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Experimental studies on hole making process parameters using abrasive water jet machining

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Abstract - Abrasive Water Jet Machining (AWJM) is a nonconventional machining it is used to cut both hard and soft materials. AWJM is widely used in industries for machining the hard materials. In this study, an attempt has been made to drill 304-stainless steel and 2205-super alloy using AWJM by varying the process parameters. Selected number of experiments has been conducted in through-hole making on both work materials. Drilled hole dimensions and surface finish are measured for all the experiments and the results are tabulated. From the study, the suitable process parameters are recommended to achieve the dimensions and surface finish for the given material.

Key words: Abrasive Water Jet machining, through-hole, surface finish

I. INTRODUCTION

The ability of abrasive water jets to carryout accurate cutting of stainless steel and super alloy and other exotic metals has been known for some time in the conventional shaping of parts. Abrasive water jet machining is used to cuts on ductile materials such as steel, aluminium,brass also it is cut brittle materials as glass, stone. The abrasive water jet machine is cutting purpose machine. This mechanism is used for material removal process. The high pressure water jet is used to remove the materials from the work piece. This is very fast process. Abrasive water jet cutting of materials involves the effect of high velocity jet of water with abrasive particles on the material to be cut.

This method is used in various operations of high difficult areas like manufacturing, aero space industry and milling slots. It is very easy and faster process to be cut the any type of materials. This process is fully controlled by the abrasive water jet machining. This process is widely used for aero space industry because of the wings.

This process is very easy to cut the materials and less amount of heat is produced while machining. The abrasive water jet machining is quick process it can cut any type of material. The abrasive particles are used to drill the materials. It is mixing with the water and the water is used as lubrication of the abrasive particles. Garnet is used as an abrasive particle it is very small in size so it is called as grains and in the mixing chamber both water and grain particles are mixed together. The water jet focussing the point mean the abrasive particles cut that particular area only.

The abrasive particles are recycled while machining because the cost of the machining is high by recycling abrasive particle the cost of the operation is reduced. The small grains are fully filtered and dried. The dry particles are used another process of abrasive water jet machining processes. The focusing nozzle size undergoes changes in its geometry due to wear and impact caused by high velocity water and abrasive particles. Abrasive water jet is formed by mixing abrasive particles with high velocity water jets in mixing tube. AWJM is an emerging machining technology option for hard material parts that are extremely difficult to machine by conventional machining process.

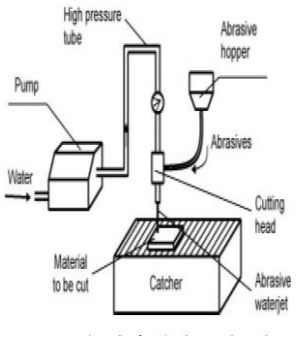

Fig. 1 Outline of abrasive water jet machining

The abrasive water jet machine help to cut the hard material with high accuracy. It will cut any type of material in this process it helps to cut the materials with high performance. It is variable performance machine the pressure and the depth of cut can be adjusted as we required. If Pressure and the depth of cut is reduced, then the surface roughness value will be increased.

II. LITERATURE SURVEY

[1] M. Kantha Babu has attempted to study the effect of local garnet abrasive cutting stainless steel using abrasive water jet machining. It is easy to cut and easy to recycle the abrasive particles. The surface finish is too good and accuracy is high.

[2] S. Zhang described that abrasive water jets offer low temperature, low damage method for machining of the super alloy material. It is easy to cut all type of materials and performance of the water jet machining is very high. The super alloy material surface finishing is very good.

[3] M. EIT obgy explained that a different type of material is removed in this process. It can remove all type of materials. The main mechanism for material removal. This process can safe for the material because of it is fully safe for material damage. The water jet machining is very easier and safe process. The mechanism is used to drilling all type of material.

[4] D.S. Balaji studied that the process parameters are very high and accuracy is very good in the drilling operation. It will cut the material in accurate drilling the blind hole in this process is highly used in various operation of drilling. The various drilling industries prefer abrasive water jet drilling process to cut the materials. In this operation used in automobile and aero space industries.

III. MACHINE COMPONENTS

3.1 Abrasive Nozzle

In the abrasive water jet nozzle, the high pressure water is forced to pass through the control valve the water passed through the small hole in a jewelled orifice typically made of sapphire or diamond. The water pressure inside the abrasive water jet is more than 424 bar. The water entered into the nozzle with high pressure at the top of the cutting nozzle. and it is forced through an orifice which has small hole to create high pressure of water, then the abrasive particle is added in the water. The abrasive particles such as Garnet, Silicon carbide and Aluminium oxide with varies size are mixed water. The water with high pressure moves to mixing tube the abrasive particles is connected to the bottom of the mixing tube through the tube. The water and abrasive particles are mixed with the high pressure and directly focused to the work material through the nozzle.

