International Journal of Engineering Research and General Science Volume 3, Issue 2, Part 2, March-April, 2015
ISSN 2091-2730

WATER JET MACHINING: AN ADVANCE MANUFACTURING PROCESS

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Abstract*:* - Use of water jet has been in existence for over twenty years, but it is yet to reach its full potential in the construction industry. This study examines the role of water jet in heavy construction in general and particularly how it affects the regional contractors in the northeast. A survey was conducted among 215 civil contractors of the Northeast region of the United States and the results were documented in various categories. The paper presents aspects regarding an innovative nonconventional technology, abrasive water jet machining. The study also presents results regarding other technological operations possible to be performed with abrasive water jet.

Keywords— water jet, abrasive, nonconventional, technological, construction, innovative, industry

I. INTRODUCTION

Water jets were introduced in the United States during the 1970's, and were utilized merely for cleaning purposes. As the technology developed to include abrasive water jets, new applications were disco verged. However, until recently this tool had not been used to a great extent in the construction industry.

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 gives 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 (as per Frost & Sullivan and the Market Intelligence Research Corporation). Water jets are used in high production applications across the globe. They complement other technologies such as milling, laser, EDM, plasma and routers. No toxious 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 thin details in stone, glass and metals; to rapid hole drilling of titanium; to cutting of food, to the killing of pathogens in beverages and dips, the water jet has proven itself unique

II. DEFINITION AND CONSTRUCTION

Water jet machining is a mechanical energy based non-traditional machining process used to cut and machine soft and non-metallic materials. It involves the use of high velocity water jet to smoothly cut a soft work piece. In water jet machining, high velocity water jet is allowed to strike a given work piece. During this process its kinetic energy is converted to pressure energy. This induces a stress on the work piece. When this induced stress is high enough, unwanted particles of the work piece are automatically removed. The apparatus of water jet machining consists of the following components:

a) **Reservoir:** It is used for storing water that is to be used in the machining operation.

b) **Pump:** It pumps the water from the reservoir. High pressure intensifier pumps are used to pressurize the water as high as 55,000 psi. For the abrasive water jet, the operating pressure ranges from 31,000 to 37,000 psi. At this high pressure the flow rate of the water is reduced greatly.
c) **Intensifier:** It is connected to the pump. It pressurizes the water acquired from the pump to a desired level.
d) **Accumulator:** It is used for temporarily storing the pressurized water. It is connected to the flow regulator through a control valve.
e) **Control Valve:** It controls the direction and pressure of pressurized water that is to be supplied to the nozzle.
f) **Flow regulator:** It is used to regulate the flow of water.
g) **Nozzle:** It renders the pressurized water as a water jet at high velocity. Once the water is pressurized, it is forced through a sapphire nozzle which is composed of the natural sapphire stone due to the strength of the stone. The diameter of the nozzle can be varied depending on the application for which the water jet is being used. A damaged nozzle leads to poor cohesion of the stream, thereby reducing the cutting ability greatly. The nozzle typically lasts 100 to 200 hours before it needs to be replaced.
h) **Mixing Tube:** The stream of water which emerges from the nozzle is then mixed with the abrasive. This takes place in the mixing tube, which is usually constructed out of tungsten-carbide. Wear of the mixing tube, due to the abrasive, is a problem and it needs frequent replacement. When the tube becomes worn, the jet no longer is cohesive and loses power and cutting ability rapidly.
i) **Catchers:** After the cut has been made, the water abrasive material is collected in a catcher. In a field situation there are still problems catching the waste material. Often catchers need to be custom designed for a specific job

III. WORKING OF WATER JET MACHINING

The water jet machining follows the following procedure:

1. Water from the reservoir is pumped to the intensifier using a hydraulic pump.
2. The intensifier increases the pressure of the water to the required level. Usually, the water is pressurized to 200 to 400 MPa.
3. Pressurized water is then sent to the accumulator. The accumulator temporarily stores the pressurized water.
4. Pressurized water then enters the nozzle by passing through the control valve and flow regulator.
5. Control valve controls the direction of water and limits the pressure of water under permissible limits.
6. Flow regulator regulates and controls the flow rate of water.
7. Pressurized water finally enters the nozzle. Here, it expands with a tremendous increase in its kinetic energy. High velocity water jet is produced by the nozzle.
8. When this water jet strikes the work piece, stresses are induced. These stresses are used to remove material from the work piece.
9. The water used in water jet machining may or may not be used with stabilizers. Stabilizers are substances that improve the quality of water jet by preventing its fragmentation

IV. SOME APPLICATIONS OF WATER JET MACHINING

In metal cutting, in the construction industry, the abrasive water jet will most likely be used for cutting steel beams and concrete sections. For steel, the cutting rates are slower with the water jet than for other tools, such as plasma arcs. However, often the cost is offset by the time saved by reducing or eliminating finishing steps. This is because there is no heat affected zone with the water jet. The water jet has also been able to cut through thick slabs of concrete. This will save in the cost of buying diamond tipped saws and sharpening them. Abrasive water jets are ideally suited for tough and lucrative applications such as titanium, brass, and tool steel, with aluminium and steel being the most commonly cut materials. Abrasive water jets cut material from 1/16" inch to 8" inches thick, in high or low volume. Typical part tolerances range from between 0.003" and 0.005" of an inch, although tolerances as close as 0.001" of an inch can be achieved as well. Because there is absolutely no mechanical stress, heat distortion or heat-affected zone (HAZ), secondary processing can be eliminated in many cases. Material can be stacked to increase productivity. Setup and fix Turing are complete in just minutes.

