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"A REVIEW ON NOZZLE WEAR USING CFX ANALYSIS IN ABRASIVE WATER SUSPENSION JET MACHINING"

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ABSTRACT

Abrasive waterjet (AWJ) machining process utilized increasingly in industrial applications. It is a non-traditional machining process and involves complex mechanics. The main problem of AWSJ machining process is nozzle wear during the process. The wear of nozzle depends on various parameters such as water jet characteristics, abrasive size and nozzle geometry, etc. Also the inlet pressure of the abrasive water suspension has significant influence on the erosion characteristics of the inside surface in the nozzle. The uncontrolled nozzle wear can affect the effectiveness and surface finish obtained through the AWSJ machining process. The wear rate of the nozzle can be minimized by controlling these parameters. This paper discusses a review on nozzle wear in abrasive water jet machining. In machine tools industry is very important to reduce the costs when are using the lubricant and coolant fluids to increase the productivity. It was been performed a simulation of the fluid flow through a nozzle, that nozzle type is commonly used for pressure cooling of the machined area. In these types of nozzles can be made a mixture of two types of fluids, such as air and water, to increase machined productivity and decrease the quantity of lubricant used for cooling systems.

KEYWORD: *Abrasive water jet (AWJ) machining, nozzle geometry, nozzle wear, fluid flow, pressure, lubricants*

I. INTRODUCTION

Coolants used in machine building are polluting, excessively using of coolants are improper from point of view of its costs. According to the researches carried out in that field, costs of acquisition and maintenance of cooling fluids occupies 7.5 % and 17 % of the total production, respectively where the cost of tools is only 4 % [1]. Coolants generally may not be easily recycled due to chemical reactions that occur during processing at the contact between liquid and the surface to be cooled. Furthermore flow of coolant leads several particles, dust, metal powder which is very harmful to the environment. Another problem of cooling liquids may be the volatile substances can be released to machined process these can be inhaled by the operator could be unwholesome [2]. A generally accepted trend is to reduce the amount of fluid used for machining process by finding of appropriate geometries of the dispersion nozzles. The choosing of these cooling liquids is been made from several points of view: by achieving of cooling in the processed area, by the lubrication and its impact on the environment. Complete renunciation of using cooling fluids may not be always possible; knowing that the cooling fluid removes most of the heat generated in machining process also decreased and the residual stresses which may occur in the worked piece, the resulting most improved quality of the machined surface [3]. In the cutting process to reduce costs of coolants and increase productivity may be used

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mixed fluids blended in a nozzle specifically designed for this purpose and it shall be released into the cutting zone by air-liquid mixture (aerosols). By this technique is also achieved savings of working fluids, being able to achieve their optimization in order to use a minimal amount of the coolant [4]. This paper aims at an analysis the way in which a fluid flows through a small dimensions convergent nozzle. That nozzle combines two working fluids, one gas (air) and another liquid (water). Nozzle type chosen is a common type with a high degree of processing and low price cost. That fluid flow study is needed to understand the occurring phenomena and ways to improve cooling by accurately directing of the fluid flow by using a minimal quantity of lubricant to achieve cooling of the processed area.

Figure.1 Fountain water nozzle

Nozzle Characteristic:

Nozzle acts as three important functions in the abrasive water jet machining process. The first function is to enable the action of jet pumping for abrasive entrainment and also provides the environment for abrasive acceleration. Nozzle also helps in focusing the abrasive during the machining process. Parameters that are used in abrasive water jet machining process will affect the wear of the nozzle Normally the materials used to produce nozzle are silicon carbide, tungsten carbide, boron carbide, tungsten carbide cobalt and also composite carbide.

Wear Characteristic:

Wear of the nozzle will lead to the degradation of the quality of the cut surfaces and causes the undesirable changes in the geometry of the work pieces. Nozzle wear is the result of the process of material removal as the two surfaces are in sliding contact. Wear test has been done in order to get the nozzle wear profile. Nozzle wear test typically falls into two categories which are accelerated wear test and regular wear test. Accelerated wear test is either using soft nozzle material or using hard abrasive such as aluminium oxide or silicon carbide. The tests are useful for a quick screening and comparing the nozzle material. While, regular wear test or actual test is conducted using application-specific nozzle or standard nozzle and standard abrasive material that are used in the industry to determine the wear performances [4]. Nozzle wear profile can be determined using several methods which are nozzle bore profile, weight loss method and gage pin method. Nozzle bore profile can be found out by sectioning the nozzle longitudinally and measuring the profile using coordinate measuring machine. The other method is by making casting of the bore using a silicon resin [6]

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II. LITERATURE REVIEW

Syazwani [1] published "A review article on nozzle wear in abrasive water jet machining application." Design, materials, and life of the nozzle give significance effect to the nozzle wear. A new nozzle using a tungsten carbide-based material has been developed to reduce the wear rate and improve the nozzle life. Apart from that, prevention of the nozzle wear has been achieved using porous lubricated nozzle.

Rakesh Kumar Sahu and Saurabh Verma [2] worked on "Optimization of Parameters to Minimize the Skin Friction Coefficient in Abrasive Water Suspension Jet Machining through TLBO (Teaching-Learning-Based Optimization)". In this work According to the structure of nozzle computational domain has been modeled using commercially available preprocessor routine called GAMBIT, and CFD Analysis has been performed in ANSYS (fluent) to obtain the values of SFC for values of parameters.

Md. G. Mostofa and Kwak Yong Kil [3] worked on "Computational fluid analysis of abrasive waterjet cutting head." This paper presents computational fluid dynamics (CFD) and theoretical analyses to optimize the mixing of components by the multi-phase approach. Result shows that nozzle length has an effect on the mixing of water, air, and the abrasives, and that the velocity of the water jet influences the erosion rate at the nozzle wall.
M. Nanduri et al [4] has investigated experimentally the effect of nozzle geometric parameters and system parameters on nozzle wear was studied. An empirical model was developed for the prediction the wear .A Beautiful attempt to decrease the nozzle wears in AWSJ cutting.

