304 stainless steel
- **Conclusion :** Surface roughness and roundness improved most when 1 ㎛ diamond abrasive particles were used, with results as good as 0.06 ㎛ and 0.12 ㎛. Improvement in surface roughness occurred when vibrational motion was induced on the workpiece.

5. Nazar kais M.naifet al. [5]

- **Input Parameter :**

  Workpiece speed : 175 - 350 - 525 rpm

  Excitation current : 1.5 - 2.5 - 3.5 A

  Working gap : 1.5 - 2.5 - 3.5 mm

- **Material :** Brass cuzn33
- **Abrasive :** AL2O3 and iron powder
- **Conclusion :** The improvement of the surface roughness from 1.046µm to 0.131µm shows the effectiveness and validity of a MAP method to refine rough surface of brass.

6. Y. Choopani et al. [6]

- **Input parameter:**

  Workpiece speed : 355rpm

  Excitation current : 1.5-2.5A

  Working gap : 2mm

  Abrasive particle: diamond

  Magnet: Permanent magnet: Ø25mm×25 mm

  Magnetic flux density: 1.4 T

- **Material:** AISI 440C stainless steel
- **Conclusion:** Decreasing the working gap, the surface roughness increases.

7. T. A. El-Taweel et al. [7]

- **Input parameter:**

  Workpiece speed : 125-750rpm

  Applied voltage : 8-24V

  Working gap : 1.5mm

  Electrode gap: 2mm

  Abrasive particle : Aluminium oxide

  Magnet: Permanent magnet: Ø40mm×40 mm

  Magnetic flux density: 0-0.24 T
- **Material:** 6061 Al/Al2O3 (10% wt)
- **Conclusion:** Increasing both the applied voltage and the tool feed rate leads to an increase of machining efficiency, and improves the surface roughness significantly.

8. Geeng-Wei Chang et al. [8]

- **Input parameter:**

  Workpiece speed : 200-800rpm

  Excitation current : 0.5-2.5A

  Working gap : 1 mm

  Electrode gap: 5, 3, or 2 mm

  Abrasive particle: Steel grit

  Magnet: Permanent magnet: 70mm×40mm×30mm

  Magnetic flux density: 0.85 T

- **Material:** SKD11
- **Conclusion:** Increasing both the electrolytic current and the rate of workpiece revolution increases finishing efficiency, and the surface roughness improves rapidly.

9. Min-seog choi et al. [9]

- **Input parameter:**

  Applied voltage : 0.5-7.5V

  Working gap : 2mm

  Electrode gap: 1-4mm

  Abrasive particle: Silicon carbide

  Magnetic flux density: 0-0.28 T

- **Material:** SM45C
- **Conclusion:** For the highest finishing efficiency, an optimal magnetic flux density exists and it was 0.06 T for an electrode gap of 1 mm.

