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WATER QUALITY USED BY WATER JET MACHINES

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Abstract: Water jet cutting is one of the newest techniques in non-traditional machining processes. With the water jet process, the same tooling and system can be used to cut virtually any material, such as steel, stainless steel, high-nickel alloys and polymer composites.

Water quality in water jet cutting machines can drastically shorten the life span of high pressure elements, especially water orifice. This paper discusses the problem of water quality used by water jet cutting machines.

Keywords: water jet cutting, water quality, advance machining

1. INTRODUCTION

New, difficult-to-machine materials and increased part complexity have resulted in the creation of new manufacturing processes, known as nontraditional manufacturing processes. Water jet cutting (Fig. 1) is one of the newest technique in non-traditional machining processes. The use of the abrasive water jet for machining or finishing purposes is based on the principle of erosion of the material upon which the jet hits. Each of two components of the jet, i.e. the water and the abrasive material has both a separate purpose and a supportive purpose. It is the primary purpose of the abrasive material within the jet stream to provide the erosive forces. It is the primary purpose of the jet to deliver the abrasive material to the workpiece for the purpose of erosion. However the jet also accelerates the abrasive material to a speed such that the impact and change in momentum of the abrasive material can perform its function. In addition it is an additional purpose of the water to carry both the abrasive material and the eroded material clear of the work area so that additional processing can be performed. In one way or another in any machining process the spent material must be gotten our of the way and the water jet provides that mechanism [1].

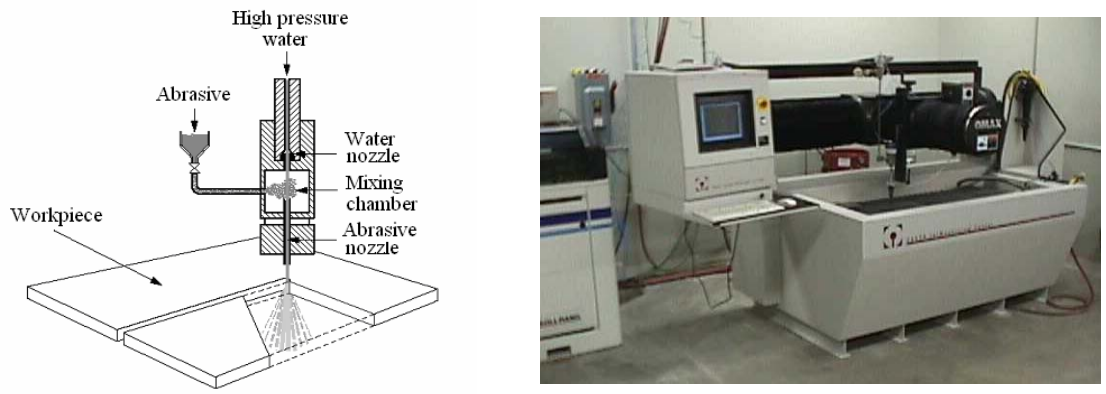
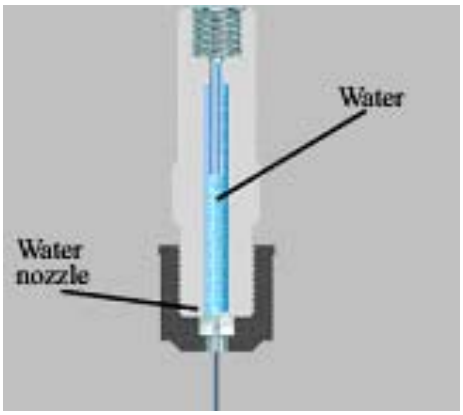


