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Experiment Investigation And Optimization On Surface Roughness In Abrasive Water Jet Cutting For Automobile Disc Brake

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Abstract: Abrasive Water Jet Machining (AWJM) is one of the recent Non-traditional manufacturing technologies in which mixture of high pressure water and Abrasive particle is used to remove the surplus material without any distortion and microstructure changes. In AWJM, major problem is to produce rough on the cutting-edge during machining on circular path. The main aim of this research is to cut disc brake of automobile vehicle using AWJM to optimize surface roughness and process parameters. In this study parametric study of traverse speed, nozzle diameters, abrasive mass flow rate, and stand of distance were carried out with disc brake of material SS420 with 4 mm thickness. Experiments are performed on Karolin Machine Tool (KMT) at Param Technocrafts and JRD Technocrafts with nozzle diameter 0.25mm, 0.30mm, 0.35mm. The surface roughness is measured by using SJ 210. Optimization of surface roughness is obtained through response surface methodology. Optimum value of surface roughness is 0.45-degree, 2.356 micron obtained for stainless steel 420 materials.

INDEX TERMS **- ABRASIVE WATER JET MACHINING, PROCESS PARAMETER, SURFACE ROUGHNESS.**

I. INTRODUCTION

Abrasive water jet machining is a mechanical material removal process used to erode hole and cavities by impact of Abrasive partial of the slurry on hard & brittle material [1]. The main aim of study is to minimize kerf taper angle in Abrasive water jet machine for Automobile disc brake [2]. Since the process is non thermal, non-chemical & non electrical it creates no change in physical properties of the work piece [3]. Basic principle abrasive water jet machining is non-traditional machining processes, which make use of the principal of Abrasive water jet machining & Water jet machining [4].

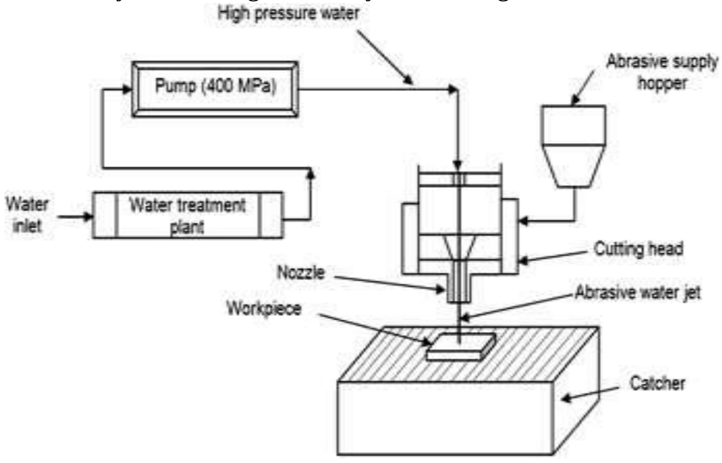

Figure 1.1 Abrasive water jet cutting system [1]

1.1. SCIENCETIFICT PRINCIPAL OF ABRASIVE WATER JET MACHINING

"Principal (AWJM) mixing of abrasive particles in water jet in such a manner that water jet's momentum is transferred to abrasive, abrasive water jet that exit nozzle has ability to cut various material" [5].

The Abrasive jet machining process involves the application of high-speed stream of abrasive particle assisted by the pressurized air on to the work surface through nozzle of small diameter [6]. Material removal takes place by abrading action of abrasive partial. Water pressurizes a steam of pure water flow without abrasive to cut material such as Rubber, Plastics, Cloth, and Wood. Abrasive jet mixing abrasive garnet to pressurized water stream to cut harder material is stainless steel, titanium glass, ceramic tiles, marble& granite [7]. Water jet cutting machine very little heat and therefore there is no Heat Affected Zone [8]. Water jet machining is also considered as a cold cutting process and therefore safe cutting Flammable material such as Plastic & Polymer etc [9].