10. Asit Shukla et al. [10]

- **Input parameter:**

  Excitation current : 0.5-1.0A

  Working gap : 1.25,2.25 mm

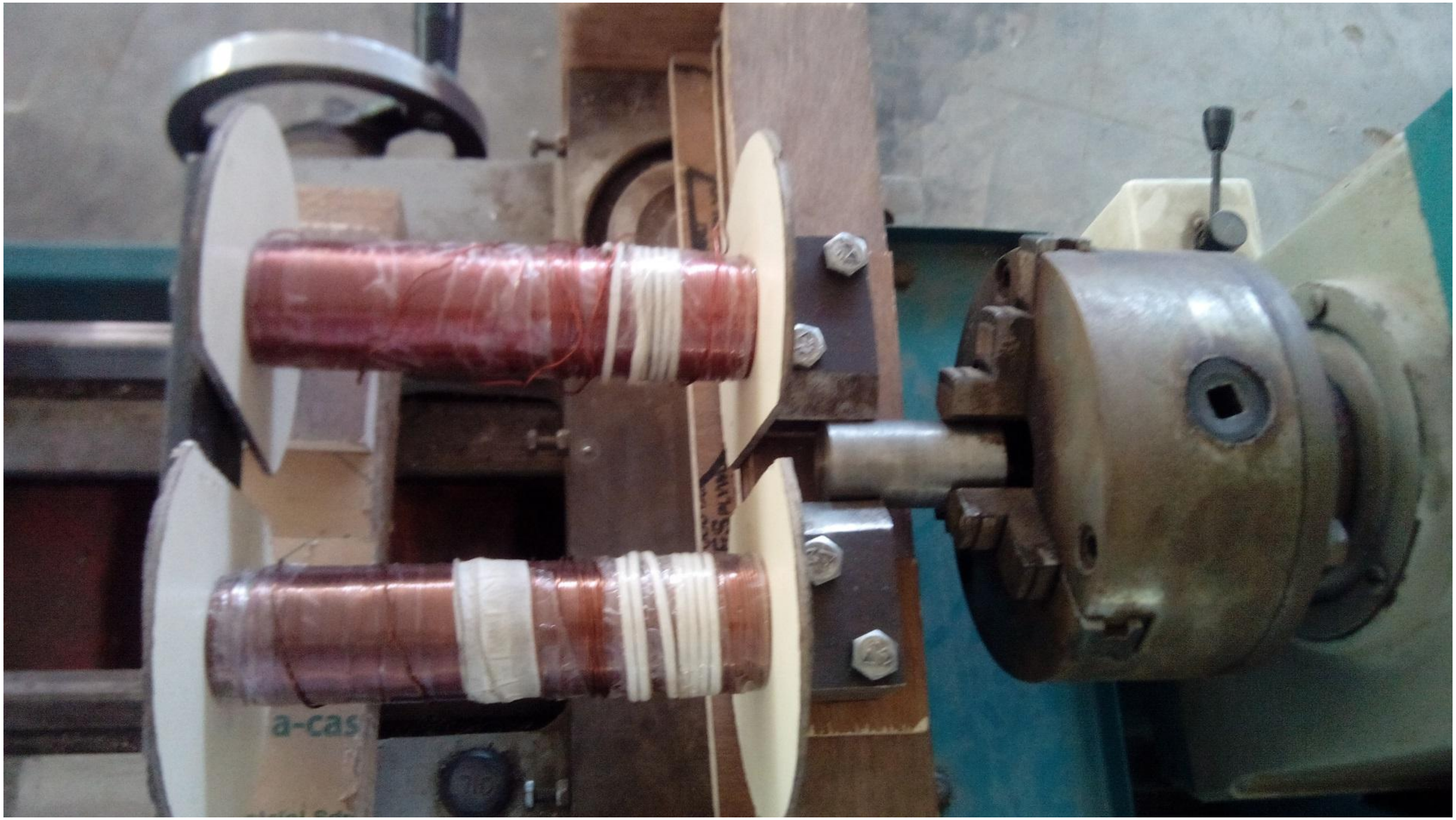
  Abrasive particle: Aluminum oxide

  Magnet: Magnetic flux density: 0-0.24T
- **Material:** Alloy steel
- **Conclusion:** It can be said that response of magnetic abrasive finishing process can be controlled by controlling process parameter variables, which are current(magnetic flux density) , machining.

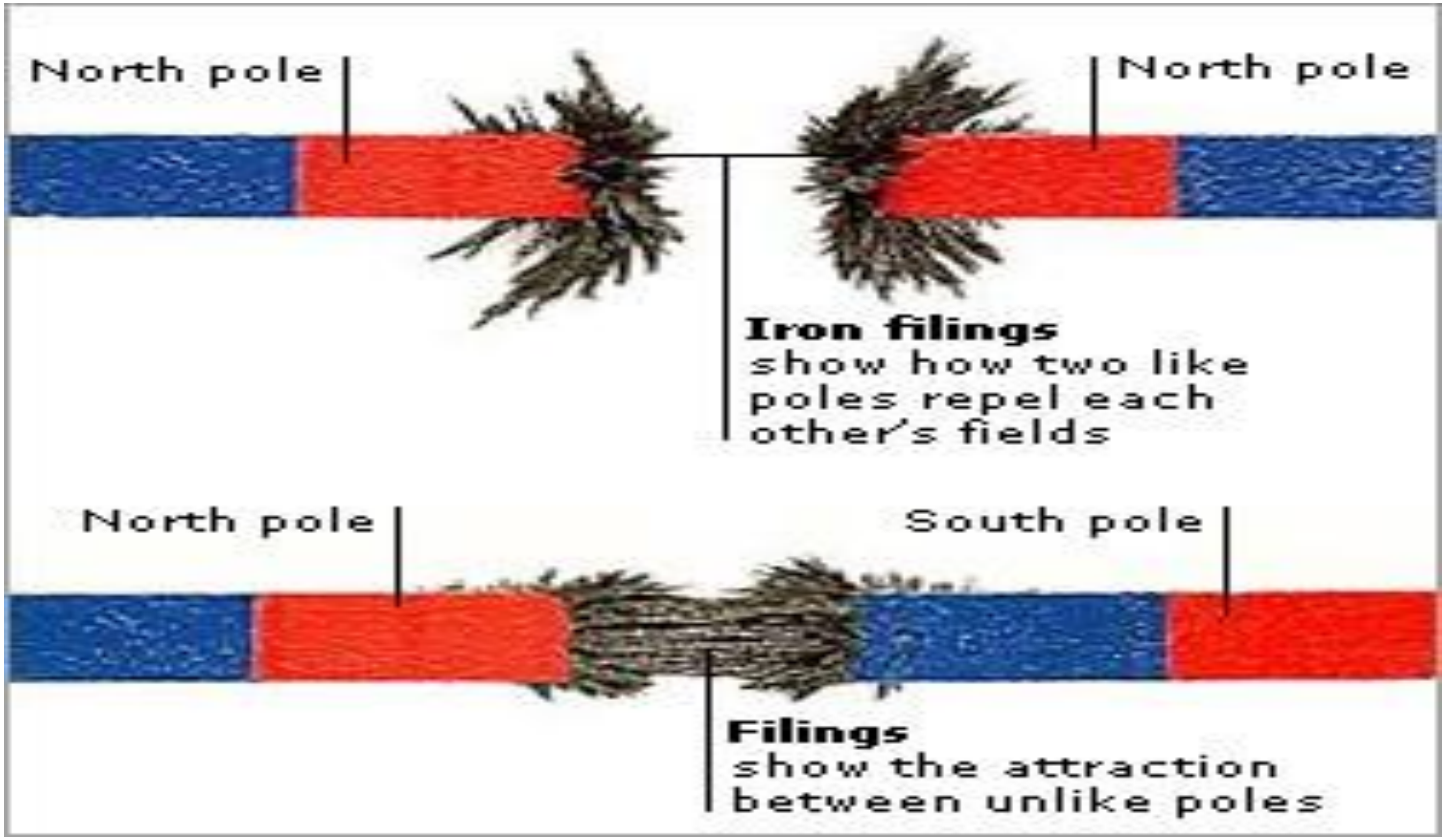
PRINCIPLE OF MAF:

- MAF is essentially the manipulation of a homogeneous mixture of magnetic particles and abrasive particles with a magnetic field to impart a machining force on a workpiece. Relative motion between the particle mixture and the workpiece surface result in material removal. Additionally careful selection of magnetic particles and abrasive particles give rise to surface texture and roughness control that was previously impossible especially for hard to access areas.

