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Analysis on Surface Roughness of Aluminium in Abrasive Water Jet Cutting

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Abstract: Abrasive Water Jet is an innovation process which proves to be a good solution for cutting, drilling, polishing for various materials. Abrasive Water Jet Machining is extensively used in many industrial applications. Abrasive Water Jet Machine is non-conventional machining process. The material removal process in mainly by erosion where material removal rate by impact of high pressure, high velocity of water and high girt abrasive. In work piece now there are many parameters affect in machined surface to be cut by abrasive water jet machine. The effect of material thickness, traverse speed and abrasive mass flow rate during abrasive water jet cutting of aluminium on surface roughness were investigated. Surface roughness was measured across of depth of cut. The experimental results show that poor surface roughness at bottom of cut. Based on the experiments the optimal process parameters for each material thickness were defined.

***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].

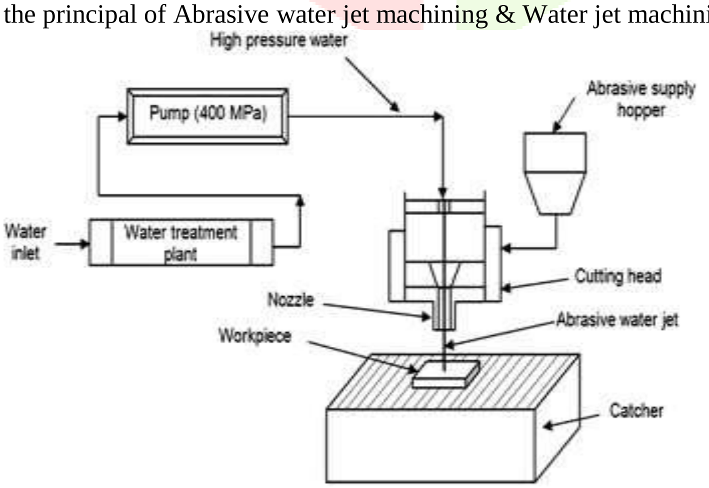

Figure 1.1 Abrasive water jet cutting system [1]

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].

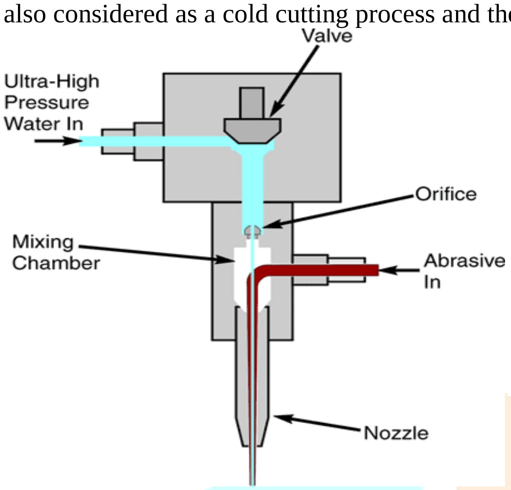

Figure 1.2 Basic principle of abrasive water jet machine [4]

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 Aluminium of size 16 mm and 32 mm thickness will be cut on material Al6082 using abrasive water jet machine. The specification of abrasive water jet machine and process parameter using experimental work is explained below.

Figure 2.1 Basic principle of 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 x 8m
5	Abrasive Size	80 mesh
	Movement Nozzle	
	X	3 m
	Y	8 m
	Z	200 m
7	Pump	50 hp
8	Traverse Speed	5000 mm/min
9	Abrasive Type	Garnet
10	Nozzle Material	Tungsten Carbide
11	Nozzle life	120hrs

III. EXPERIMENTAL AND WORK

3.1. Parameters Selection

The Experimental will be conducted on Abrasive water jet machining system with Karolin Machine Tool (KMT) LINE JL-I50 ultra high-pressure pump capable providing maximum pressure water 3500 bar cutting was performed on Al6082 Plate of thickness of 16 mm and 32 mm. The constant parameters and variable parameters are show in table.

