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Experimental Investigation of Pocket Milling on Aluminium 8011 using Abrasive Water-Jet Machining

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Abstract - Abrasive water jet machining is the most popular method in unconventional machining process. In current research in abrasive water jet machining(AWJM) process is focused on milling applications. In our experiments were carried out on Aluminium 8011 for the AWJM process for producing 3D features such as pockets of size 20mm x 10mm an input variables such as Water Jet Pressure(P), Abrasive Flow Rate(AFR), Step over, Traverse Speed(TS),Stand of Distance(SOD) as 2 mm, Orifice diameter as 0.35 mm and abrasive size 80# mesh and obtained output parameters like Material removal rate (MRR), Depth of cut (DOC) and Surface roughness (Ra). The results have known that the fixture angles and water jet pressure is affected the output parameters DOC, MRR and Ra.

Index words - Abrasive water jet machining, Garnet abrasive, Depth of cut.

I. INTRODUCTION

Abrasive water jet machining is the fastest growing tech in un conventional machining process. It is used to cutting the wide range of materials. In abrasive water jet machining water is pumped to a very high pressure (138 - 413MPa). Its industrial use depends on its cost effectiveness. In general the overall cost of an abrasive water jet machining system will be high then compare to traditional machining techniques. In abrasive water jet machining abrasive particles usually garnet is introduce in high velocity. The abrasive particle is targeted on the work piece. Abrasive water jet machining as a unique advantage there is no thermal distraction and also high flexibility. It has an ability to cut tough materials.

Abrasive water jet machining involves many process parameters including in the below following

- Water jet pressure
- Water jet orifice diameter
- Mixing tube length
- Mixing tube diameter
- Abrasive material and particle size
- Transverse speed
- Angle of cutting
- Abrasive flow rate

The influence of these parameters on the output response has to be studied for aluminium 8011.

1.1 Nomenclature

AFR	Abrasive flow rate (kg/min)
DOC	Depth of cut (mm)
MRR	Material removal rate (mm3/min)
P	Water pressure (Bar)
SO	Step over (mm)
SOD	Standoff distance (mm)
Ra	Surface roughness (µm)

II. LITERATURE SURVEY

Fowler et al [1]have carried out AWJPM in titanium alloy to study the effects of while using different abrasive particles like Garnet, White aluminium oxide, Glass beads. The abrasive particles are differ from size and shape. The ratio between hardness of the work piece and the abrasive particle shape. If increasing abrasive hardness the MRR and Ra will be increase.

Hashish [2] developed the isogrid patterns in aluminium and titanium using AWJPM to increase the strength of materials on the iso grid structure extremely used aero dynamics.

Shipway et al [3] studied the surface characteristics of AWJPM on titanium alloy (Ti6A14V).They observed that the material removal rate is about 55% lower at higher traverse speeds (0.01 m/s) with smaller grit size (80 mesh) than that of with the larger grit size (200 mesh). However, the material removal rate decreases as the impingement angle moves towards the normal (90°). They observed that the surface waviness and surface roughness significantly change proportionally with the impingement angle while using both the grit sizes. They have also observed that increase in traverse rate results in the reduction in surface waviness, while using both grit sizes of abrasives (garnets). They have also observed that the surface roughness decreased as the impingement angle decreases for both grit sizes (mesh 80 and mesh 120). For smaller grit sizes (#80), low surface roughness was achieved with

S. No	Water pressure (MPa)	Angle (degree)	Material removal rate (mm^3/min)	Surface Roughness (µm)
1	220	0	1214.56	10.386
2	220	5	1227.56	10.758
3	220	10	1219.76	10.360
4	220	15	1206.76	11.646
5	220	20	1180.75	11.525

impingement angles between 30° to 90°. While for the larger grit sizes (#120),there was an increase in the roughness values at an impingement angle of 60°.

Srinivasu Rao [4] investigated the effect of abrasive mass flow rate on MRR in AWJM.The SOD increases Depth of Cut and MRR should be increases and the optimal values it begins decreasing.

III. CUTTING PATH STRATEGY

3.1. HATCH STRATEGY

The strategy is also called as Zigzag, facing, direction parallel, stair case.