Set up



Magnetic field

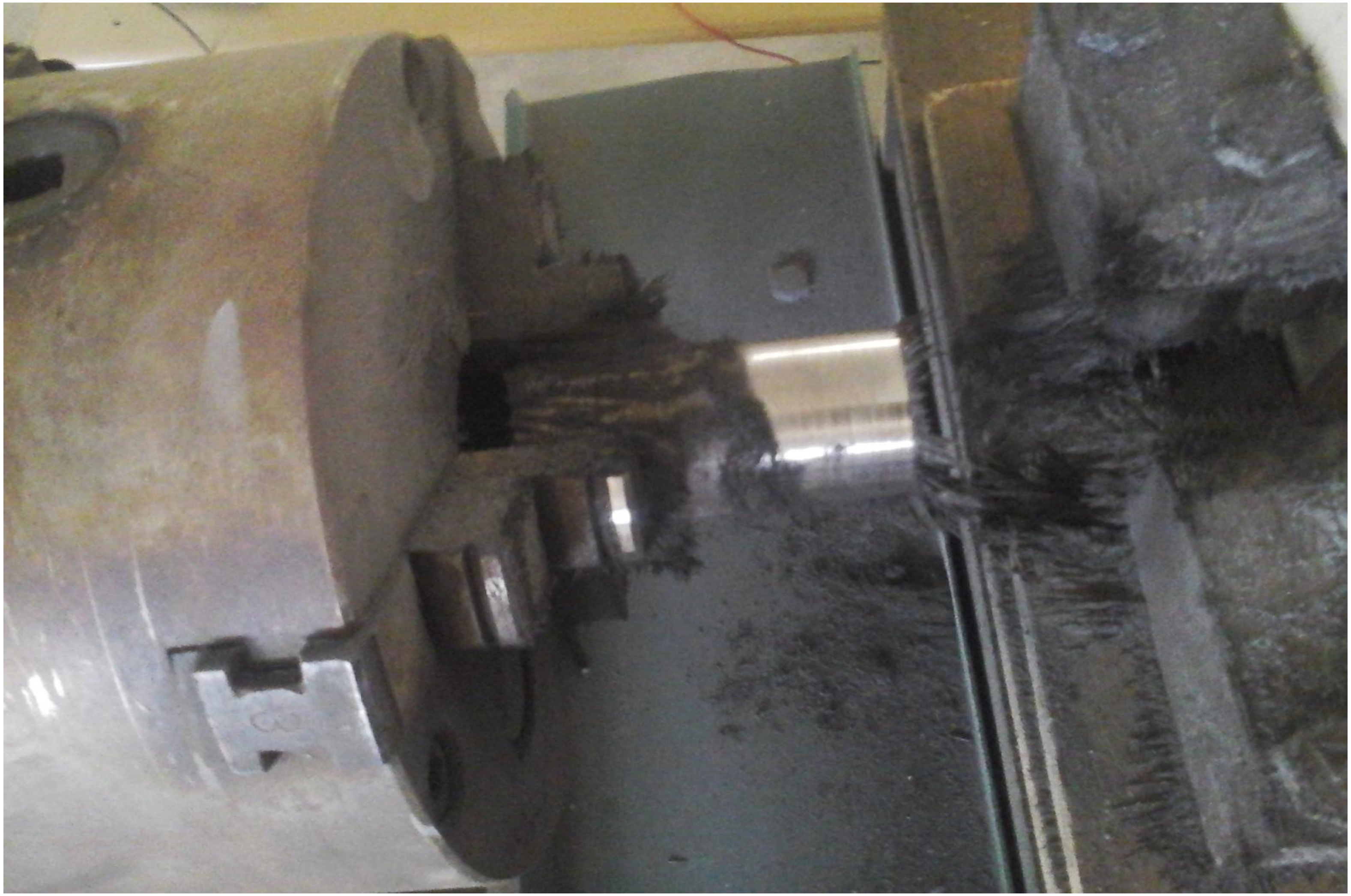


Set up component

poles

Insulation on rod

Working of MAF



Working video

Benefits of MAF Process:

- This process can be used to produce efficiently mirror like good surface quality of the order of a few nanometer on flat surfaces as well as internal and external surfaces of tube type work pieces.
- It possesses many attractive advantages such as Self adaptability and controllability. The finishing tool requires neither compensation nor dressing.
- The method can finish ferromagnetic materials but as well as non-ferromagnetic materials.

TYPES OF ABRASIVES

- **Conventional Abrasives**

  a. Aluminum oxide (Al_2O_3)

  b. Silicon carbide (SiC)

- **Super abrasives**

  c. Cubic Boron Nitride (CBN)