Table 3.1 Constant Parameters

Parameters	Variables
Abrasive Type	GMT Garnet
Abrasive Size	80 Mesh
Pump	50 hp

Table 3.2 Variable Parameters

Variable Parameters	Traverse Speed (mm/min)	Abrasive Mass Flow Rate (g/min)
Material Thickness 16 mm	100,150,200,250,300	100,200,300,400,500
Material Thickness 32 mm	40,56,64,80,96	100,200,300,400,500

3.2. Experimental Run

The number of experimental runs obtained through Minitab 13 for Al6082 plates. Experimental runs show in below table.

Table 3.2.1 For 16 mm job variation operating parameter

Job Number	Abrasive Flow Rate (g/min)	Traverse Speed (mm/min)	Time (Second)
1	400	100	36.37
2	400	150	31.17
3	400	200	22.42
4	400	250	14.22
5	400	300	11.45
6	100	100	36.37
7	200	100	36.37
8	300	100	36.37
9	400	100	36.37
10	500	100	36.37

Table 3.2.2 For 32 mm job variation operating parameter

Job Number	Abrasive Flow Rate (g/min)	Traverse Speed (mm/min)	Time (Second)
1	500	40	95.22
2	500	56	78.54
3	500	64	68
4	500	80	48.41
5	500	96	40.89
6	100	40	95.22
7	200	40	95.22
8	300	40	95.22
9	400	40	95.22
10	500	40	95.22

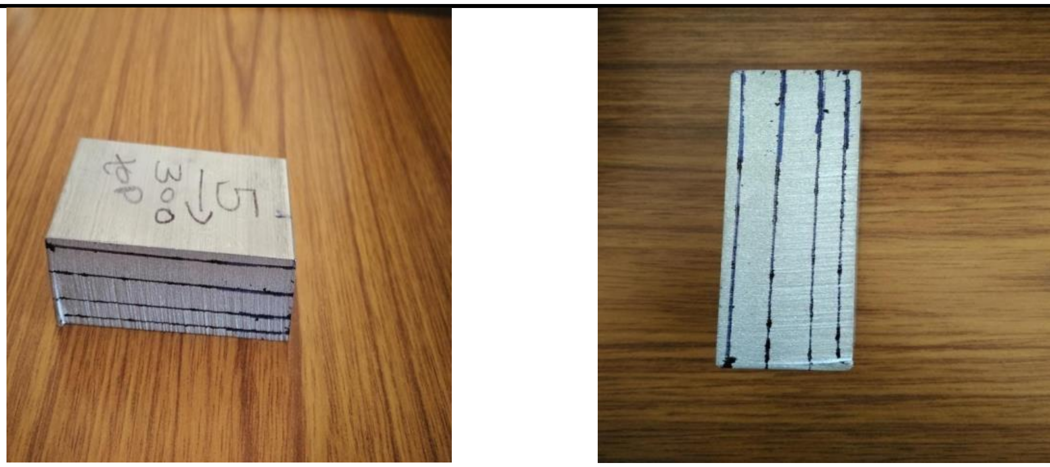

Figure 3.2.1 16mm and 32mm Job Cut Surface

IV. ANALYSIS OF SURFACE ROUGHNESS

The surface roughness was measured by using surface roughness tester SJ-210 is a shop floor type surface roughness measuring instrument, which traces the surface of various machine parts, calculations their surface roughness based on surface standards and display result. Wide measurement range various roughness parameters have a maximum range of 360µm (-200µm to +160µm) and can display various roughness parameters about the surface roughness.

