A COMPREHENSIVE REVIEW IN THE FIELD OF NOZZLE IN AWSJ MACHINING

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Abstract

The progress in research and development in the field of making composites and advanced ceramic formulated in high performance material, but on other hand it also offers various challenges when shaping (cutting) them in desired shape and size. It also believed that these materials cannot be effectively been machined by conventional machining techniques. Excluding economics, the selection process mainly depends upon the machined surface integrity. The water jet with multiphase i.e. liquid + abrasive + air, makes this cutting process one viable option as compared to other conventional processing.The process use an abrasive jet with high velocity, to remove material and provide smooth surface finish to hard metallic work pieces. In an abrasive water suspension jet produce be an Abrasive particles in the suspension mixture which cause acute skin friction effect thereby effectively changing the jet diameter due to wear, which itself influences jet exit kinetic energy. The nozzle wear is not fully understood experimentally; also the uncontrolled nozzle wear can affect the effective and surface finish obtained through the AWSJ machining process. In the present work, the effect of geometrical parameters of single step nozzle and abrasive size on skin friction coefficient at the wall of nozzle due to wall shear stress and jet exit kinetic energy has been analyzed by ANSYS software. This analysis is totally depends on nozzle geometry and nozzle material is taken same for all cases. This analysis can be highly helpful for understanding nozzle wear during the AWSJ machining process.

Keywords: AWSJ, Process Parameters, Optimization

1. Introduction

Abrasive water suspension jet (AWSJ) machining process is non-conventional machining process, which has been used in industrial applications. AWSJ machining process operates at relatively high pressure (10-1000 M Pa) and focused stream of abrasive particles carried by high pressure water is made to impinge on the work material is removed by erosion by high velocity Abrasive particles. In abrasive water suspension jet machining process pure water (tap water) is used and for abrasive particles like sand (SiO2), glass beads, Aluminium oxide, and silicon carbide is generally used. In AWSJ machining in which suspended abrasive particles in liquid medium called slurry is pressurized and expelled through the nozzle. Slurry is accelerated through a fine orifice to produce a high velocity stream, which is capable of machining a range of materials. Two types of nozzles generally useful for average material removal, tungsten carbide nozzle have a useful life of

12 to 13 hr. and sapphire nozzles have a useful life of 3hr. Benefit of AWSJ over AWJ is the generation of static jet with higher power density, which tends to efficient energy transfer to abrasive particles. The Nozzle wear is a complex phenomenon, which is not only influenced by the material properties of the nozzle but also by the its geometry and operating parameters of AWSJ. M. Nanduri et al [5] has investigatedexperimental effect of nozzle geometricparameters and system parameters on nozzle wear was studied. An empirical model was created for the prediction the wear. Umanganand et al [6] has done experimental investigation that, a used porous nozzle surrounded by are servoir containing high viscosity lubricant and reach agreement that type of nozzle used for preventing nozzle wear in AWSJ cutting. Kyriaki et al [7] has done software analysis on AWJ machining analyzes in detail the work piece material behaviours under water jet impingement, a non-linear FE model (using LS-DYNA 3D code) was developed for studying the water jet cutting process and it also used for the optimization of the water jet parameters. Mostofa et al [8] CFD and theoretical analysis of abrasive water jet cutting head the simulation results show that the velocity of the water jet contribute the erosion rate at the nozzle wall, and erosion rate increases on the focusing tube wall with in the change in the particle shape factor. Deepak et al [1] CFD investigation shows that how effect of inlet operating pressure on skin friction coefficient and jet exit kinetic energy in single stepnozzle in AWSJmachining.

2. Literature

D. Deepak el at [1] 2012, CFD Simulation of flow in an Abrasive Water Suspension Jet: The Effect of Inlet Operating Pressure and Volume Fraction on Skin Friction and Exit Kinetic Energy.The work examines the effect of inlet pressure on skin friction coefficient and jet exit kinetic energy. It is inferred from the analysis that an increase in inlet pressure causes a significant increase in skin friction coefficient and also results in proportional increase in the exit kinetic energy of the jet. Further, it is revealed from the analysis that an increase volume fraction of abrasive (abrasive concentration) in water results in significant decrease in the skin friction coefficient and jet exit kinetic energy.