3.2 Abrasive Catcher Tank

In the abrasive water jet machining the catcher tank is placed bellow the work table to catch the abrasive particles to reuse and this process helps to reduce the cost of the machining. Water will be exit through the outlet valve in the abrasive catcher tank. The air with high pressure is required to operate the valves that raise and lower in the water level and turns On and OFF the nozzle water and abrasive flow.

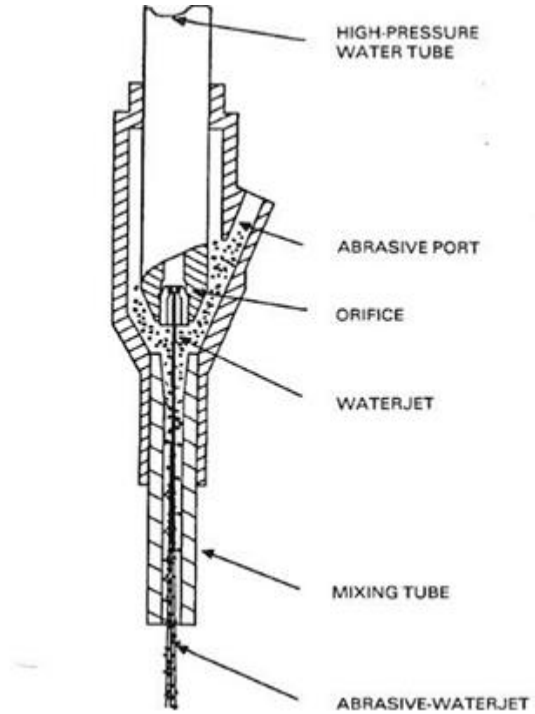

Fig.2 Abrasive nozzle

3.3 Abrasive Hopper

The abrasive hopper is collection of abrasive particles in it and the hopper holds up to 25 pounds (11 kg) and the abrasive flow rate is controlled by the computer and the orifice is placed at the bottom of the hopper. The surface finish is based on the quality of the abrasive particles. The high quality abrasive particles contain very less amount of dust and if the dust is presented in the abrasive particles. The static electrical charges may build up and the quality of the surface finish is reduced.

IV. EXPERIMENTAL SETUP

The abrasive water jet is directly focused to the work material through the nozzle. The high pressure water and abrasive particles are mixed in the mixing chamber and directly produced to the work piece through the orifice hole.

Table 1. Machine specifications

Maximum traverse speed	4572 mm/min
Jet impingement angle	90°
Orifice diameter	0.33 mm
Abrasive flow rate	0.226 kg/min
Mixing tube diameter	0.762 mm
Mixing tube length	101.6 mm
Maximum working pressure	410 Mpa

The abrasive water jet machine is a high power machine where the hard material can be cut easily with high level of accuracy. The garnet is used as abrasive particles for machining. The head mechanism is required for the jet to focus the water to work material.

Table 2. Material specification

Material	Property			
	Quantity		Value	Unit
Stainless steel	Mechanical	Young's modulus	1963000	MPa
		Shear modulus	62100-86000	MPa
		Tensile strength	2.76-3000	MPa
		Elongation	0-62	%
		Fatigue	85-1070	MPa
	Physical	Thermal expansion	10-17.5	e^{-6}/k
		Melting temperature	1230-1530	°C
		Density	7990	kg/m^3
AI-2205	Mechanical	Young's modulus	70000	MPa
		Shear modulus	27500	MPa
		Tensile strength	240-280	MPa
		Elongation	1-3	%
		Fatigue	80	MPa
	Physical	Thermal expansion	15-23	e^{-6}/k
		Melting temperature	550-650	°C
		Density	2750	kg/m^3

The head mechanism helps to increase the focus level of water jet and the pump is connected between the water tank and nozzle to increase the pressure of water. The work piece is placed in the work table and it holds the work piece to reduce the vibration. Jet focus on the particular area for impact. The present work is making nine holes in the two different materials and to check the surface roughness. Different parameters are used as input for the machining. By increasing the traverse speed, the machining time is reduced and that is shown in the flow chart.

The angle of water jet is 90° to make the drill and the pressure, Abrasive flow rate is changed to make the holes. The different readings of different input parameters are noted. The same input parameters for both materials are given the timing and surface roughness is changed because of the material hardness. The abrasive water jet machine is cutting, drilling, and machining the work pieces. This process we are using drilling purposes because of it can drilling the soft and hard materials, in this process is taken less time of drilling the soft material. It will take little time to make a drill in hard material. Abrasive particles are used to drilling the work pieces also the water is used as a lubricant of the materials. The water is help to reduce the temperature of the work piece in this process is used to reduce the drilling timing.

First we are setup the machine on the drilling process and we are check the table movement and nozzle also water tubes of the abrasive water jet machining. Then we are fully set the computer design of the cutting and specifications of the drilling in the work piece these are all fully checked in the experimental setup.