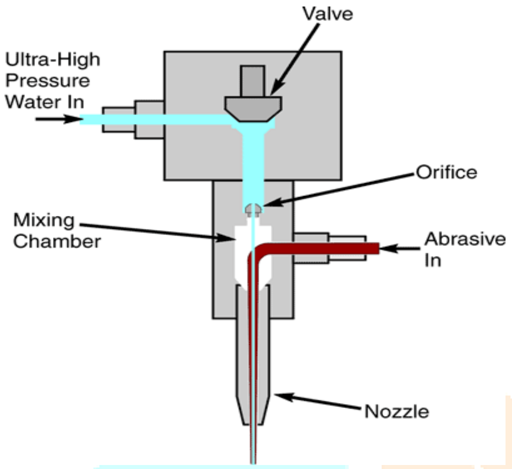

Figure 1.2 Basic principle of abrasive water jet machine [4]

In Abrasive Water Jet Machining, the practical is Mixed with water and forced through the small nozzle at high pressure so that the abrasive impinges on work surface at high velocity. Each of the two components of jet [10], the water and Abrasive material have both are separate purpose and supportive purpose [11]. The primary purpose of the abrasive material in the jet stream is providing the erosive forces. The water in the jet acts as the coolant and carries both the abrasive material and eroded material to clearof the work [12]

II. EXPERIMENTAL SET- UP

In this research work disc brake of size Ø230mm x Ø110mm x 4mm thickness will be cut on material SS420 using Abrasive water jet machine. Surface Roughness method is used to performed of experiments to minimise surface roughness angle and to optimize process parameters. The specification of AWJM and process parameter use for experimental work is explained below.

Fig. 2.1 Abrasive water jet machine.

Table 2.1 Specification of abrasive water jet machine

Sr no	Detail	Description
1	Inner Diameters	0.9 mm
2	Outer Diameters	9.30 mm
3	Water Pressure	3500 bar
4	Cutting table Size	3m× 8m
5	Abrasive size	8o mesh
6	Movement Nozzle	
	X	3m
	Y	8m
	Z	200mm
7	Pump	50 hp
8	Traverse speed	5000mm/min
9	Abrasive type	Garnet
10	Material nozzle	Tungsten carbide
11	Nozzle life	120 hrs

III. Experimental and Work

3.1 Parameters Selection

The Experiment will be conducted on Abrasive Water Jet Machine system with a Karolin Machine Tool (KMT) LINE JL-I50 ultra high pressure pump capable providing maximum water pressure 3500 bar cutting was performed on Stainless Steel 420 plate of Thickness 4 mm. The variable parameters are show in table.

Table 3.1 Constant parameters

Parameters	Variables
Abrasive type	GMT garnet
Abrasive size	80 mesh
Pump	50hp

Table 3.2 Variable parameters

Factor	Level 1	Level 2	Level3
Nozzle diameter (mm)	0.25	0.30	0.35
Traverse speed (mm/min)	50	100	150
Abrasive mass flow rate (g/min)	75	125	175
Stand of Distance (mm)	1	2	1.5

3.2 Experimental run

The number of experimental runs obtained through MINITAB17 for stainless steel 420 plates. Taguchi method is used to obtained experimental runs. In Taguchi method for four variables and three levels are used which gives total 27 experimental runs, shows in below table.

Table 3.2.1 Number of runs for experiments

Sr no	Nozzle Diameter (mm)	Traverse speed (mm/min)	Abrasive mass flow rate (g/min)	Stand of Distance(mm)
1	0.25	50	75	1
2	0.25	50	125	1.5
3	0.25	50	175	2
4	0.25	100	75	1.5
5	0.25	100	125	2
6	0.25	100	175	1
7	0.25	150	75	2
8	0.25	150	125	1
9	0.25	150	175	1.5
10	0.30	50	75	1
11	0.30	50	125	1.5
12	0.30	50	175	2
13	0.30	100	75	1.5
14	0.30	100	125	2
15	0.30	100	175	1
16	0.30	150	75	2
17	0.30	150	125	1
18	0.30	150	175	1.5
19	0.35	50	75	1
20	0.35	50	125	1.5
21	0.35	50	175	2
22	0.35	100	75	1.5
23	0.35	100	125	2
24	0.35	100	175	1
25	0.35	150	75	2
26	0.35	150	125	1
27	0.35	150	175	1.5

3.4 Analysis of Surface Roughness

The surface roughness was measured by using Coordinate measuring machine shows design of matrix which is different combination of process parameters and response show in below table.

