A Review on Effect of Process Parameters on Abrasive Water Jet Machining

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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. The research works on abrasive water jet cutting is discussed in this paper. There are so many process parameters which directly influence kerf cutting edge during machining in abrasive water jet machine. Kerf cutting involves kerf width and taper angle in which kerf taper angle requires to minimize because it will creates mismatch while assemble a parts. As Process parameters such as traverse speed and stand of distance are most dominant factor which affects the taper angle. This paper also discusses the future trend of research work in the area of AWJM.

Index Terms **- Abrasive water jet machining, Process parameter.**

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].

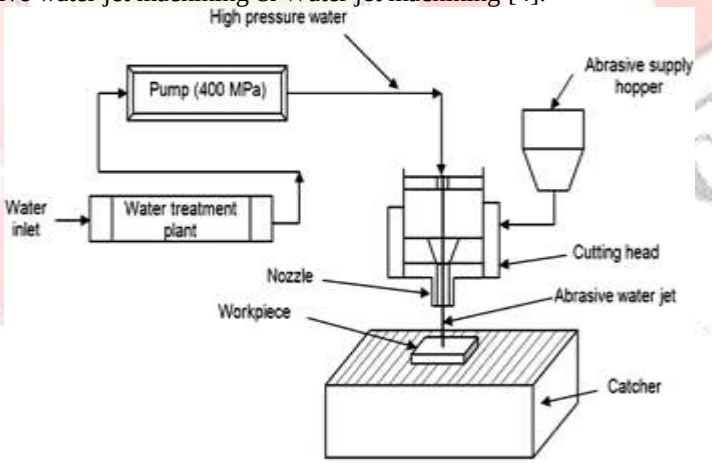

Figure 1.1. Abrasive water jet cutting system [1]

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].

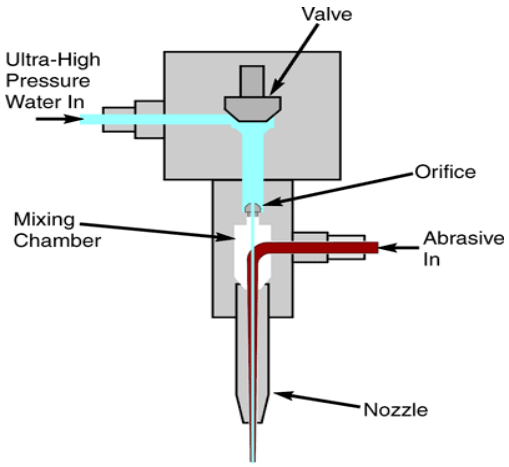

Figure 1.2 Basic principal of abrasive water jet machine [4]

In Abrasive Water Jet Machining, the practical are 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 clear of the work [12].

II. LITERATURE REVIEW

Table 1 Literature review on Abrasive Water Jet Machine

Sr. No.	Title	Author	Publisher and year	Journal	Materials	Problem Discussed & Outcome
1	Minimize of kerf taper angle and kerf width using taguchi method in AWJM Marble	Vishal Gupta, et al.[1]	Elsevier 2017	Procedia Material science	Marble	For minimum kerf taper angle lowest levels of water pressure and nozzle transfer speed at 200 Mpa and 50 mm/min emerged as optimal settings.
2	Analysis of kerf Taper angle in abrasive water jet cutting of Makrana White Marble	M.P.Garg, R.Khanna et al.[2]	Elsevier 2013	Procedia Material science	White marble	Nozzle traverse speed most significant affect kerf angle, and water pressure less significant affect kerf taper angle& very very less affect abrasive flow rate. Result of concluded WP 200mpa, TS 50mm/min, AFR 300g/min has given optimum result of kerf taper angle.
3	Exploration on Kerf angle and Surface Roughness in Abrasive Water jet Machining using Response Surface Method	Munuswamy Naresh Babuet al.[3]	Springer 2017	Procedia Material science	Mild steel	The Traverse speed is the most significant parameter controlling the responses on kerf-angle. The optimal settings observed reduce of kerf angle(0.32°)traversespeed91mm/min,SOD 1.9, AFR 81 g/min, WP 348 mpa,