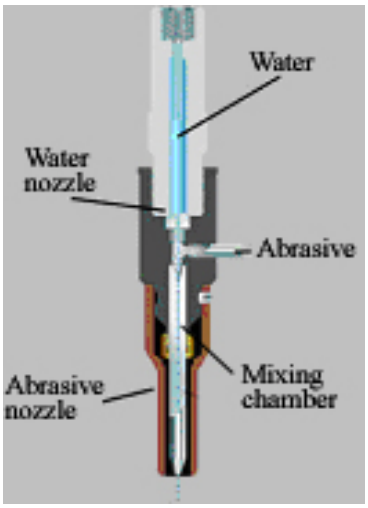
Figure 1. Abrasive water jet cutting

2. WATER JET CUTTING PROCESS

Water jet cutting technology is a unique process that is able to cut almost all materials cost effectively. The basic technology is both simple and extremely complex. At its most basic, water flows from a pump, through plumbing and out a cutting head. Essentially, there are two types of water jets:

(a) pure water jet cutting - WJC (Fig 2. a) and
(b) abrasive water jet cutting AWJC (Fig 2. b)





a) Pure water jet *b) Abrasive water jet*

Figure 2. Two types of water jets

Pure water jet cutting, uses only water, and found early applications cutting corrugated cardboard and food items such as cakes and candy bars. Today, applications include cutting diapers, tissue paper and automotive interior parts, plastics.
The high pressure pump generates the required operating pressure (up to 400 MPa). The cutting head is supplied with pressurized water by means of a high pressure supply line. The pressurized water is relived by the nozzle (0.1 to 0.4 mm in diameter) when water jet forms and can be utilized for cutting. When the water jet reaches its target, the energy, which the jet contains, as a result of its speed, is changed back into impact pressure in order to get an effective amount of desired work done on the surface.

The abrasive water jet differs from the pure water jet in just a few ways. In pure water jet, the supersonic stream erodes the material. An additional abrasive head is attached for abrasive water jet cutting. Solid abrasive material is added to the water jet in a mixing chamber in the abrasive cutting head. The abusive enriched water jet is subsequently focused in an abrasive nozzle (70 mm long and with an inside diameter between 0.8 and 1.2 mm). The abrasive water jet is hundreds, if not thousands of times more powerful than a pure water jet.

The water jet cutting process is environmentally clean and safe. The water jet cuts cleanly, taking kerf material with it, eliminating airborne dust, and producing smooth edges that never need deburring. In addition, water jet cutting, unlike laser of flame cutting, will never weaken the edge of the material being cut. The water jet cutting system also offers important additional benefits. They include an ability to cut materials up to 150 mm thick, productive cutting speeds and easy integration with computers, robots and controllers. In Tab. 1 are given values for some of parameters influencing water jet cutting process [2].

Table 1. Influencing parameters of water jet cutting

INFLUENCING PARAMETERS		
Parameter	Pure water jet cutting	Abrasive water jet cutting
High pressure pump (MPa)	300 - 400	
Water nozzle diameter (mm)	0.1 - 0.4	0.8 - 1.2
Jet stream velocity (m/s)	540 - 1200	
Water supply volume (l/min)	1.6 - 4.5	
Stand of distance (mm)	0.5	2 - 5
Cutting speed (mm/min)	100 - 1000	

Principal components of machine for abrasive water jet cutting (schematic shown on Fig. 3) are:

- water preparation system
- high pressure pump
- high pressure supply line
- cutting head and
- table and motion system

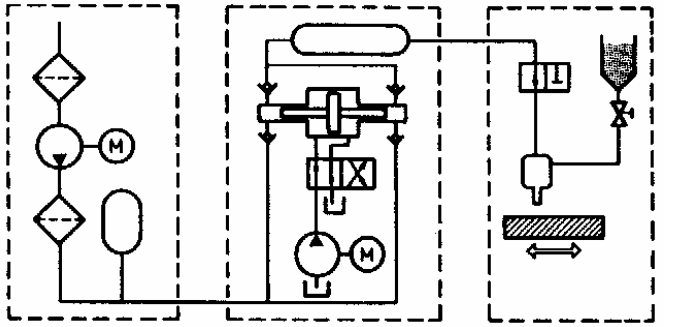


Figure 3. Schematic display of machine for abrasive water jet cutting

Poor water quality causes mineral deposits and other problems with water nozzle and other high pressure components and therefore one of important component of water jet cutting machine is water preparation unit [3].