Table 3.4.1 Design matrix for kerf taper angle

Sr No	Nozzle diameter (mm)	Traverse speed (mm/min)	Abrasive mass flow rate (g/min)	Stand of distance (mm)	Surface Roughness (Ra µm)
1	0.25	50	75	1	4.131
2	0.25	50	125	1.5	6.066
3	0.25	50	175	2	7.104
4	0.25	100	75	1.5	6.851
5	0.25	100	125	2	7.002
6	0.25	100	175	1	2.756
7	0.25	150	75	2	9.125
8	0.25	150	125	1	5.011
9	0.25	150	175	1.5	5.854
10	0.30	50	75	1	2.891
11	0.30	50	125	1.5	4.974
12	0.30	50	175	2	6.258
13	0.30	100	75	1.5	5.963
14	0.30	100	125	2	6.812

15	0.30	100	175	1	2.356
16	0.30	150	75	2	8.995
17	0.30	150	125	1	4.236
18	0.30	150	175	1.5	5.589
19	0.35	50	75	1	2.879
20	0.35	50	125	1.5	6.125
21	0.35	50	175	2	6.945
22	0.35	100	75	1.5	6.002
23	0.35	100	125	2	7.014
24	0.35	100	175	1	2.487
25	0.35	150	75	2	9.025
26	0.35	150	125	1	4.843
27	0.35	150	175	1.5	5.756

After performing experimental work, next step is to measure the response and finding the result it requires the effects of different parameters on the response i.e. Surface roughness using methods of response surface methodology and Box- Behnken design.

IV. Optimization Of surface Roughness for SS 420 Material

In this contour plot (2D) and response surface plot (3D) for Surface Roughness is show in below figure. This figure is used to different parameters combination for given Surface Roughness.

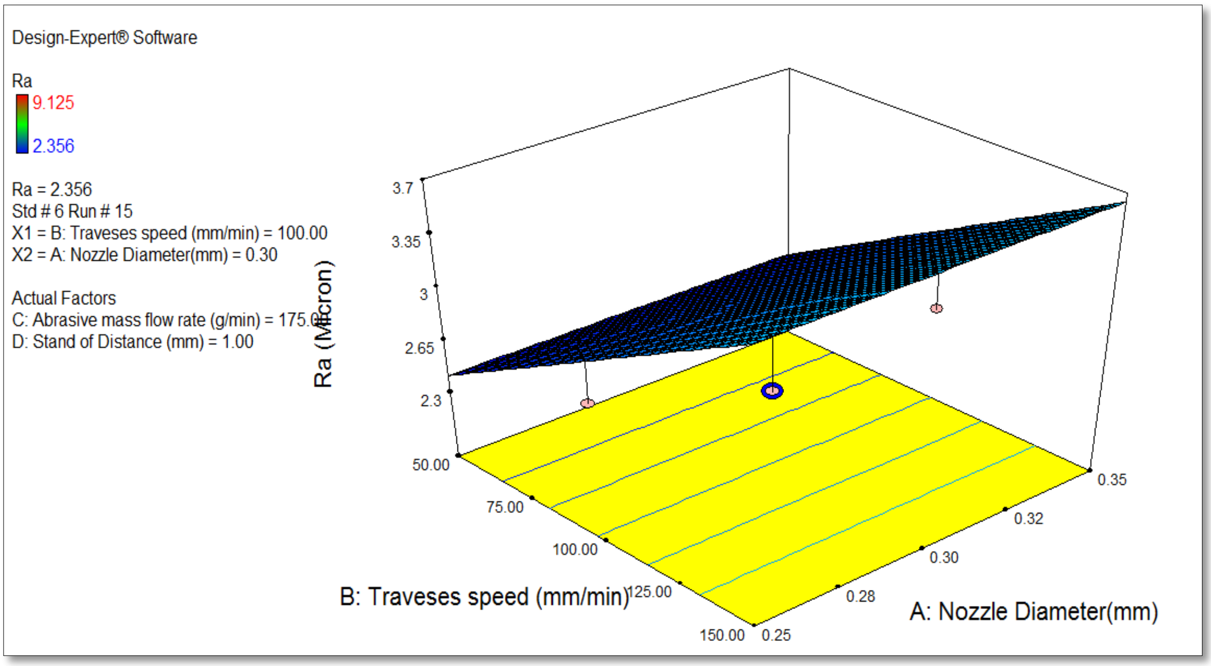

Fig 4.1 Response surface plot for Surface Roughness in Nozzle diameter Vs Traverse speed.