Figure 4.1 Surface Roughness Measuring Device

Table 4.1 Reading for 16mm Thickness Job

Job Number	2mm Thickness			6mm Thickness			10mm Thickness			14mm Thickness		
1	4.389	4.332	4.240	5.563	4.715	4.336	4.949	4.943	4.965	5.826	5.382	5.510
2	5.328	5.140	4.291	5.201	5.613	5.717	6.143	5.553	5.363	7.045	5.575	5.528
3	4.594	4.916	4.919	5.305	5.856	5.636	5.196	5.483	5.541	5.237	6.328	7.018
4	4.277	4.873	5.007	4.883	5.287	5.647	5.855	5.615	5.883	6.997	5.890	7.119
5	4.915	4.886	4.923	6.238	6.715	6.173	6.947	5.774	7.019	6.633	6.317	7.094
6	4.378	5.304	5.031	5.196	6.499	6.368	5.624	5.722	7.540	7.059	7.643	7.034
7	4.831	5.449	4.527	5.557	6.325	6.562	6.439	6.930	6.530	7.375	7.447	7.544
8	4.958	4.481	4.727	4.909	5.480	5.086	5.830	5.433	5.673	5.274	5.638	5.767
9	4.389	4.332	4.240	5.565	4.715	4.336	4.949	4.943	4.965	5.820	5.327	5.501
10	4.500	4.696	4.124	5.512	4.426	4.832	4.426	4.892	5.521	4.953	5.170	5.382

Table 4.2 Reading for 32mm Thickness

Job Number	2mm Thickness			12mm Thickness			22mm Thickness			30mm Thickness		
1	3.797	3.869	4.037	4.577	4.397	4.363	4.918	4.745	4.177	5.139	5.033	4.438
2	4.119	4.108	4.291	4.394	4.696	4.626	4.398	4.327	5.028	4.862	4.462	4.952
3	4.143	4.375	4.534	4.773	4.710	4.830	4.702	4.529	5.298	6.892	6.831	6.239
4	4.326	4.876	5.266	4.772	5.218	5.281	5.250	5.677	5.002	5.807	6.265	5.841
5	4.985	4.974	4.673	5.341	4.811	5.390	4.847	5.697	6.555	5.958	6.110	6.337
6	4.088	4.332	5.202	5.384	5.172	5.363	6.101	6.293	5.355	6.860	7.572	6.942
7	4.226	4.420	5.045	5.171	4.907	5.175	5.192	5.746	5.446	7.283	7.256	5.925
8	4.658	4.998	4.534	4.604	4.543	5.239	4.800	4.919	4.973	6.188	4.876	5.183
9	3.930	4.124	4.183	4.558	4.467	4.312	5.340	5.435	4.494	4.852	5.467	4.447
10	3.797	3.869	4.037	4.577	4.397	4.363	4.198	4.745	4.177	5.139	5.033	4.438

V. RESULT

5.1 Results and Discussions

In this Section, the effect of the process parameters such as traverse speed, abrasive mass flow rate and material thickness on the surface roughness during abrasive water jet cutting of aluminium plate was analyzed.

The effect of traverse speed on the surface roughness.

The effect of the traverse speed on the surface roughness during abrasive water jet cutting of 16 mm thick aluminium was shown in fig 5.1. Experimental were made at constant value of abrasive mass flow rate, m 400 g/min.

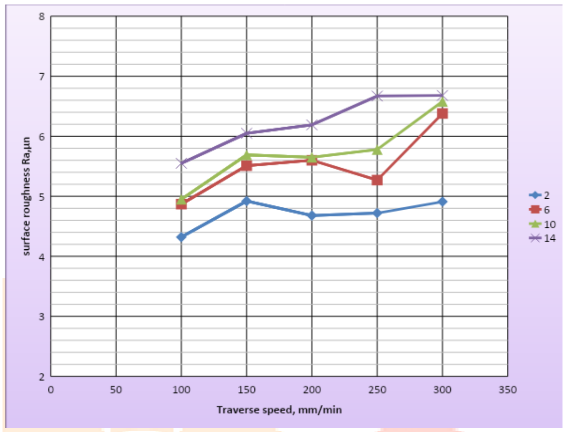

Figure 5.1 The effect of traverse speed on the surface roughness on different zones of the cut surface 16 mm thickness.

The effect of the traverse speed on the surface roughness during abrasive water jet cutting of 32 mm thick aluminium was shown in fig 5.2. Experimental were made at constant value of abrasive mass flow rate, m 500 g/min.