4	Minimize of kerf taper in AWJM of Aluminum ceramic composition technique	D.K. Shanmugam et al.[4]	Elsevier 2014	International journal of machine & manufacturing	Aluminum ceramic	increase in water pressure and abrasive mass flow rate decrease in the kerf taper, angle nozzle traverse speed can be increased to increase the cutting rate and abrasive mass flow rate can be reduced to reduce the process costs, achieving small kerf taper angles
5	An investigation on kerf characteristics in Awjm of layered composites	S.H. masod et al.[5]	Elsevier 2019	International journal of machine & manufacturing	Composite Graphite epoxy,	Based on the test conditions a combination of high water pressure, low traverse speed, and low Sod, recommended minimising kerf taper angle.
6	Taper of cut at Abrasive water jet cutting of an aluminum	Zsolt Maros et al.[6]	Springer 2012	International Adv Manuf Technol	Aluminum alloy	increasing the pressure decreases the taper angle of the kerf becauseOf the lower feed rate Awjm,Increase of the abrasive mass flow rate decreases the taper to by increasing the number of abrasive grain & increases the energy of jet.
7	The effect of traverse speed on kerf width in AWJ cutting of ceramic tiles	Daniel Krajcarz et al.[7]	Elsevier 2017	Procedia Engineering	Ceramic tiles	An increase in abrasive water jet traverse speed gives rise to taper Of through cut.The limiting traverse speed for brittle materials is higher as compared to ductile materials, smooth surface achieved minimize kerf angle at the lower TS in all material.
8	Effect of Traverse Speed on the Kerf characteristics in ductile and brittle Material in AWJM	B.A Modi et al.[8]	Nirma university 2011	Institute of Technology nirma	Aluminum, Marble, Sand Stone	An increase in abrasive water jet traverse speed gives rise to taper Of through cut.The limiting traverse speed for brittle materials is higher as compared to ductile materials, smooth surface achieved minimize kerf angle at the lower TS in all material.
9	A correlation for predicting the kerf profile from abrasive water jet cutting	C. Ma et al.[9]	Elsevier 2005	Experimental Thermal and Fluid Science	Acrylic Plastic	The kerf width developed in this work has shown that there are two regions, the first region which end 2mm of cutting depth velocity profile jet changing from a uniform profile,

						the second cutting depth become wider narrower depend on cutting speed. the correlation used to identify the cutting speed.
10	Effect of traverse speed on abrasive water jet machining of Ti–6Al–4V alloy	Ahmet Hascalik et al.[10]	Elsevier 2007	Experimental Thermal and Fluid Science	Titanium Alloy	As the traverse speed increases, the AWJ cuts narrower kerf with a greater kerf taper ratio. This is because the traverse speed of abrasive water jet allows fewer abrasives to strike on the jet target and hence generates a narrower slot
11	Investigation of the Taper of Kerf Cut in Steel by Abrasive water Jet machine	Libor m Hlavac et al.[11]	Springer 2014	International Adv Manuf Technol	Steel	Two different method of taper of kerf , Vernier Caliper & Average the area of slot opening on material. -Experiment results investigation kerf taper optimization parameters are traverse speed 40mm/min and more than 50mm/min minimize kerf taper.
12	Ceramic sponge Abrasive Water jet(AWJ)precision cutting through a temporary filling procedure	F.Vigano et al.[12]	Elsevier 2017	Journal Of Manufacturing processes	Solid YZA Ceramic	The proposed process parameters(TS150 mm/min, P380 Mpa) allow obtaining precise parts, thus complying with tight dimensional and geometric tolerances and fulfilling the functional needs
13	ANSYS Analysis of Braking Rotor Of Two Wheeler	Akshay Pophaleet al.[13]	Technical 2015	Technical Journal	Stainless Steel	Normal frequencies of disc brake of bike increase as the disc thickness decrease, Disc brake of bike decrease as the disc hole diameter Increase till 7th natural frequencies but reverse effect after 7th natural freq. but seventh frequency is changed very less.
14	Kerf formation analysis in the abrasive water jet cutting Of industrial ceramics	P. Gudimetla et al.[14]	Elsevier 2002	Material Processing Technology	Industrial ceramic	The abrasive water jet is an effective tool for the machining of alumina ceramics .The kerf finish is dictated by the jet traverse speed and abrasive flow rate in linear cutting alumina ceramic can be used to develop a comprehensive cutting.
15	Analysis of kerf angle of granite machined by abrasive water jet	Izzet Karakurt et al.[15]	Springer 2011	International Journal of Engineering & Materials science	Granite	In General increases traverse speed, Sod &water pressure increases kerf angle, increases AFR did not have effect of kerf angle of Granite.
16	Comparative study of jetting machining technologies over laser machining	F.L. Chen et al.[16]	Elsevier 2002	Composite Structure	Composite material	Abrasive water jet cutting promises better cutting compared to the other two, and better result were obtain water jet cutting fact use very slow decrease cutting speed for abrasive water jet would decrease kerf angle.