S. No	Water pressure (MPa)	Angle (degree)	Material removal rate (mm^3/min)	Surface Roughness (µm)
1	140	0	663.19	9.425
2	140	5	668.40	8.569
3	140	10	668.40	8.666
4	140	15	655.39	7.099
5	140	20	642.39	8.241

S. No	Water pressure (MPa)	Angle (degree)	Material removal rate (mm^3/min)	Surface Roughness (µm)
1	180	0	923.27	8.088
2	180	5	938.88	8.945
3	180	10	910.27	10.329
4	180	15	907.67	9.221
5	180	20	858.25	6.962

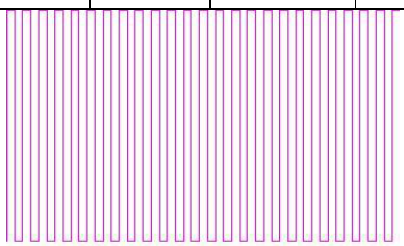

Fig. 1 Hatch strategy

In zigzag pocketing the cutter removes the machining area in same zigzag manner the strategy is to be draw in the CAD and the file is imported on intellimax software.

TABLE I Input and output parameter vales for hatch strategy

TABLE II Machine Specifications

High pressure	413MPa
Table size	1168 x 787 mm
X-Y cutting travel	737 x 660 mm
z-axis travel	203 mm
Accuracy and repeatability	± 0.0025 mm
The mixing tube diameter	0.76 mm
Orifice diameter	0.35 mm
Power	22KW,50Hz

IV. EXPERIMENTAL SETUP

The experiments were conducted on aluminium 8011 wrought alloy of 10mm plate with AWJM(OMAX 2626) provided at the manufacturing laboratory Anna university Chennai. This work aims for pocket milling of size 20mm x 10mm.The workpiece is fixed in the machine with proper fixtures and fixed stand of distance. In our work we have to change the fixture angles up to 0,5,10,15,20 degree and the water jet pressure also changed up to 140,180,220MPa.The values of input parameters namely pressure(P),Step over, Traverse speed(TS) and abrasive flow rate(AFR) using Hatching Strategy. The input variables and the recorded output readings are namely depth of cut (DOC),Material removal rate(MRR) and surface roughness(Ra) are shown in table -1.

Fig.2 AWJ machining center at Anna University, Chennai.

TABLE III Chemical composition of aluminium 8011

V. ANALYSIS OF SURFACE ROUGHNESS

ANOVA successfully yielded the significant parameters for the required depth of cut. There is no effect while changing the pressure and fixture angles.

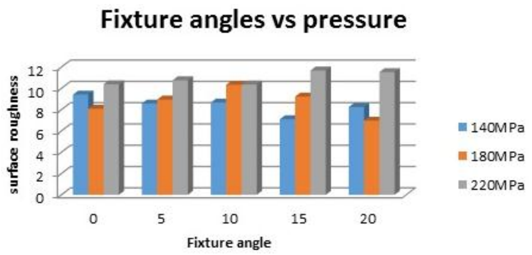

Fig-3.Fixture angle Vs Pressure

The values come below less than 15 microns. So there is no effect while changing this process parameter.

VI. RESULTS AND DISCUSSION

The observed depth of cut and surface roughness values obtained are given table -1 ANOVA TM software is used for statical analysis. The input parameter which contribute significantly have been determined.

VII. CONCLUSIONS

In this study an attempt has been made determine the material removal rate (MRR) and Surface Roughness (Ra) of Aluminium Alloy 8011 by applying constant pressure and various angles. Mathematical calculation is carried out to find out the process parameters and the results were tabulated. There is no effect on surface roughness while changing process parameters.

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Aluminium (Al)	97.5 to 99.1 %
Iron (Fe)	0.5 to 1.0 %
Silicon (Si)	0.4 to 0.8 %
Residuals	0 to 0.15 %
Chromium (Cr)	0 to 0.1 %
Copper (Cu)	0 to 0.1 %
Magnesium (Mg)	0 to 0.1 %
Manganese (Mn)	0 to 0.1 %
Zinc (Zn)	0 to 0.1 %
Titanium (Ti)	0 to 0.050 %

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