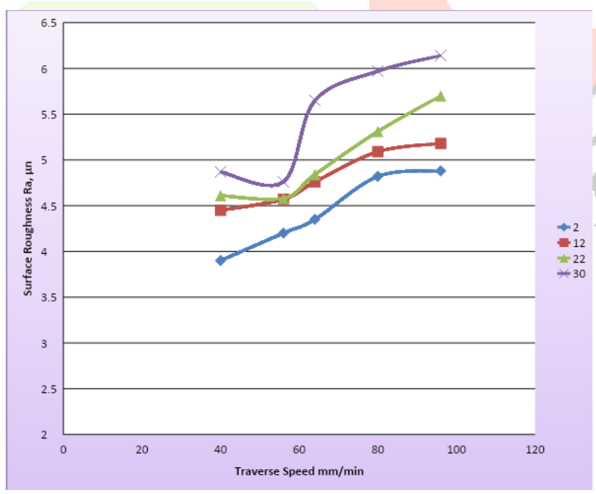

Figure 5.2 The effect of traverse speed on the surface roughness on different zones of the cut surface 32 mm thickness.

The effect of the abrasive mass flow rate on the surface roughness during abrasive water jet cutting of 16 mm thick aluminium was shown in fig 5.3. Experimental were made at constant value of traverse speed, v 100 mm/min.

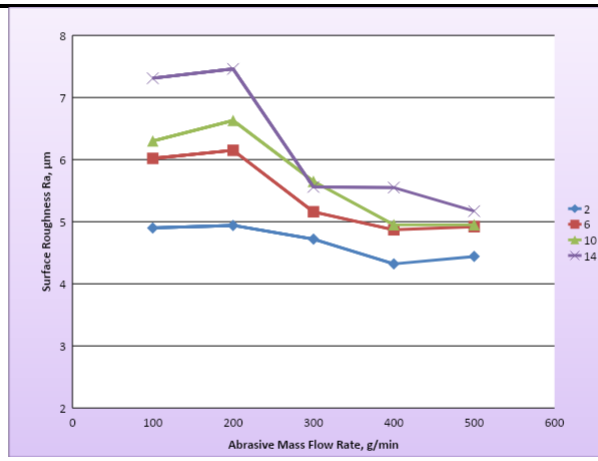

Figure 5.3 The effect of abrasive mass flow rate on the surface roughness on different zones of the cut surface 16 mm thickness.

The effect of the abrasive mass flow rate on the surface roughness during abrasive water jet cutting of 32 mm thick aluminium was shown in fig 5.4. Experimental were made at constant value of traverse speed, v 40 mm/min.

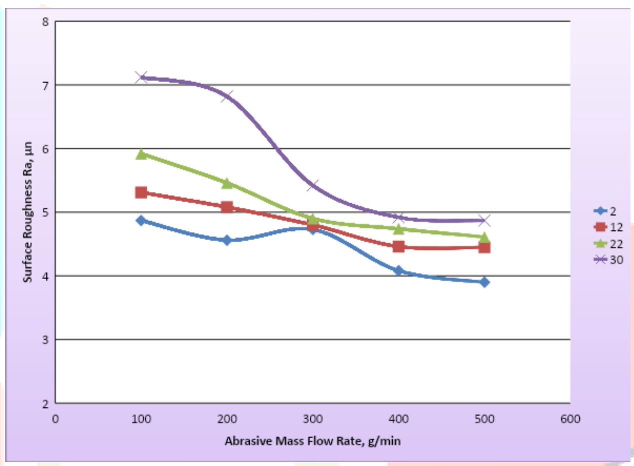

Figure 5.4 The effect of abrasive mass flow rate on the surface roughness on different zones of the cut surface 32 mm thickness.

VI. CONCLUSION

From experimental results and analysis following conclusion cab be narrated that,

The Surface being cut by the abrasive water jet was characterized by two of surface texture. The first texture was located at the beginning of the cut and was characterized by smooth surface. The second texture was located at bottom of and was characterized by rough surface.

The optimal solution is the choice of medium traverse speed with which can be achieved higher productivity with acceptable surface roughness. The reduce processing cost by the abrasive mass flow rate may be reduced but reducing abrasive mass flow rate may be led to rough surface.

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