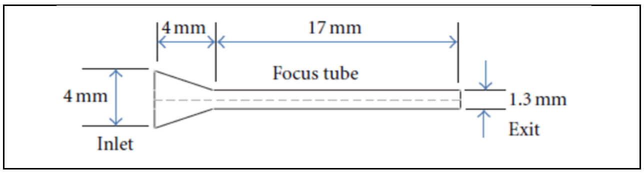

Figure 1 : Computational model of AWSJ nozzle

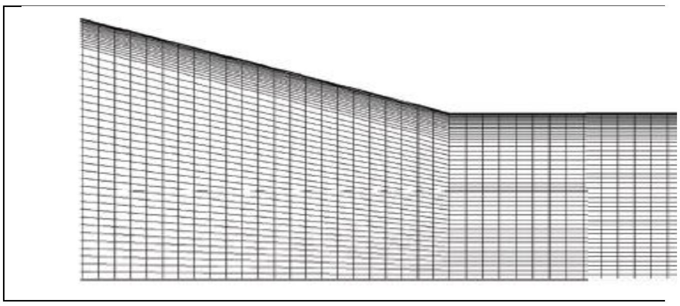

Figure 2: A portion of the meshed domain near the critical section

Saurabh Verma1 el at 2014, CFD analysis of nozzle in abrasive water suspension jet machining. The effect of geometrical parameters of single step nozzle and abrasive size on skin friction coefficient at the wall of nozzle due to wall shear stress and jet exit kinetic energy has been analyzed by ANSYS software.

S Venugopal 1M Chandresekaran2 V Muthuraman3 and S Sathish4, Computational Fluid Dynamics Analysis of Nozzle in AbrasiveWater Jet Machining. The analysis would be carried out by varying the inlet pressure of the nozzle, so as to obtain optimized process parameters for minimum nozzle wear.

Shukla and Singh 2017 experimentally examined the parameters of the abrasive water jet machine and applied a optimization technique i.e. Taguchi and evolutionary approach. Their paper illustrates the application of applied optimization approach. Optimal process parameters of AWJM has been given and for experimentation AA6351 Al alloy has been used where effect of kerf top width and tape angle has been parametrical investigated. The obtained result has been compared with seven different optimization algorithms and the results are showing good validation.

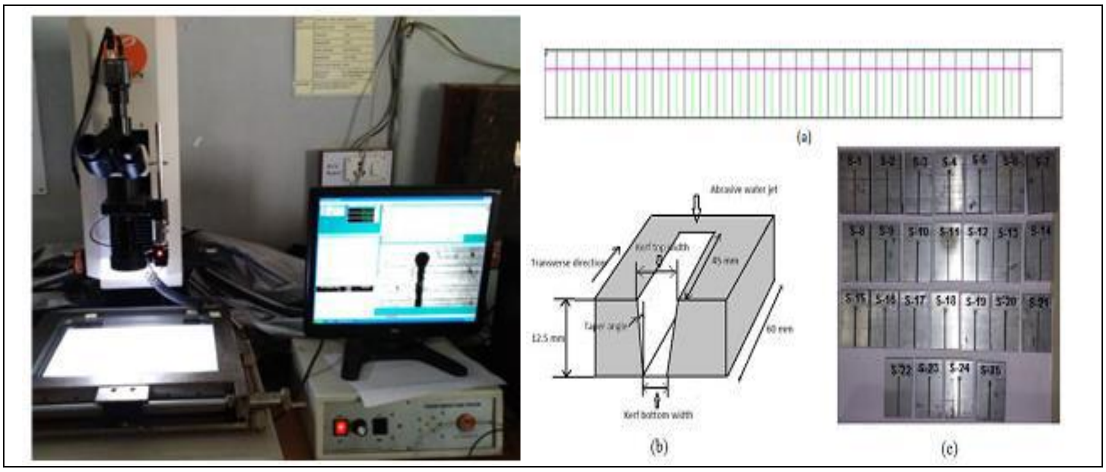

Figure 3. (a) Workpiece design in AutoCAD for straight cut in AA6351 T6 specimen (b) schematicdiagram for parameters (c) Prepared specimens [1]

SookhakLari et al. 2017 use an novel rotating Elastomeric mask system for forming 3 dimensional characteristic by means of abrasive jet micro machining. Their work explains the new technique to instant machining through AJM. The validation of experimentation has been done by W-shaped symmetric and asymmetric, trapezoidal and wedge shaped footprints. Moreover, they also explain the benefits of the novel rotating mask system.

