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STRESS ANALYSIS ON ABRASIVE WATER PIPLINE OF ABRASIVE WATER JET MACHINING USING CAESAR-II

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ABSTRACT

Variety of distinctive advantages over the additional Conventional material elimination method. It is an efficient machining method for processing a range of Hard and Brittle objects and has a non-traditional cutting technology, such as, high machining adaptability, smallest amount of stress on the workpiece, more Abrasive water jet machining is the non-flexibility no thermal deformation, and little cutting forces. The AWJM is a abrasive water jet machine and housed with various types parts like as motor, pump, intensifier, accumulator, controls, hydraulic unit, valves, nozzle. AWJM process is briefly explained in the introduction section of the paper. It is very useful in fields were cutting and drilling soft materials is required, it used in turning operation and also in paint removal. This paper is developing the major drawback of pressure drop due to high stress produced on the pipe. The paper concentrated on major drawback of pressure drop and gas leakage occurs.so, the material ASTM A106 Grade A Carbon Steel is used.This paper illustrates the wide range of abilities, backgrounds and will cover the fundamental principles and concepts used in pipe stress analysis. This analysis pipe is used to give the benefit of the industry for reduce the cost and maintenance and increases the lifetime of pipe.

Keywords*: ASTM B31.3, Restrain, Nozzle, Expansion joint, CAESAR II*

I. INTRODUCTION

Water Jet Machining (WJM), or in other words water jet cutting, is a mechanically advanced unconventional machining process where water having a very high velocity is used to erode away small portions of materials from the workpiece surface. WJM was initially used for cutting soft materials, cleaning and removal of coating in early 70s. Softer materials like wood, plastic and rubber were cut using this technique. It does not encounter any vibration problems. However, in order to machine hard materials like metals and granite, another machining process called Abrasive Water Jet Machining (AWJM) was developed. Figure 1 shows as .Abrasive Water Jet Machining.

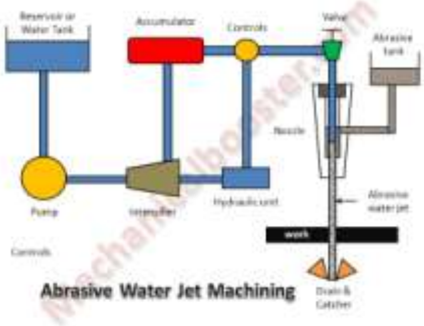

Figure 1.Abrasive Water Jet Machining

AWJM is an unconventional machining process which gets results by the combined efforts of abrasive jet machining and water jet machining (WJM) such that the drawbacks of each individual process is overcame. It enhances and betters the capability of WJM for machining hard or strong materials. In AWJM, jet of water having very high velocity is mixed with abrasive particles to improve the efficiency of the process in terms of material removal rate and making it possible to cut all the materials (NO matter hard or soft). Here, the high velocity and high pressure of water is mixed with small abrasive particles on the workpiece which erodes the material due to impact causing material removal. This process is environmentally friendly and does not affect the properties of the materials (or) its internal structure) as it has no thermal effects. Both WJM and AWJM are modern machining process that do not create any heat affected zone or residual stress on the machined surface or workpiece. Analysis of AWJM piping system to use the CAESER II piping software with the various cases used to find out the data.

II. LITERATURE SURVEY

Hague.M.M et al (1907) analyses the performance of different abrasive particles in abrasive water jet machining of glass. They compare the effect of different abrasives on taper of cut by varying the stand-off distance, work feed rate, pressure. Garnet abrasive produce the largest taper of cut, followed by aluminum oxide, and silicon carbide. The study also describe that the taper of cut increases with increase in the standoff distances because water jet get widen with increase in standoff distance. The taper of cut decreases with increase in jet pressure, with increase in pressure the cutting energy of jet increases. The depth of penetration of jet increases with increases in hardness of abrasives.

Ahsan.A.K et al (1977) conducted a practical study for analyzing the surface roughness and kerf taper ratio of glass/epoxy composite laminate machined using abrasive water jet machine. The various process parameters considered are abrasive types (2-level), hydraulic pressure (3-level), standoff distance (3-level), abrasive flow rate (3-level), traverse rate (3-level), cutting orientation (3-level). The optimization of AWJM was done with the use of Taguchi method and ANOVA (analysis of variance). The ratio of top kerf width to bottom kerf width is called Kerf taper ratio. Types of abrasives and traverse speed are insignificant parameter for surface roughness while hydraulic pressure is most significant factor that influences surface roughness in AWJM. Standoff distance (SOD), cutting orientation and abrasive mass flow rate are equally significant factors that influence surface roughness, but the kerf taper ratios are influenced by hydraulic pressure, abrasive mass flow rate and cutting orientation. Abrasives type, standoff distance and traverse speed are most significant factors that had significant influences on kerf taper ratio. The quality of cutting in AWJM can be increased by increasing the kinetic energy of the water jet.