	technology for cutting composite materials					
17	Taper Of Kerf Made in Rocks By Abrasive water jet	Libor M.Halvac et al.[17]	Springer 2016	International Adv Manuf Technol	Rock Material	Divergent taper decreasing trend regrinding increases traverse speed most of rocks but divergent taper start increase again TS higher than respective limit TS on rock higher strength
18	Effect of Slurry Temperature of Kerf Taper angle in Abrasive water jet machining	Vadana Jain et al.[18]	Springer 2014	International In eng and tech	MS A36	After experimental investigation, it is inferred that kerf taper angle depends on viscosity of slurry, which is a function of temperature. Hence, kerf taper can be reduced by lowering the slurry temperature
19	ANN modeling of Kerf taper angle in CO_2 laser Cutting and optimization of cutting parameters using Monte carol method	Milos Madic et al.[19]	Research Gate 2015	International Journal of Industrial eng Computations	SS 304	ANN model can predict the kerf taper with good accuracy it was focusing laser beam about 2/3 material thickness low gas pressure 9 bar low power 1.6 kw cutting speed 3m/min produced acceptable kerf taper angle.
20	Experimental Investigation into Abrasive water jet machining of carbon fiber Reinforced plastic	Prasad D. Unde et al.[20]	Hindawi 2015	International Adv Manuf Technol	CFRP	In cutting CFRP laminate using AWJM, The stand of distance and Traverse speed has been significant influence on kerf taper angle, The laminate 45° fiber orientation show kerf taper angle 0.029 while 60° and 90° show 0.036 and 0.038 respectively
21	An experiment study of kerf properties of lead Zirconate Titanate Ceramic machined by AWJM	Ravi prakash Upadhyai et al.[21]	Sme 2017	Journal of Manufacturing eng	PZT 5H ceramic	Traverse speed and water pressure are the most significant factors followed by stand-off distance to control kerf taper. Kerf taper decreases with increase WP and decreases traverses rate & sod
22	Parametric Analysis of Abrasive Water Jet Machining of Aluminum 6351 T6	Mayur C. Patel, et al.[22]	Springer 2014	International Adv Manuf Technol	Aluminum 6351 T6	Kerf Angle decreases as Abrasive mass flow rate increases. Among the process parameters considered in this study Abrasive mass flow rate have most Significant Parameter on Kerf Angle, stand of distance increases kerf also increase

III. CONCLUSION

From literature review it observed that mostly combination of process parameters like abrasive mass flow rate, traverse speed, stand of distance and water pressure performance measures as kerf taper angle investigation. Traverse speed increase, kerf taper angle slightly decrease but higher traverse speed gives large kerf taper angle. As abrasive mass flow rate increase kerf taper

angle decrease, as stand of distance increase kerf taper angle drastically increase. It was found that many researchers have employed different optimization techniques like Taguchi method, ANOVA, Regression analysis to find out the optimum cutting condition for AWJM operation. Also very little work has been reported on effect of nozzle diameters and orifice diameters. So, more work is required to be done in this area.

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