Žarko et al. 2016 applied extreme learning machine approach to develop a model to examine the roughness of machined surface by abrasive water jet machining. The result predicted by ELM model has been compared with genetic algorithm of ANN model. It has been found that the results of ELM model has high degree of accuracy and can be utilized for further work.

Chetana S. Chopade1, Navneet K. Patil2, A Review on Nozzle Wear Using CFD Analysis in Abrasive Water Suspension Jet Machining.A review on nozzle wear in abrasive water jet machining. A comprehensive literature review for the proposed work is also being described. This analysis can be highly helpful for understanding nozzle wear during the AJM process.

K. Sreekesh1 and P. Govindan2, Experimental Investigation and Analysis of Abrasive Water-Jet Machining Process. This paper presents a comprehensive experimental investigation of the process, based on the material removal mechanism. Also indicated a possibility of applying abrasive water jet machining for fine polishing of machined surfaces.
1B. Satyanarayana, 2G.Srikar, Optimization of abrasive water jet machining process parameters using taguchi grey relational analysis (TGRA).To optimize material removal rate and kerf width simultaneously using AWJM process on INCONEL 718. The process parameters are chosen as abrasive flow rate, pressure, and standoff distance. Taguchi Grey Relational Analysis is opted because of multi response optimization. The optimal parameter values are abrasive flow rate at 20.41 gm/sec, pressure at 344.7Mpa and standoff distance at 3mm. At these parameters the values of MRR and kerf width are 1053.2 mm3/min and 1.54mm respectively. It is shown that the performance characteristics of the AWJM process, namely water jet pressure, abrasive flow rate and standoff distance are improved together by using Taguchi Grey Relational Analysis.
Santhosh Kumar el at 2017, A Review on Abrasive Flow Machining (AFM).An attempt has been made to review various published technical papers on AFM and segregated into four categories - experimental setups, abrasive media, modeling and optimization and applications. Media development usually uses the available polymer media are polyborosiloxane and silicone rubber andcommonly used abrasives are silicon carbide, aluminum oxide, boron carbide and polycrystalline diamond.

3. Conclusions

On the basis of literature review various conclusion has been drawn which has been in enlisted below.

- It has been found that AWJM is significantly gaining an attention in the area of material cutting and machining particularly in machining advanced material such as ceramic and composites. Since this offer various unique benefits over other conventional and non-conventional techniques which make it a most promising choice in the machining industry.
- Insufficient literature available so far revelation the standoff distance at the optimal value during the AWJ cutting process by monitoring and control. This kind of work has not been seen reported for any other parameters. So, more work is required to be done in this area.
- In most of all research work, mainly traverse speed, waterjet pressure, standoff distance, abrasive grit size and abrasive flow rate have been taken into account. Very little work has been reported on effect of nozzle size and orifice diameter.
- Most of the research on optimization work has been carried out on process parameters for improvement of a single quality characteristic such as depth of cut, surface roughness, material removal rate, kerf geometry and nozzle wear.
- There is no any research paper found based on the optimization for the power consumption, dimension accuracy and multi-objective optimization of AWJM process. So, this area is still open for future research work.
- parameters that influence the nozzle wear are nozzle length, nozzle diameter, nozzle inlet angle, orifice diameter, water pressure and abrasive flow rate is done.
- Increase in orifice diameter results in significant decreases in the skin friction coefficient and also decrease in jet exit kinetic energy.
- Increased in abrasive particle density results in significant decreases in the skin friction coefficient and also decrease in jet exit kinetic energy.

- Increase in abrasive size results in slightly increase in the skin friction coefficient and also slightly increase in jet exit kinetic energy.

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