  d. Diamond

Ferromagnetic particles

Iron powder

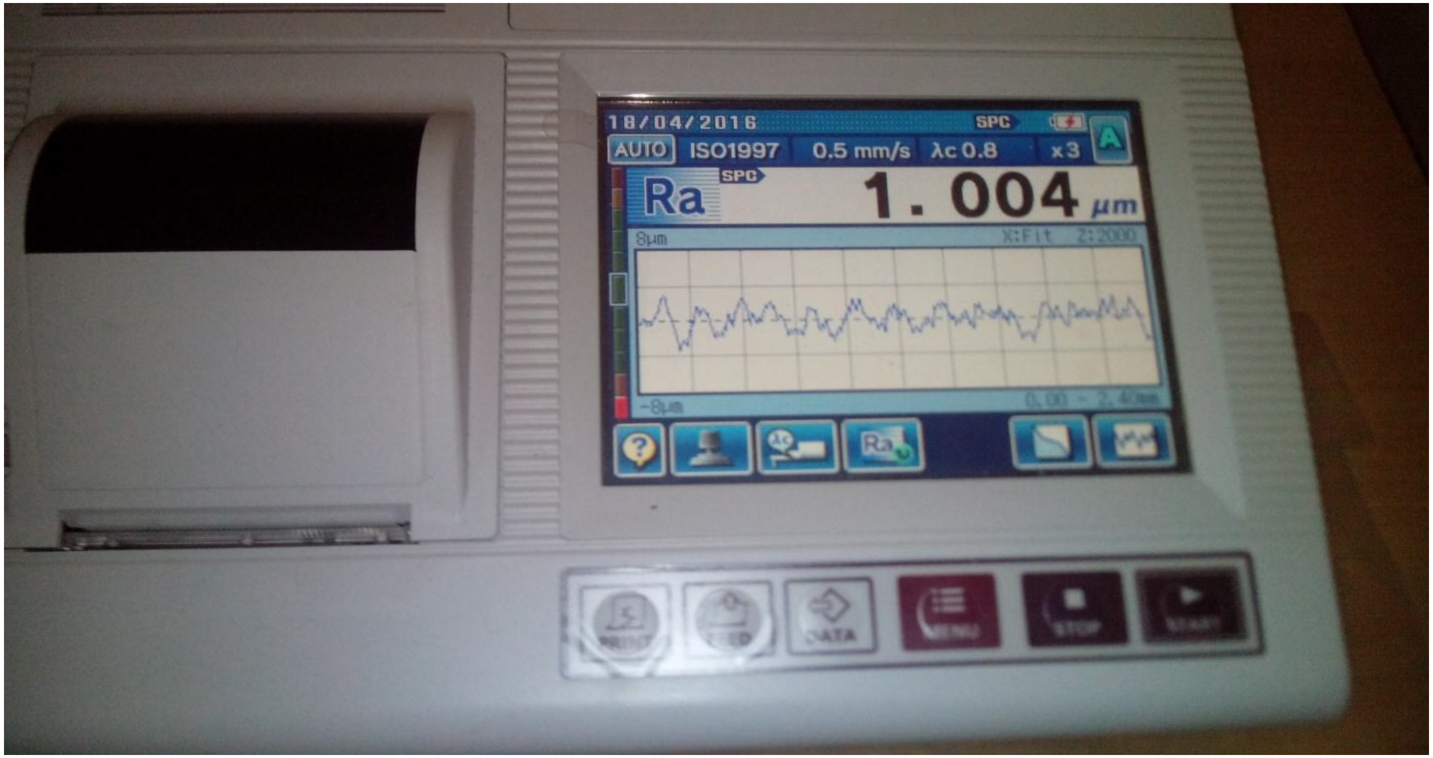
Abrasive Material

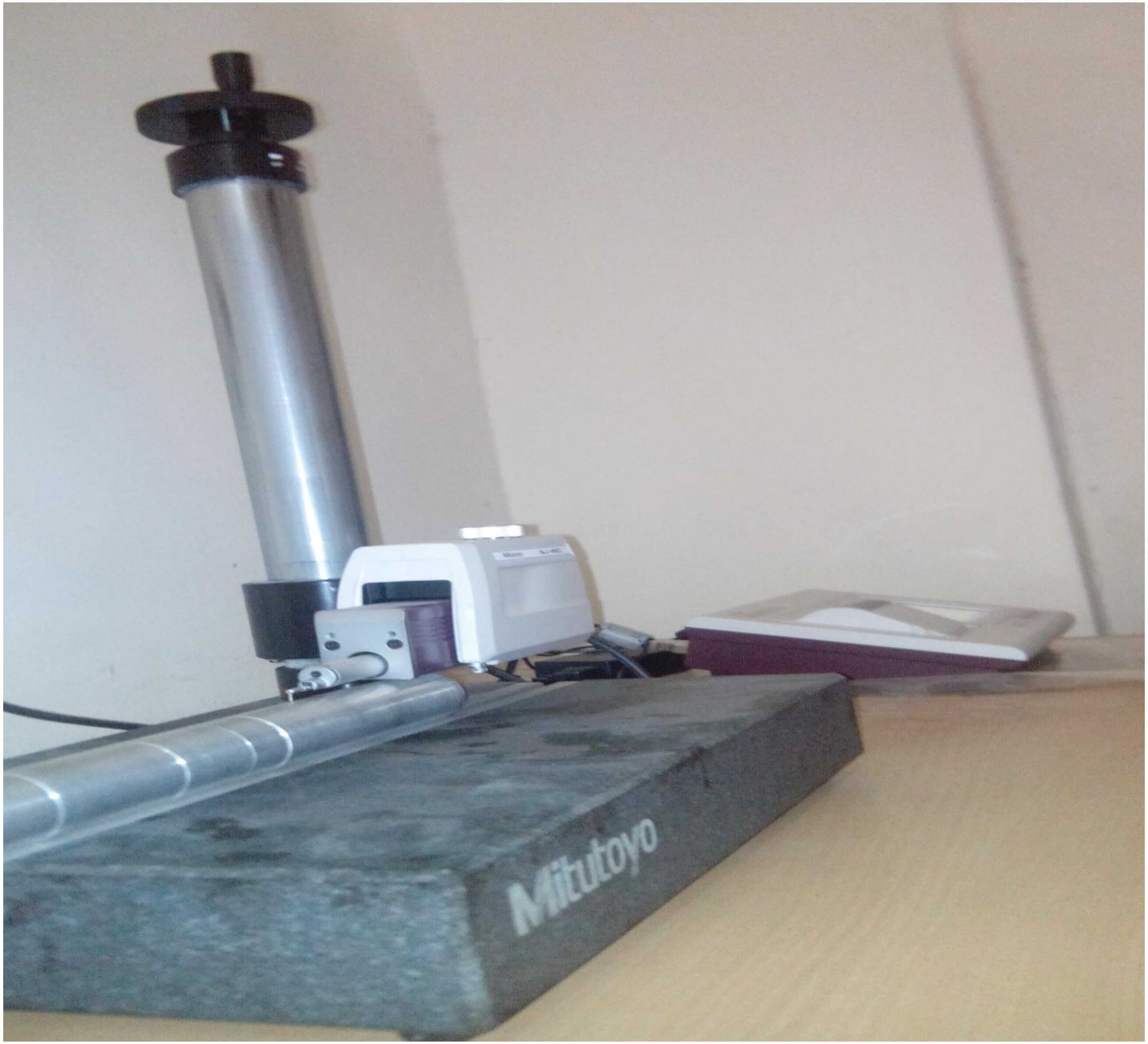
Silicon carbide

Workpiece rod

Surface roughness tester

- Measure the surface roughness in GEC Patan




Mitutoyo

Surface roughness measuring

Experimental condition

Sr no.	Input parameter	Value of the parameter
1	Workpiece material	Aluminum 6061 (non-magnetic)
2	Working gap	1.0,1.5,2.0 mm
3	Workpiece rotational speed	345,535,800 rpm
4	SiC particle size used	#400(38µm), #800(19 µm), #1200(12.67 µm)
5	Ferromagnetic particle size	#250(60 µm)
6	Voltage	16,20,24 V
7	Weight ratio(Fe:SiC)	60:40
8	Finishing time	5 min.

Experimental reading parameter

w/p rotational speed	voltage	working gap	abrasive material number	Ra
345	16	1	400	1.746
535	16	1	400	1.592
800	16	1	400	1.47