Saurabh Verma and S. K. Mishra [5] have worked on "CFD analysis of nozzle in abrasive water suspension jet machining." This paper aims to study nozzle wear during the process, which depends on various parameters such as water jet characteristics, abrasive size and nozzle geometry, etc.

M. Hashish et al. [6] experimentally investigated observations of wear of abrasive-water jet nozzle materials. The objective was to use the abrasive-water jet to find a correlation between the candidate nozzle material's wear performance and its machinability.
The main objective of this test was to determine the critical ratio of particles diameters to tube diameter at which the wear rate stabilizes and become very slow.

Deepak D [7] worked under the title "Numerical Analysis of Flow through Abrasive Water Suspension Jet." They studied Effect of Inlet pressure on wall shear stress and jet exit kinetic energy. It is found from the analysis that an increase in inlet pressure results in significant increase in the wall shear stress induced. Also an increase in inlet pressure results in proportional increase in the jet kinetic energy. From the work he concluded that Increase in inlet operating pressure results in significant increase in the wall shear stress.

M. Rajyalakshmi and P. Suresh Babu [8] published "A review paper on current development in Abrasive Water Jet Machining." They studied that quality of the work piece is depends on various design parameters. The quality parameters considered in AWJM are Material Removal Rate (MRR), Surface Roughness (SR), Depth of Cut, kerf Characteristics and Nozzle wear.. Various statistical and modern approaches are applied to optimize these process parameters to improve the performance characteristics.

Umang Anand [9] worked under the title "Prevention of Nozzle Wear in Abrasive Water Suspension Jets (AWSJ) Using Porous Lubricated Nozzles." The research introduces a new method for preventing nozzle wear in abrasive water jets by using a porous nozzle, surrounded by a reservoir containing high-viscosity lubricant, which is exposed to the same driving pressure as the flow in the nozzle. This paper clearly demonstrates that the porous lubricated nozzles can substantially reduce the extent of nozzle wear of abrasive water suspension jets.

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Saurabh Verma [10] worked under the title "Nozzle Wear Parameter in Water jet machining." From this paper it has concluded that the Efficiency of AWJM process is depending on nozzle wear and nozzle wear is depending on so many process parameter and geometrical parameters.

Deepak D, Anjaiah D, and Yagnesh Sharma[11] worked on "Numerical Analysis of Flow through Abrasive Water Suspension Jet: The Effect of Garnet, Aluminum Oxide and Silicon Carbide Abrasive on Skin Friction Coefficient Due to Wall Shear and Jet Exit Kinetic Energy." They studied that the erosion characteristic of each abrasive is different. Numerical simulation indicates that garnet abrasives produce better jet exit kinetic energy than aluminum oxide and silicon carbide.

Rajeev Kumar [12] worked under the title "Analysis on Performance of Different Parameters during Abrasive Jet Machining by Taguchi Method." In this research the effects of parameters of micro AJM onmaterial removal rate (MRR, gm/sec) and overcut (mm) during micro machining of Silicon glass. It is observed that MRR of glass, machining by AJM, is increased by increasing Pressure. MRR also increased by decreasing Nozzle Diameter.

H. Liu et al [13] studied a abrasive water jet characteristics by CFD simulation and CFD models produced for abrasive water jet and ultrahigh velocity water jets were established using the Fluent6 flow solver.

III. Objective

A. Study of wear problem of nozzle:
Wear of the nozzle becomes a major problem since it may affect the water jet machining performance. Design, materials, and life of the nozzle give significance effect to the nozzle wear. Furthermore, wear of the nozzle will lead to the degradation of the quality of the cut surfaces and causes the undesirable changes in the geometry of the work pieces. Nozzle wear is the result of the process of material removal as the two surfaces are in sliding contact.

B. Study of factors affecting on wear rate:

Various parameters may influence the wear rate of the nozzle such as
Nozzle Length
Nozzle Inlet angle
Nozle diameter
Orifice diameter
Abrasive flow rate
Inlet operating pressure of water

C. Study of the effect of geometrical parameters of single step nozzle
The effect of geometric parameters like length of nozzle, nozzle diameter, Inlet diameter of nozzle, orifice diameter is studied.

D. Study of the effect abrasive size on skin friction coefficient
There is presence of skin friction coefficient at wall of nozzle due to wall shear stress. The effect of abrasives i.e. size of abrasive particles, abrasive flow rate will be studied.

IV. Discussion

This literature review presents various researchers' work for minimizing wear rate of nozzle. Various analyses are done to study effect of nozzle geometry, abrasive size, focus length of nozzle, orifice diameter on skin friction coefficient and jet exit kinetic energy. The literature found related to modeling and optimization of AWJM is mainly based on statistical design of experiments (DOE) such as Taguchi method and response surface method. Few researchers concentrated on modeling and optimization of AWJM through other techniques such as artificial neural network (ANN), fuzzy logic (FL), genetic algorithm, grey relational analysis, simulated annealing, artificial bee colony etc.

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V. CONCLUSION

Nozzle wear is the result of the process of material removal as the two surfaces are in sliding contact. The study of parameters that influence the nozzle wear are nozzle length, nozzle diameter, nozzle inlet angle, orifice diameter, water pressure and abrasive flow rate is done. Various researchers have done remarkable investigation on these parameters for controlling wear rate of nozzle. From literature, it shows that CFD solutions get validated with experimental as well as analytical results. In the long run, further study should be done to find the solution on the nozzle wear.

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