Ahmet Hascalilk et al (2014) has carried out the study of effect of traverse speed on AWJM of Titanium alloy. The width of cutting, changes with changes in traverse speed. The study also reveals that the kerf taper ratio and surface roughness increases with increases in traverse speed. The increase in traverse speed reduces the interaction of abrasives particles and the work piece thus narrow kerf widths with a greater kerf taper ratio can be cut with AWJM.

N. Ramesh Babu et al (2017) .worked on 6063-T6 aluminum alloy to find efficient strategy and quality cutting of materials with abrasive water jets considering the variation in orifice and focusing nozzle diameter in cutting. The study found that the effect of orifice size and focusing nozzle diameter on depth of cut, material removal rate, cutting efficiency, kerf geometry and surface roughness. The study suggested that a ratio of 3:1 between focusing nozzle diameter to orifice size was best suited combination to achieve the maximum depth of cut out of several combinations of focusing nozzle to orifice size. They suggest that the ratio of 5:1 and beyond cause ineffective entrainment of abrasives in cutting head. The investigation also analyze that the increase in hydraulic pressure for different combinations of orifice and focusing nozzle size the depth of cut increases. The material removal rate also increases with an increase in the size of focusing nozzle up to 1.2 mm diameter and further increase tends to decrease the material removal rate. The abrasive flow rate has less significant on kerf width. This study suggests that taper of kerf can be minimized by maintaining the orifice size and focusing nozzle size within certain limits raging from 0.25–0.3 mm and 1.2 mm, respectively. The surface quality does not depend on the increase in the size of orifice and focusing nozzle but larger size of orifice, produce a better surface finish on cut surface.

W.C.K. Wong et al (1999) conducted a statistically designed experiment to study the effect of abrasive water jet cutting of metallic coated sheet steels. The relationship between kerf characteristics and process parameters are also investigated in this experiment. An empirical model was developed for kerf geometry and quality of cut for the prediction and optimization of AWJ cutting performance. A three-level four-factor full factorial designed experiment performed for analyzing the AWJM process. The various process parameters used are water jet pressure, traverse speed, abrasive flow rate and standoff distance (SOD). The study found that the top and bottom kerf widths increase with increase in hydraulic pressure, standoff distance but the rate of increase for the bottom kerf width is smaller. The traverse speed produces a inverse effect on the top kerf width and bottom kerf widths but at same time the kerf taper increase as the traverse speed increase. The surface roughness of the cut surface decreases with an increase in the abrasive flow rate.

Mohemed Hashish (1996) observed that as the pressure increases the power required for cutting get reduced drastically. This suggests that cutting at higher pressure is more efficient than at low pressure for the same power consumption. Plain waterjets are capable of cutting thin sheet metals at pressure of 600 Mpa. Elevated pressure promise cost reduction due to reduction in abrasive usage or increased cutting speed. The study shows that the depth of cut increases with increases in water pressure.

K.R. Chang et al (2001) conducted experimental evaluation on the kerf formation over ceramic plate cut with an abrasive water jet. It found that a critical combination of hydraulic pressure, abrasive flow rate and traverse speed are required for through- out cut of ceramics, below which it cannot be achieved for certain thickness. A sufficient supply of hydraulic energy, fine mesh abrasives at moderate speed gives smooth kerf surface. By experiment investigation they found that International Journal of Recent advances in Mechanical Engineering (IJMECH). increase in traverse speed and decreases with increase pressure and abrasive size. Abrasive flow rate has no influence over taper ratio.

III OBJECTIVES

The main objectives,

- To overcome this problem,carbon steel (ASTM A106 Grade A) Material is replaced by nylon material.
- To increase the lifetime of piping in abrasive water jet maching **.**

IV METHODOLOGY

The basic rules for piping engineering are ASME B31 codes. The important codes in Fig:1 (ASME:AMERICAN SOCIETY OF MECHANICAL ENGINEERING)

- ASME B31.1 - Power Piping ,
- ASME B31.2 - Fuel Gas Piping,
- ASME B31.3 - Process Piping
- ASMEB31.4 - Liquid Piping
- ASME B31.5 - Refrigeration Piping,
- ASME B31.8 - Gas Distribution and Transportation
- ASME B31.9 - Building Service Piping
- ASME B31.11 - Slurry Piping Each Code provides the typical loading conditions to be considered; allowable stresses; minimum wall thickness calculations; and minimum fabrication, inspection and testing requirements.

