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WATER JET CUTTING & MACHINING

Shree venkateshwara hi-tech engineering college, mechanical department,

Ramu .M, Ramesh .R and Sridhar.S.

Abstract—In the battle to reduce costs, engineering and manufacturing departments are constantly on the lookout for an edge. The water jet process provides many unique capabilities and advantages that can prove very effective in the cost battle. Learning more about the water jet technology will give us an opportunity to put these cost-cutting capabilities to work. Beyond cost cutting, the water jet process is recognized as the most versatile and fastest growing process in the world. Water jets are used in high production applications across the globe. They compliment other technologies such as milling, laser, EDM, plasma and routers. No poisonous gases or liquids are used in water jet cutting, and water jets do not create hazardous materials or vapors. No heat effected zones or mechanical stresses are left on a water jet cut surface. It is truly a versatile, productive, cold cutting process. The water jet has shown that it can do things that other technologies simply cannot. From cutting whisper, thin details in stone, glass and metals; to rapid whole drilling oftitanium; for cutting of food, to the killing of pathogens in beverages and dips, the water jet has proven itself unique. THEORY OF WATER JET CUTTING Most water jet cutting theories explain water jet cutting as a form of micro erosion as described here. Water jet cutting works by forcing a large volume of water through a small orifice in the nozzle. The constant volume of water traveling through a reduced cross sectional area causes the particles to rapidly accelerate. This accelerated stream leaving the nozzle impacts the material to be cut. The extreme pressure of the accelerated water particles contacts a small area of the work piece. In this small area the work piece develops small cracks due to stream impact. The water jet washes away the material that "erodes" from the surface of the

work piece. The crack caused by the water jet impact is now exposed to the water jet. The extreme pressure and impact of particles in the following stream cause the small crack to propagate until the material is cut through instructions give you guidelines for preparing papers for IEEE conferences. Use this document as a template if you are using Microsoft Word 6.0 or later. Otherwise, use this document as an instruction set. Instructions about final paper and figure submissions in this document are for IEEE journals; please use this document as a "template" to prepare your manuscript. For

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I. INTRODUCTION

In the battle to reduce costs, engineering and manufacturing departments are constantly on the lookout for an edge. The water jet process provides many unique capabilities and advantages that can prove very effective in the cost battle. Learning more about the water jet technology will give us an opportunity to put these cost-cutting capabilities to work. Beyond cost cutting, the water jet process is recognized as the most versatile and fastest growing process in the world. Water jets are used in high production applications across the globe. They compliment other technologies such as milling, laser, EDM, plasma and routers. No poisonous gases or liquids are used in water jet cutting, and water jets do not create hazardous materials or vapors. No heat effected zones or mechanical stresses are left on a water jet cut surface. It is truly a versatile, productive, cold cutting process. The water jet has shown that it can do things that other technologies simply cannot. From cutting whisper, thin details in stone, glass and metals; to rapid whole drilling of titanium; for cutting of food, to the killing of pathogens in beverages and dips, the water jet has proven itself unique.

II.THEORY OF WATER JET CUTTING

Most water jet cutting theories explain water jet cutting as a form of micro erosion as described here. Water jet cutting works by forcing a large volume of water through a small orifice in the nozzle. The constant volume of water traveling through a reduced cross sectional area causes the

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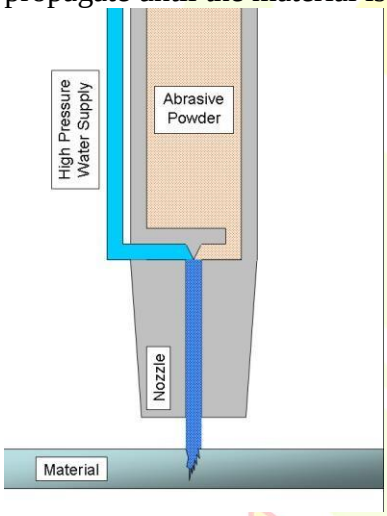

Figure 1: WORKING PRINCIPLE

For cutting thicker materials some abrasives like garnet is added to pure water jet. This is called abrasive water jet and cutting using abrasive jet is called abrasive jet cutting. The high-pressure abrasive jet cuts thicker and harder materials. Abrasive jet cutting is advancement in the field of water jet cutting

III.WATER JET CUTTING PROCESS

Pure water jet is the original water cutting method. Water jet cutting uses only a pressurized stream of water to cut through material. This type of cutting is limited to material with naturally occurring small cracks or softer materials like disposable diapers, tissue paper, and automotive interiors. In the cases of tissue paper and disposable diapers the water jet process creates less moisture on the material than touching or breathing on it. The figure shows the water jet cutting process.

In this process water is increased in pressure by high-pressure pump to about 40000-60000 PSI and is forced through the orifice on to the target material. This high-pressure water on striking the surface performs the machining operation. The potential energy contained in the water is converted in the process to kinetic energy, i.e., into jet velocity, thus achieving its "cutting" effect.