345	24	1.5	400	1.563
535	24	1.5	400	1.454
800	24	1.5	400	1.382
345	20	2	400	1.246
535	20	2	400	1.007
800	20	2	400	0.838
345	20	1	800	1.004
535	20	1	800	0.924
800	20	1	800	0.837
345	16	1.5	800	1.147
535	16	1.5	800	0.983
800	16	1.5	800	0.927

345	24	2	800	1.419
535	24	2	800	1.29
800	24	2	800	1.007
345	24	1	1200	0.849
535	24	1	1200	0.792
800	24	1	1200	0.685
345	20	1.5	1200	0.86
535	20	1.5	1200	0.819
800	20	1.5	1200	0.744
345	16	2	1200	0.926
535	16	2	1200	0.814
800	16	2	1200	0.742

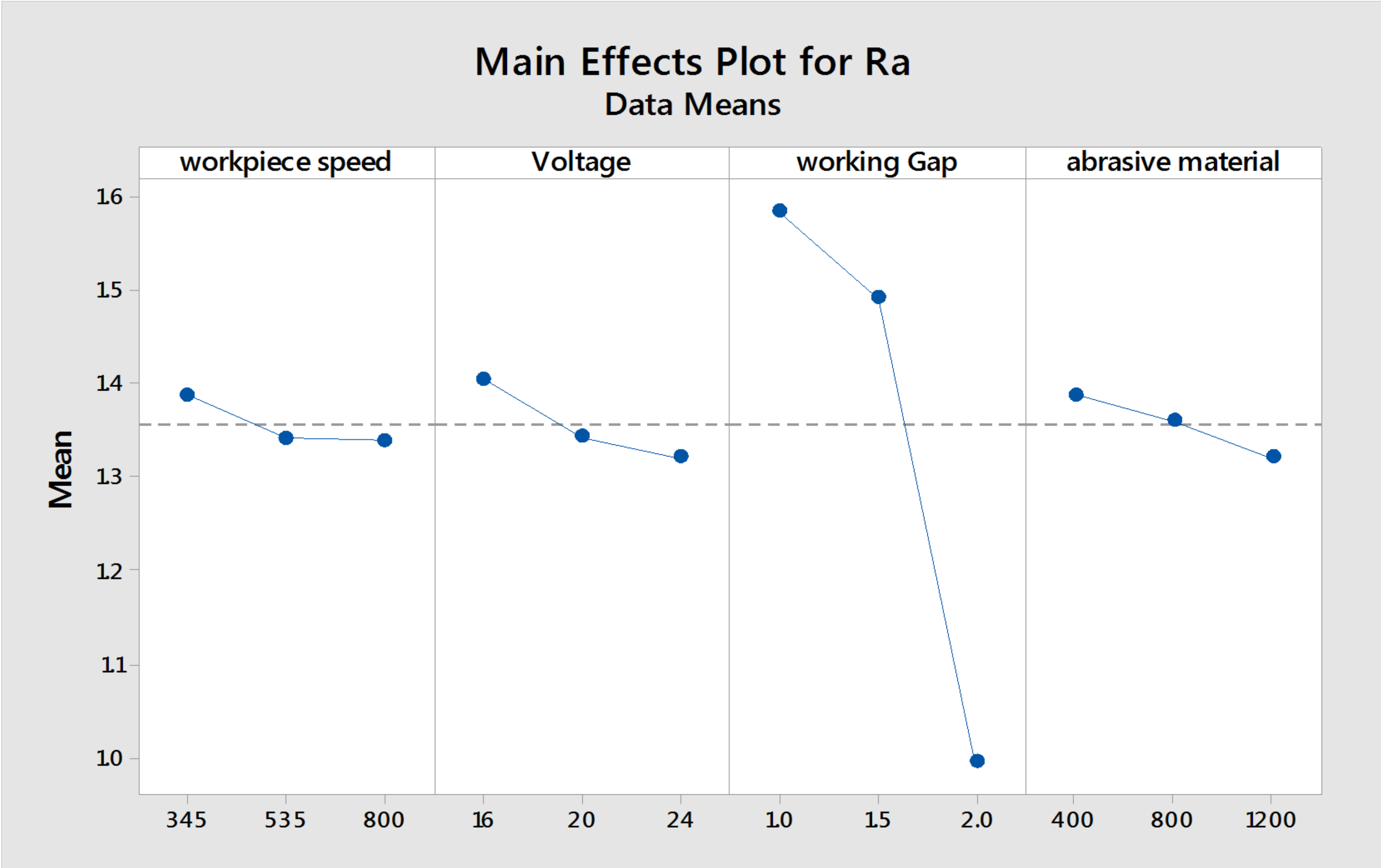
Regression Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	4	1.69630	0.42408	12.64	0.000
w/p rotational speed	1	0.24878	0.24878	7.41	0.012
voltage	1	0.00049	0.00049	0.01	0.031
working gap	1	0.02067	0.02067	0.62	0.048
abrasive material number	1	1.42636	1.42636	42.50	0.000
Error	22	0.73828	0.03356		
Total	26	2.43458			