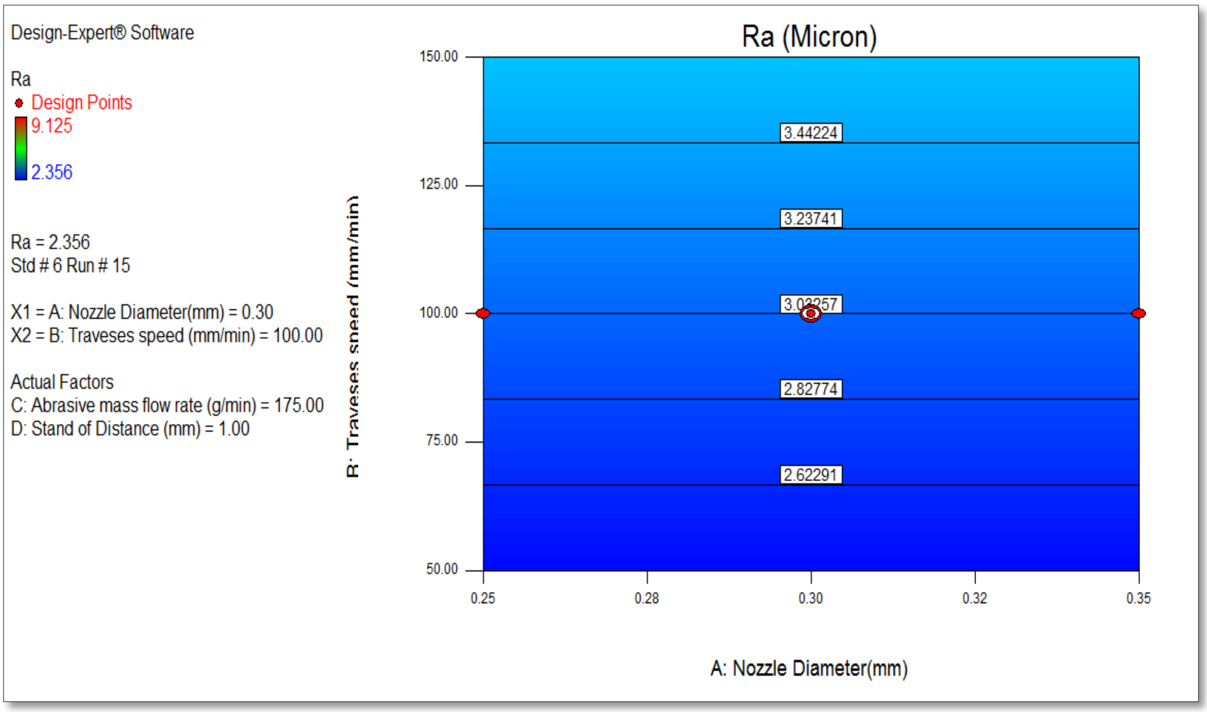

Fig 4.2 Surface Roughness for Contour plot in Nozzle diameter Vs Traverse speed.