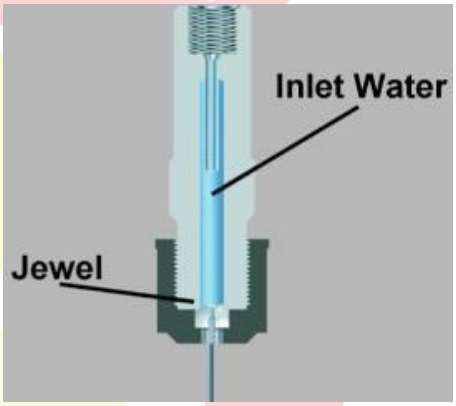

Figure: PURE WATER JET

The basic water jet process involves water flowing from a pump, through plumbing, and out a cutting head.

In water jet cutting, the material removal process can be described as a supersonic erosion process. It is not pressure, but stream velocity that tears away microscopic pieces or grains of material. Pressure and velocity are two distinct forms of energy. The pump's water pressure is converted to the other form of energy, water velocity by a tiny jewel. A jewel is affixed to the end of the plumbing tubing. The jewel has a tiny hole in it. The pressurized water passes through this tiny opening changing the pressure to velocity. At approximately 40,000 psi the resulting stream that passes out of the orifice is traveling at Mach 2. And at 60,000 psi the speed is over Mach 3.

IV. WATER JET MACHINING CENTER

Basic equipment used for water jet cutting consists of:- CNC guide machine, PC based programmable controller or microprocessor based control, structural steel base, servo drive system, "X/Y" carriage, cantilever arm, motorized "Z" axis, catch tank, cutting table, work piece support grid/material, filtration system, high pressure pumps, pressure intensifiers, abrasive material disposal/removal system, injector to draw abrasives into cutting stream, mixing chamber, cutting nozzle (varying orifice size), abrasive removal system, chiller (optional).

V.APPLICATIONS OF WATER JET CUTTING

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Flexible water jet cutting technology is used in practically all sectors of industry: Aerospace, residential and industrial construction, mechanical engineering, the glass industry, the wood, textiles and paper industries, the automotive and its supplier industries, and the electrical, electronic and foodstuffs industries. Unlike traditional thermal cutting methods, water jet cutting technology wins friends with its high level of cost-effectiveness and flexibility. The most diverse materials, from metal via plastics up to and including granite, can be quickly and precisely worked using a high-pressure jet of water. Material thickness of 150 mm or more present no difficulties to our cutting processes. The water jet achieves optimum cut-edge qualities on both simple and extremely complex contours.

GENERAL 2D APPLICATIONS:

- Sheet metal: Stainless steel, carbon steel, high-alloy nickel steels, aluminum, titanium, copper
- Building: Decorative stone, marble, granite, tiles, plasterboard, glass and mineral wool
- Glass: Laminated glass, safety glass, and bulletproof glass
- Foodstuffs: Baked goods, deep-frozen products and fish
- Paper: Cardboard, corrugated cardboard, printing papers
- Miscellaneous: Plywood, leather, textiles, composites, rubber, plastics, sealing materials and foams .

3D AND ROBOT APPLICATIONS:

- ABRASIVE: TITANIUM, ALUMINUM AND STAINLESS STEEL MOTOR-VEHICLE COMPONENTS, TURBINE BLADES, DECORATIVE STONE OR MARBLE.
- PURE WATER: MOTOR-VEHICLE ELEMENTS SUCH AS CARPETS, DOOR-TRIMS, FENDERS, DASHBOARDS, INSTRUMENT PANELS, REAR SHELVES.

VI. CONCLUSIONS AND FUTURE SCOPE

Since its development, water jet machining has seen many improvements in its design. Water jet cutting technology is one of the fastest growing major machine tool processes in the world due to its versatility and ease of operation. Manufacturers are realizing that there are virtually no limits to what water jets are capable of cutting and machining. Machine shops of all sizes are realizing greater efficiency and productivity by implementing UHP water jets in their operations. Water jets are becoming the machine tool of choice for many shops. Since abrasive water jet (AWJ) technology was first invented by Flow in the early 1980s, the technology has rapidly evolved with continuous research and development. What makes water jets so popular? Water jets require few secondary operations, produce net-shaped parts with no heat-affected zone, heat distortion, or mechanical stresses caused by other cutting methods, can cut with a narrow kerfs, and can provide better usage of raw material since parts can be tightly nested. As a result of the Flow Master PC control system and intuitive operation, water jets are extremely easy to use. Typically, operators can be trained in hours and are producing high quality parts in hours. Additionally, water jets can cut virtually any material, leaving a satin-smooth edge. These benefits add up to significant cost savings per part in industries that have traditionally defined productivity by cost per hour.

The latest development in the field of water jet cutting is the use of super water for cutting, which enhances both abrasive and non-abrasive water jet cutting.

A. Advantages of using super-water for abrasive and water jet cutting are:

- Increased cutting speed
- Narrower kerf cutting width
- Decreased wear on pumps and nozzles
- Decreased abrasive use
- Improved surface finish
- Decreased taper