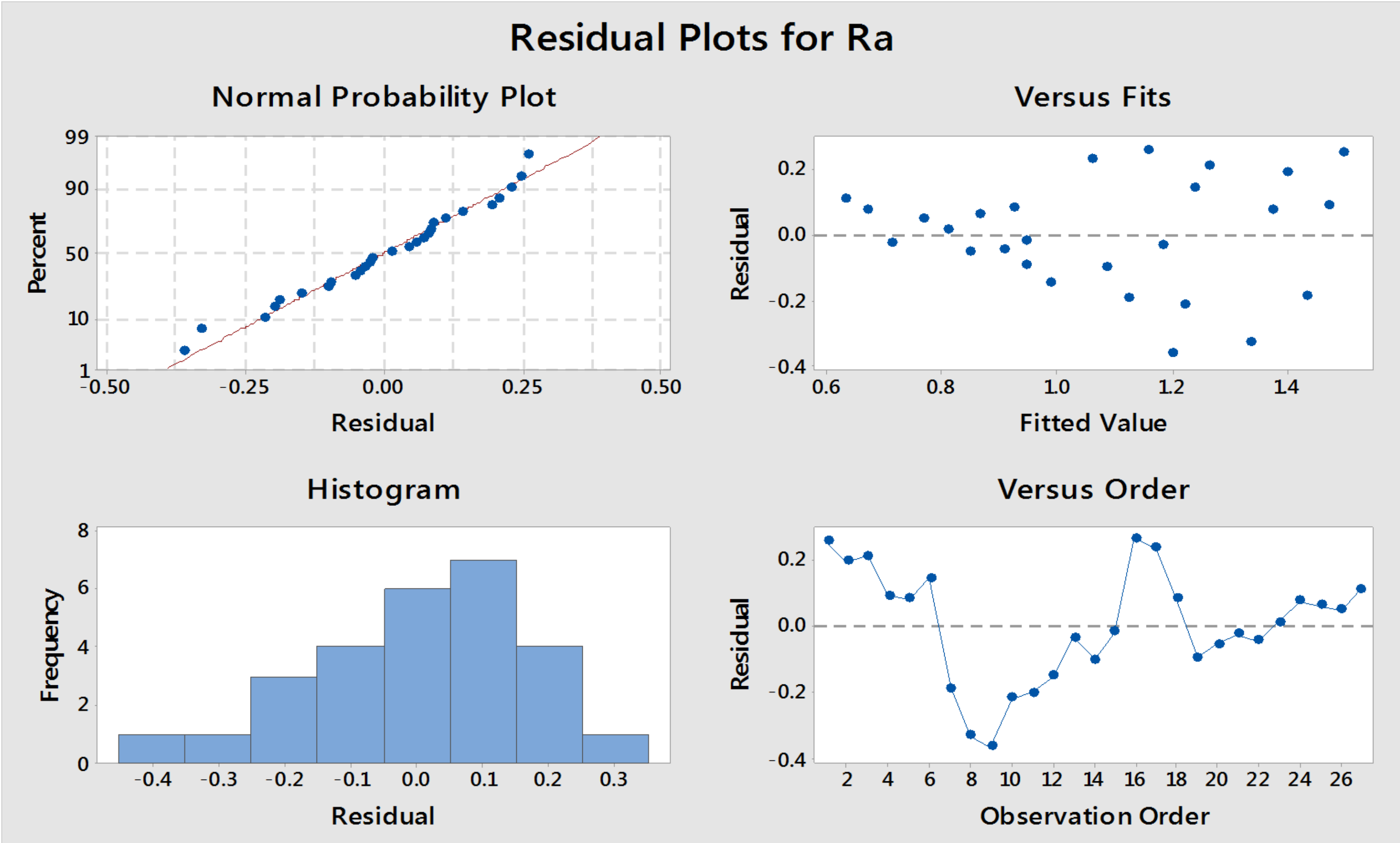
Regression Equation

Ra = 2.003 - 0.000514 w/p rotational speed + 0.0013 voltage - 0.0678 working gap - 0.000704 abrasive material number