With unique ability to cut intricate design, whether you're cutting granite, marble, slate, limestone, soapstone, travertine, engineered stone or any other material for floors and counters; porcelain or ceramic tile for inlays or medallions; or glass and metal for artistic accents and signage, the abrasive water jet's unique ability to cut very intricate designs at high speed without breakage frees your imagination and expands your business.

Cutting and piercing delicate glass works is not a problem with Flow water jet technology. From cutting of intricate stained glass to piercing holes in glass, users from a variety of industries have discovered the versatility and cost-effectiveness of cutting with water jets from Flow.

Hurricane Glass is a growing area for water jets as well. New laws are requiring the installation of hurricane glass for glass windows and doors for all new construction in specific locations. Because of its composition of glass clad/polycarbonate structure, a laminate material, hurricane glass is very difficult to cut by traditional methods such as score and fracturing, or diamond saws. Flow water jets are the superior method for cutting hurricane glass! And, because Flow water jets are Omni-directional, cutting complex patterns is easy!

Water jets have changed the way the paper industry does business. Thirty years ago, paper manufacturers faced the same concerns many manufacturers have today: reliability, redundancy, 24-hour operation.

In many tissue and towel applications, water jet slitting eliminates rewinding so you save on capital equipment expense by slitting on-line. A water jet slitter can be installed directly on the machine, and the edge meets all requirements for converting operations.

Manufacturers working with the military are constantly exploring advanced applications for the latest in lightweight, high strength materials. Cutting these exotic materials can pose a serious challenge to traditional methods. However, we do it with ease.

Flow water jets effortlessly cut through the toughest materials including Super alloys, Ceramic matrix composites, Armor, Carbides, Titanium, Kevlar, Ballistic materials and more.

From automated assembly to material handling and parts feeders to state-of-the-art water jet cutting machines, Flow Robotics is a leader in developing technology designed to address manufacturing challenges head on.

V. SOME ADVANCE APPLICATIONS OF WATER JET MACHINING

Printed Circuit Boards: For circuit boards, waterjet cutting is mostly used to cut out smaller boards from a large piece of stock. This is a desired method, since it has a very small kerf, or cutting width, and does not waste a lot of material. Because the stream is so concentrated, it can also cut very close to the given tolerances for parts mounted on the circuit board without damaging them. Another benefit is that waterjet cutting does not produce the vibrations and forces on the board that a saw would, and thus components would be less likely to be damaged.

Wire Stripping: Wire stripping is another application that can be used effectively in waterjet cutting. If no abrasives are used, the stream is powerful enough to remove any insulation from wires, without damaging the wires themselves. It is also much faster and efficient than using human power to strip wires.

Food Preparation: The cutting of certain foods such as bread can also be easily done with waterjet cutting. Since the waterjet exerts such a small force on the food, it does not crush it, and with a small kerf width, very little is wasted.

Tool Steel: For abrasive water jet cutting, tool steels are one application, although a limited one. It can be very useful though because tool steel is generally very difficult to cut with conventional machining methods, and may cause an unwanted byproduct: heat. Abrasive water jets, however, do not produce heat that could alter the structure of the material being cut, and thus the strength of the tool is retained.

Wood Cutting: Woodworking is another application that abrasive water jet machining can be used for. Since wood is a softer material compared to steel, almost all wood can be cut, and the abrasive particles sand surface, leaving a smooth finish that doesn't require sanding.

Rivet Removal: Water jet cutting was found to be a feasible method for removing rivets with thicknesses less than 2 inches. At greater thickness the quality of the cut became unacceptable, and a tool that could be inserted into the cut would be needed to perform the job . It was concluded that it is conceivable to design such a tool that would allow deeper cuts without sacrificing edge quality

Paint Removal: In the United States the removal of lead-based paint from bridges is causing big problems. Traditionally, sand blasting was carried out in the open with no concern for the surrounding environment. Today many states require the complete containment of the removed produce as well as the waste generated from blasting. Water jet technology has been used successfully for coating removal

VI. ADVANTAGES AND DISADVANTAGES

The Advantages of WJM are:

a) Water jet machining is a relatively fast process.
b) It prevents the formation of heat affected zones on the work piece.
c) It automatically cleans the surface of the work piece.
d) WJM has excellent precision. Tolerances of the order of ±0.005″ can be obtained.
e) It does not produce any hazardous gas.
f) It is eco-friendly.

As like the advantages the WJM has following disadvantages which are:

a) Only soft materials can be machined.
b) Very thick materials cannot be easily machined.

Initial investment is high

VII. CONCLUSIONS AND LIMITATIONS

It appeared after studying the advantages and disadvantages of the waterjet, that this is a tool that the construction industry should find very useful. Unfortunately, this does not seem to be the case. Many of the regional companies do not seem to have any significant knowledge of the waterjet, thus remaining unwilling to employ this technology.

The responses that we have received have left us with the inability to comment on the cost effectiveness of the water jet in the construction industry. The majority of companies that we contacted do not employ the water jet in their companies, nor do most of them have any knowledge of the abrasive water jet. These companies seem to be conservative to new technology and unwilling to take risks. This may also be due to the fact that many companies are unwilling to invest in a new technology that is not widely used.

The contractors that do employ the abrasive water jet technology did not provide us with the percentage of cost benefit to their company.

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