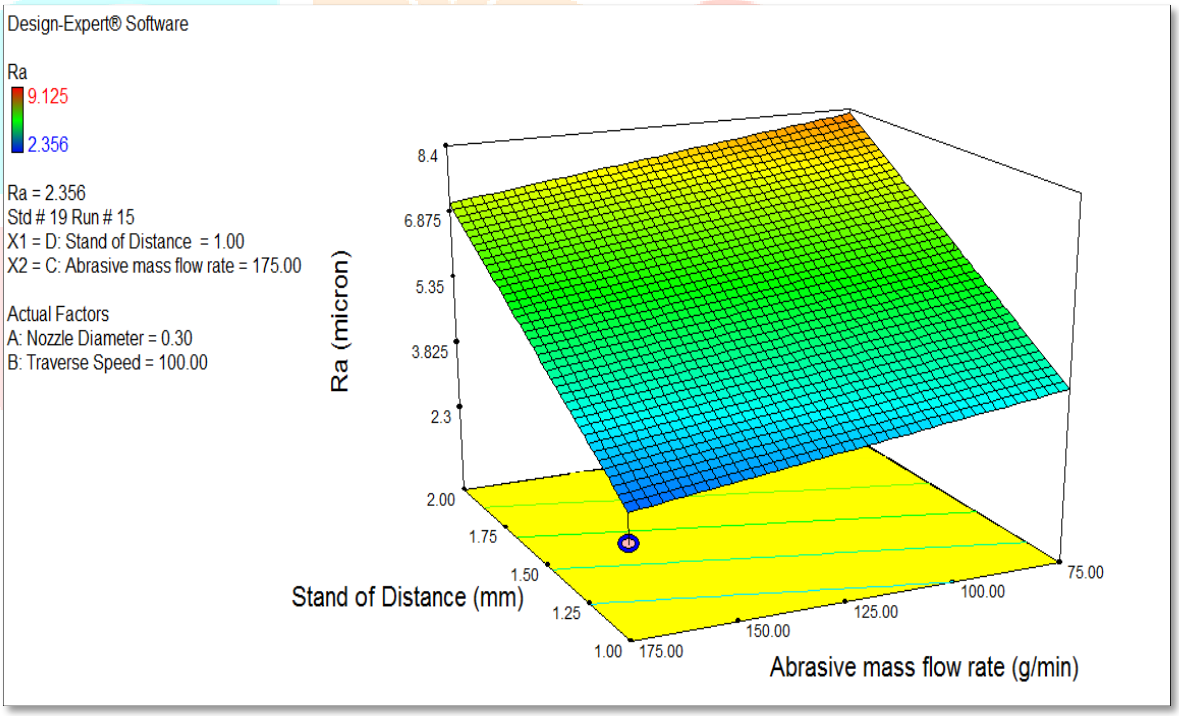

Fig 4.3 Response surface plot for Surface Roughness in Abrasive mass flow rate Vs Stand of Distance.