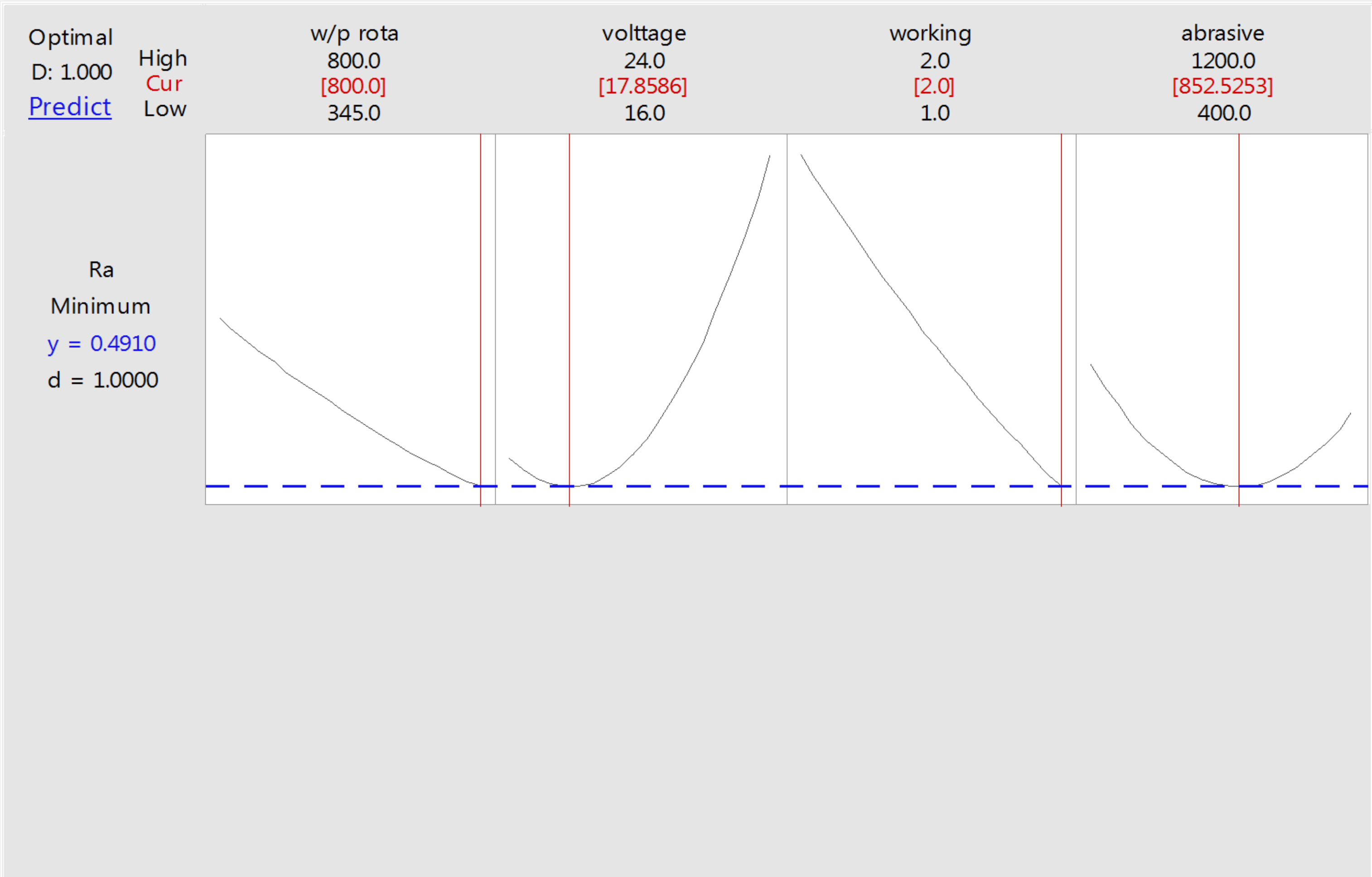
Main Effects Plot for Ra

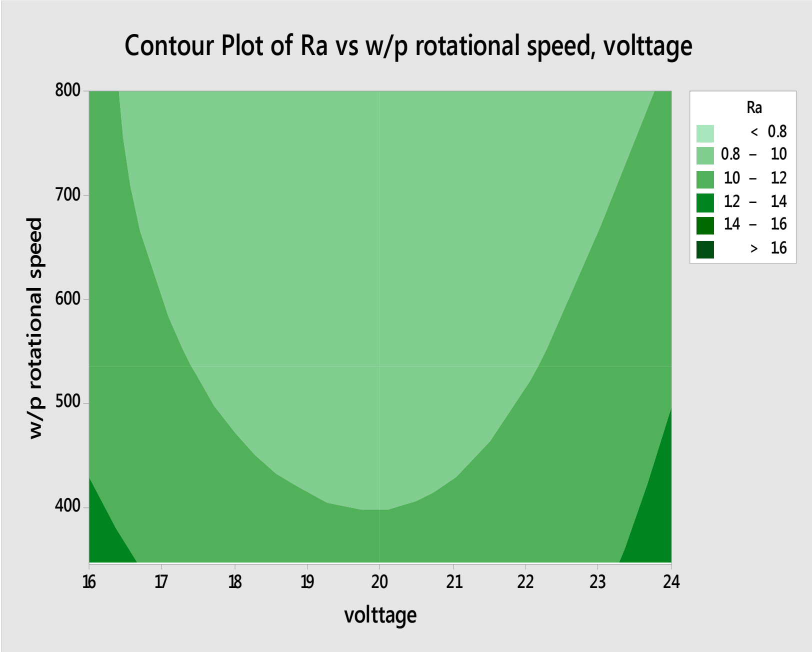


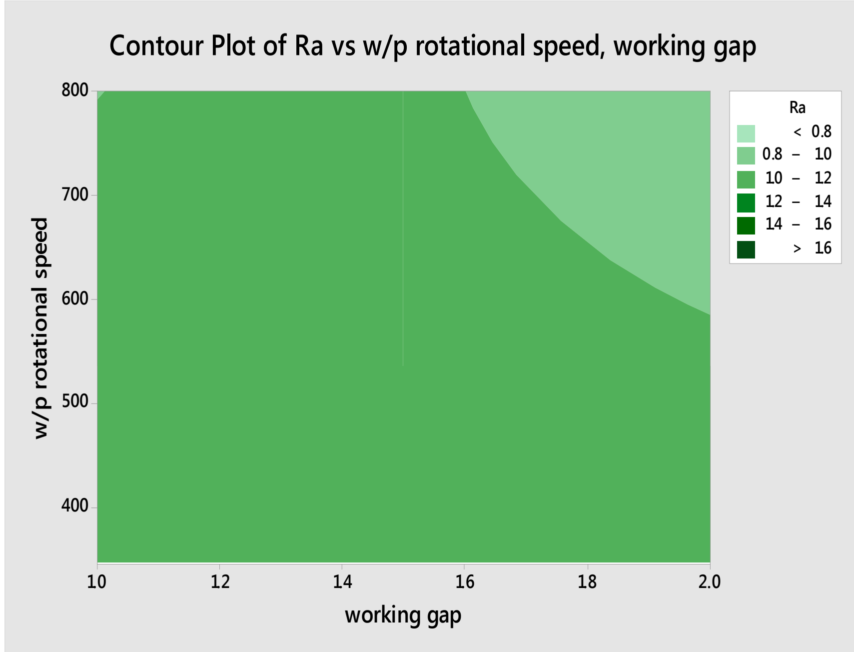
Residual plots for Ra

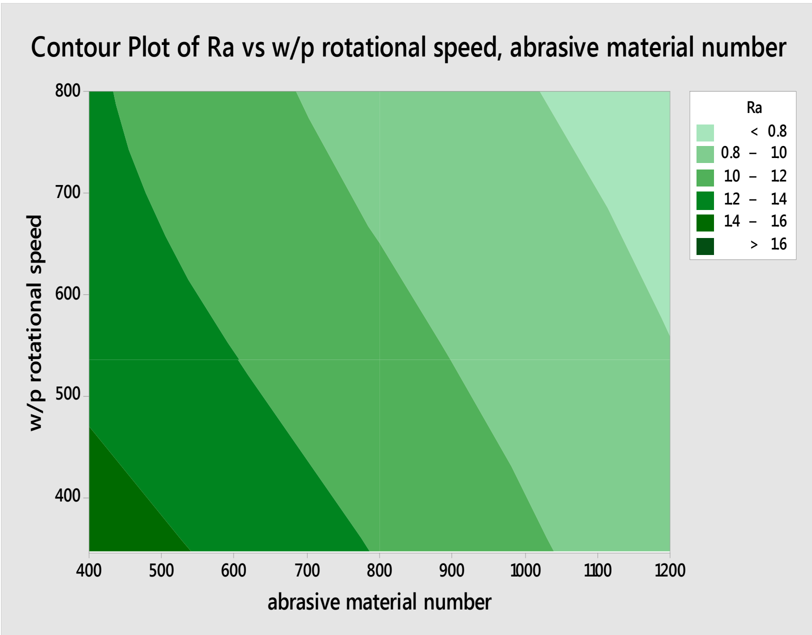


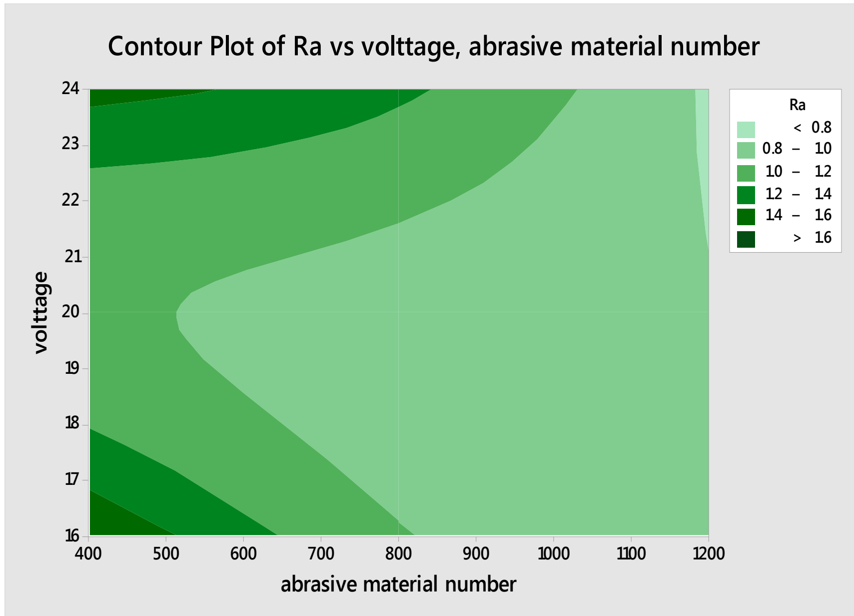
Optimization plot




Contour Plot of Ra vs w/p rotational speed, volttage
w/p rotational speed
800
700
600
500
400
16
17
18
19
20
21
22
23
24
volttage
Ra
< 0.8
0.8 – 10
10 – 12
12 – 14
14 – 16
> 16


Contour Plot of Ra vs w/p rotational speed, working gap
w/p rotational speed
800
700
600
500
400
10
12
14
16
18
2.0
working gap
Ra
< 0.8
0.8 – 10
10 – 12
12 – 14
14 – 16
> 16


Contour Plot of Ra vs w/p rotational speed, abrasive material number
w/p rotational speed
800
700
600
500
400
400
500
600
700
800
900
1000
1100
1200
abrasive material number
Ra
< 0.8
0.8 – 10
10 – 12
12 – 14
14 – 16
> 16


Contour Plot of Ra vs volttage, abrasive material number
volttage
24
23
22
21
20
19
18
17
16
400
500
600
700
800
900
1000
1100
1200
abrasive material number
Ra
< 0.8
0.8 – 10
10 – 12
12 – 14
14 – 16
> 16

Conclusion:

- In order to achieve higher machining efficiency the rotational speed, voltage, working gap and abrasive particle size should be set properly.
- The larger size of abrasive particle results in more MR whereas the smaller abrasive particles generate better surface finish.
- Working gap and abrasive particle size play a vital role during finishing and significantly affect the ΔRa.
- Very high rotational speeds have adverse effect on MR and ΔRa.

Future scope

If we use combined processes like electrochemical dissolution and magnetic abrasive finishing following advantage are to be taken :

- Achieve high surface finishing .
- Finish very hard materials efficiently.
- Material removal rate is high.

METHODOLOGY

Literature Survey

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Detailed Study of ECM and MAM

↓

Material selection

↓

Development of Experimental setup

↓

Parameter Selection

↓

Optimization

↓

Final report

WORK PLAN

Parameters	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Project definition	■									
Literature Survey	■	■	■	■	■	■	■	■		
Detailed Study of ECM and MAM		■	■							
Material selection				■	■					
Development of Experimental setup					■	■				
Parameter Selection					■	■	■			
Optimization							■	■	■	
Final report									■	■

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THANK YOU