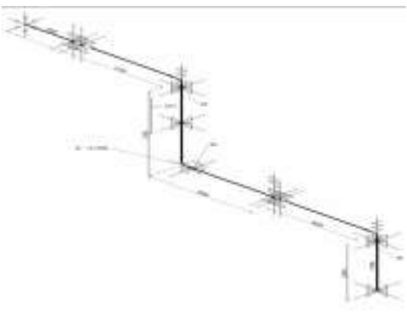

Figure1: Isometric view of piping system to be designed.

Figure2: 3D view of supply pipeline of AWJM.

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To only using the piping code 31.3 processing piping. The pipe code is used to find out stress analysis data's.

III. RESULTS AND DISCUSSION

There are cases 1 to cases with data's collecting from the CAESER II piping software, below the table column explained for displacement, restrain, nozzle check, flange PEQ, global element force, stresses, code compliance these are reports to help the analyzing.

a) STRESS ANALYSIS (Stresses in kpa)

LOADCASE 3 (OPE) W+D1+T1+P1+H			
	ASTM A106 A	Nylon	
OPE Stress	45389.7	96291.3	
Axial Stress	43177.4	43342.1	@Node 100
Bending Stress	44562.8	95182.5	@Node 40
Hoop Stress	97825	97825	@Node 98
Max Stress Intensity	138349.9	138349.9	@Node 98
LOADCASE 5 (OPE) W+T2+P1+H			
	ASTM A106 A	Nylon	
OPE Stress	45389.7	96291.3	
Axial Stress	43177.4	43342.1	@Node 100
Bending Stress	44562.8	95182.5	@Node 40
Hoop Stress	97825	97825	@Node 98
Max Stress Intensity	138349.9	138349.9	@Node 98
LOADCASE 7 (OPE) W+T3+P1+H			
	ASTM A106 A	Nylon	
OPE Stress	45389.7	96291.3	

Axial Stress	43177.4	43342.1	@Node 100
Bending Stress	44562.8	95182.5	@Node 40
Hoop Stress	97825	97825	@Node 98
Max Stress Intensity	138349.9	138349.9	@Node 98
LOADCASE 10 (EXP) L10=L3-L9			
	ASTM A106 A	Nylon	
Code Stress	44655.9	100955.4	
Axial Stress	7119.9	16096	@Node 20
Bending Stress	44648.1	100937.8	@Node 40
Hoop Stress	0	0	@Node 20
Max Stress Intensity	44655.9	100955.4	@Node 40
LOADCASE 11 (EXP) L11=L5-L9			
	ASTM A106 A	Nylon	
Code Stress	44655.9	100955.4	
Axial Stress	7119.9	16096	@Node 20
Bending Stress	44648.1	100937.8	@Node 40
Hoop Stress	0	0	@Node 20
Max Stress Intensity	44655.9	100955.4	@Node 40
LOADCASE 13 (EXP) L13=L7-L9			
	ASTM A106 A	Nylon	
Code Stress	44655.9	100955.4	
Axial Stress	7119.9	16096	@Node 20

Bending Stress	44648.1	100937.8	@Node 40
Hoop Stress	0	0	@Node 20
Max Stress Intensity	44655.9	100955.4	@Node 40

IV. CONCLUSION:

Quality of cutting surface in AWJM is depending on so many process parameters. Process parameter which affects less or more on quality of cutting in AWJM are hydraulic pressure, Standoff distance, types of abrasive, size of abrasives, abrasive flow rate, nozzle diameter, orifice size, and traverse speed. Quality of cutting surface is measured by material removal rate, surface roughness, kerf width, kerf taper ratio. From the literature review compare to above all mentioned, parameter traverse speed is most effective parameter for MRR. Abrasive flow rate is also an important parameter for increasing MRR.The Caesar ii software analysis of abrasive water pipeline to analysis to above results base. The analyzing pipe is used to benefit of industry for reduced cost and maintenance and increases the life time.

In load case 3 (Operational load condition): OPE stress of carbon steel is 50% greater than nylon. Bending Stress of carbon steel is 51% greater than nylon@ node 40. Hoop stress of both carbon steel and Nylon are Equal@ node 98. Maximum stress intensity of both carbon steel and nylon are Equal@ node 98. Axial stress of carbon steel and nylon are equal @ node 100.

In load case 10 (Exponential load condition): code stress of Carbon steel is 56% is lesser than nylon. Axial Stress of Caron steel is 54% greater than nylon.@ node 20. Bending stress of carbon steel is 56% greater than nylon.@ node40.Hoop Stress of both carbon steel and nylon is Zero@ node 20. Maximum intensity of carbon steel is 56% greater than nylon.@ node 40.

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