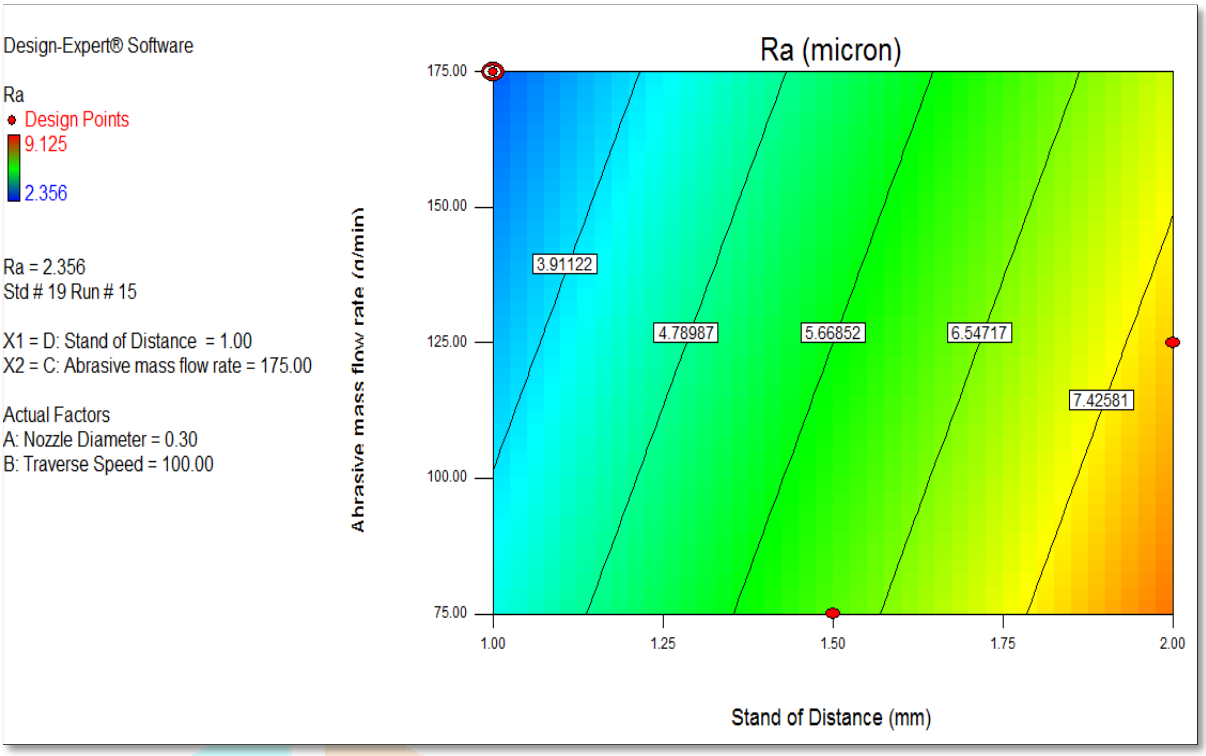

Fig 4.4 Surface Roughness for Contour plot in Abrasive mass flow rate Vs Stand of Distance.

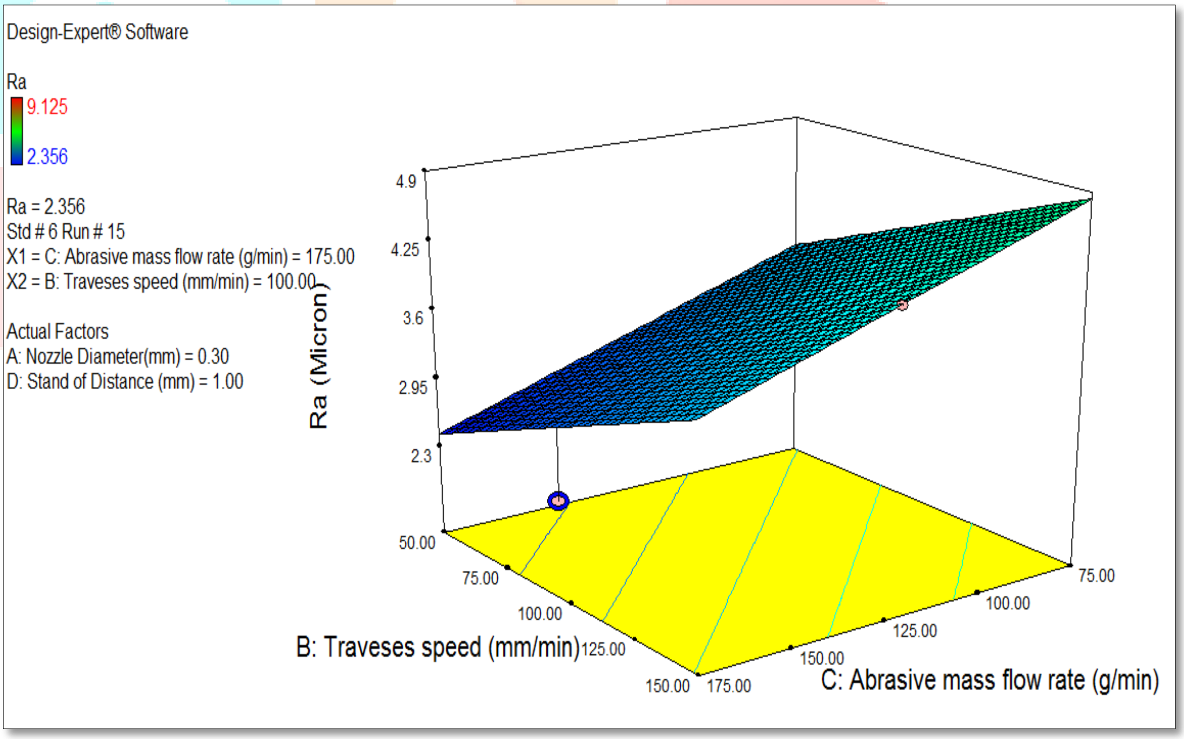

Fig 4.5 Response surface plot for Surface Roughness in Abrasive mass flow rate Vs Traverse speed.