Secondly we are fit the work pieces on the working table as well as fit the dummy material is fitted in the bottom side of the work piece. First work piece is fitted then dummy material at finally the work table these are all fitted in to the work table. Then we are going to feed the materials types and feed the transverse rate, abrasive flow rate, pressure, thickness of the materials is feed in the machine.

The abrasive head is moved to the vertical and horizontal movement. The nozzle is fitted in to the material left side top corner and it will ready to flow the abrasive particles with water. Nozzle is fitted and check the stand of distance with the feeler gauge. The feeler gauge will help to measure the stand of distance. Every time we will check the stand of distance and check the speed of the drilling time is noted in the chart, the chart is help to analysis the speed and abrasive flow rate in the drilling operation. Finally, abrasive water jet machine is drill the both materials, it will take different time period to drill the hard and soft materials.

The abrasive water jet machining can be drilling the all types of materials in the drilling process, it will drill with high pressure and accuracy. In this process is fully analysis the surface roughness. We will check the circularity and cylindersity of the hard and soft materials on the abrasive water jet drilling machine. Comparing to other machines the abrasive water jet is better because of its accuracy and less machining time.

V. WORKING PRINCIPLE

The abrasive water jet machining is used to drilling the all types of materials. This process is starts with water then the water is flow in the water tube the water is sent into the nozzle tube. The nozzle tube sent a water inside of the abrasive water jet machine then the water is sent to the small blower the blower is connected into the abrasive tube. Abrasive tube is connected in right side of the nozzle port. This both tubes are connected inside of the nozzle, then the water is continuously flow in the nozzle the abrasive particles are mixing inside the nozzle. The water is flow high pressure and velocity the nozzle tube is fitted in large into small size, the abrasive particles are mixing in the air gap of the water flow. The water is taking some air gaps the air gap is filled with the abrasive particles. The both abrasive water jet is ready to cut the any type of materials in the machining process. The abrasive water jet machining is help to drilling, cutting, machining the materials operation in the single machining process. It will take less time and less work to do the drilling the materials.

VI. RESULTS AND DISCUSSIONS

In the abrasive water jet machine is drilling the super alloy and stainless steel in accurate drilling process. The drilling is done by different levels of pressure and velocity ratios, this process can be done with minimum and maximum pressure of drilling process. The drilling part is fully checked in the circularity and cylinder city also check the surface finishing of the both materials. The accuracy is very high in different pressure of drill the through hole in the work piece.

Table 3. Drilling time by different parameters

S.No	WP (Mpa)	AFR (kg/min)	SOD (mm)	SS 304 Drilling Time (min)	AL 2205 Drilling Time (min)
1	200	2	0.24	1.75	1.89
2	300	3	0.24	0.57	0.78
3	250	4	0.24	1.13	1.41
4	250	2	0.34	0.99	1.22
5	200	3	0.34	1.48	1.56
6	300	4	0.34	0.71	0.89
7	300	2	0.44	0.64	0.86
8	250	3	0.44	0.89	0.98
9	200	4	0.44	1.34	1.46

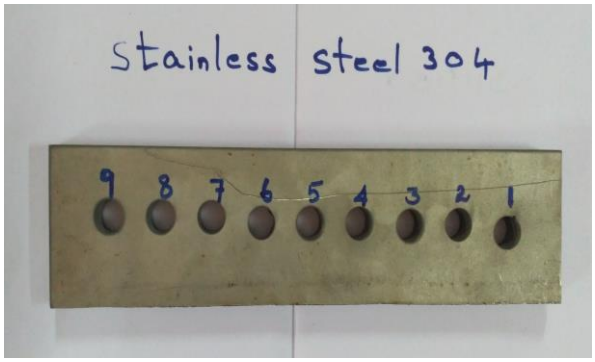

Fig. 3 Stainless Steel 304

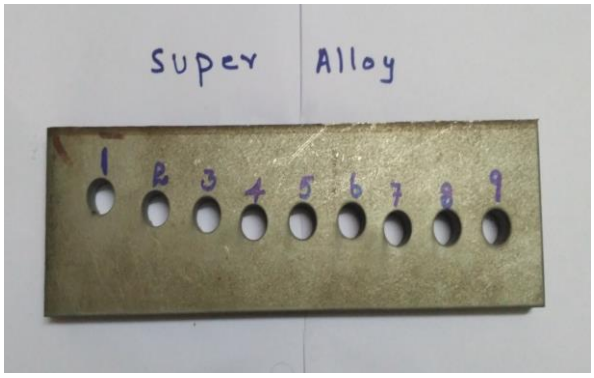

Fig. 4 Super Alloy 2205

VII. CONCLUSIONS

The present work is focused on the making nine holes with different input parameters to check the accuracy of drilling and required dimension. By adjusting the pressure, abrasive flow rate and stand of distance, the dimensions are changed and they are shown in the table. Each circle is made of 10 mm diameter. The result is tabulated for both stainless steel 304 and super alloy 2205 materials.

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