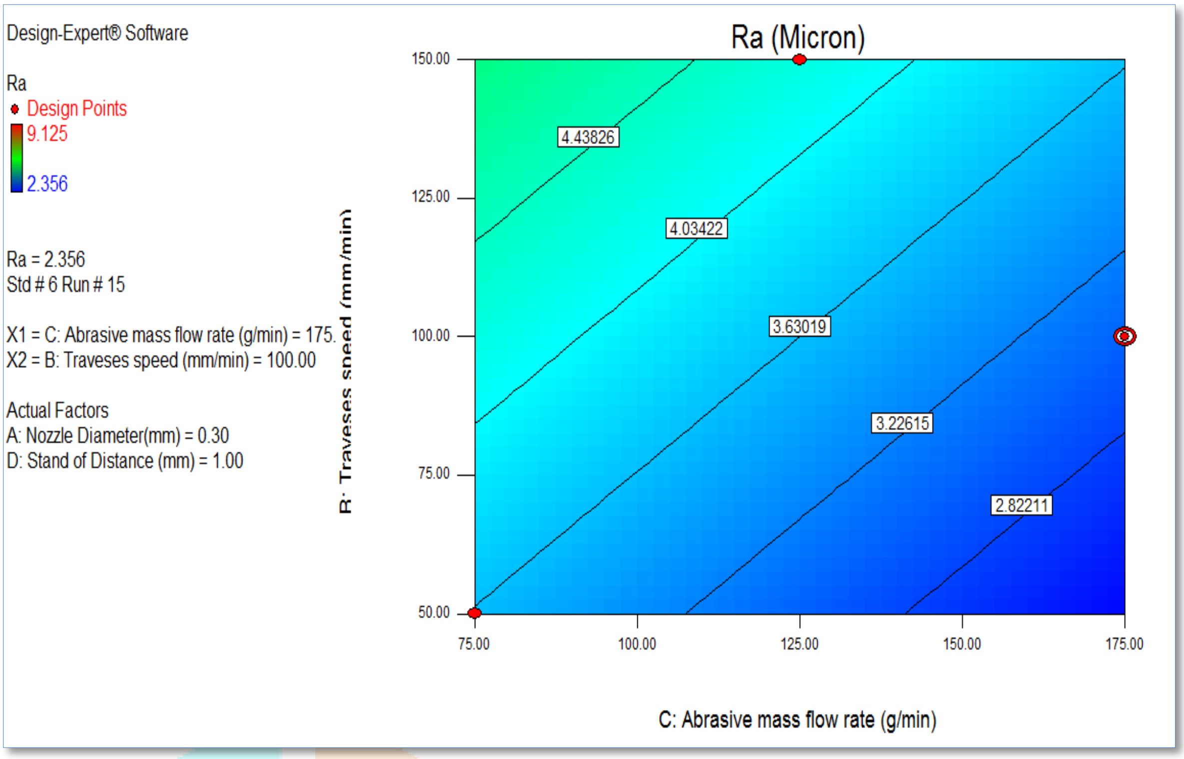

Fig 4.6 Surface Roughness for Contour plot in Abrasive mass flow rate Vs Traverse speed.

From Box-behken design obtain Surface Roughness Equation for below.

Ra(µm) = 0.76 - 3.14 Nozzle Diameter (mm) + 0.01229 Traverse Speed (mm/min) 0.01195 Abrasive Mass

Flow rate (g/min) + 4.077Stand Of Distance(mm)

V Conclusion and Future Scope

- Total number of experimental run are performed Karolin Machine Tool (KMT) LINE JL-I50 and measure surface roughness with the help of Surface tester SJ 210.
- For Stainless steel 420 most influenced parameter is Stand of distance and Traverse speed.
- Minimum Surface roughness 2.356 micron is obtained with Nozzle diameter (0.30 mm), Traverse speed (100 mm/min), Abrasive mass flow rate (175 g/min) Stand of Distance (1 mm).
- Parametric study can be carried out for other parameter such as water pressure, abrasive mass grain size, jet impact angle and different type of abrasive.
- Optimization of surface roughness can be carried out using parameters other than nozzle diameter, traverse speed, abrasive mass flow rate, and stand of distance.
- Same study carried out on other material like Grey cast iron, Carbon-ceramic, Titanium alloy, Carbon fiber etc.

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