3. WATER PREPARATION SYSTEM

All too often, issues such as power requirements and water quality are overlooked. When high pressure water jet cutting machines were first installed in factories it was anticipated that the equipment would be able to operate for a considerable period of time without needing a great deal of maintenance and upkeep. However, as equipment began to be installed in factories in different regions, a particular and unexpected problem arose form the water. The problem is that local water is not all of the same quality. The standards which the water must meet, may make the water acceptable for drinking and normal use, but can sometimes give problems in equipment where the water is subject to pressures above 350 MPa and where it is moving in excess of 700 m/sec.

The presence of small amounts of solid material in the jet fluid can cause an accelerated wear of either the nozzle body or other points within the circuit where jet velocities are high. Also, slight changes in water chemistry can significantly affect the erosion resistance of some of the components within the pump mechanism.

The problem of water quality has been recognized and addressed by the vendors of the equipment. As a result it has been found necessary to set water quality standards in order to operate high-pressure water jet cutting systems effectively. Many localities do not have water sources that satisfy these requirements. It has been found that if the water supply is inadequate then the result is equipment malfunction. A solution was found through water preparation system (Fig. 4).

Figure 4. Water preparation system

There are several ways to treat the water prior to use. The simplest is a water softening treatment similar to that used in the household. The second method is reverse osmosis, which consists of passing the water through a very fine membrane which filters out the impurities on the molecular level. And the third is de-ionizing circuit.

Ordinary tap water is used to feed the water jet systems. 90% of all water jet and abrasive water jet users require only water softening prior to sending that water through the pump's inlet water filters and then to the intensifier. Reverse Osmosis (RO) and De-Ionizers (De-I) tend to make the water so pure that it becomes "ion starved." This aggressive water seeks to satisfy its' ion starvation by taking ions from surrounding materials, such as the metals in the pump and high-pressure plumbing lines. RO and De-I can greatly extend orifice life, while simultaneously performing very expensive damage to the intensifier and plumbing. Orifices are rather inexpensive. High-pressure cylinders, check valves, and end caps damage will far outweigh orifice life improvements.

A high concentration of total dissolved solids (TDS) in your shop's water supply causes accelerated wear of pump components. If maximum values for TDS silica content and pH are exceeded, then water treatment - ranging from water softening to deionization or reverse osmosis - is required.

4. REQUIRED WATER QUALITY

Firs step in the process of making decision of whether water preparation system is needed or not is to analyze a sample of local water on certified laboratory and make a treatment recommendation.

Water should be lean top water. Although the water passes though a filtering system before it reaches the pump, the cleaner the water the less frequently you will need to service the filter. If you are using a separate water filtering system, you should make sure you service the filters at the recommended intervals.

The water should not be hard or contain large quantities of dissolved iron and silica. These materials cause problems in both the pump and the nozzle.

The water circuit consists of the inlet water filters, booster pump, intensifier, and shock attenuator. Ordinary tap water is filtered by the inlet water filtration system – usually comprising of a 1 and a 0.45 micrometer cartridge filter.

For these reasons the original 5 micrometer fiber cartridge filter fitted to the first machine has not always been adequate to protect the pump and jet delivery system, even though, in that installation, no erosion of the seals and shafts had occurred after the first six months of operation. In these circumstances, slight changes in water chemistry can significantly affect the erosion resistance of some of the components within the pump mechanism.

Table 2. Water quality required for an Ingersoll-Rand Water jet Cutting System

Attribute	Minimal requirements	Optimal requirements
water pH	6.5 to 7.5	7.0
total dissolved solids (TDS)	<500 mg/liter	150 mg/liter
iron	<0.2 mg/liter	0.1 mg/liter
manganese	<0.1 mg/liter	0
free chlorine	<1 mg/liter	0

5. CONCLUSION

Many localities do not have water sources that satisfy optimal quality requirements. It has been found that if the water supply is inadequate then the result is equipment malfunction. It has been found that the de-ionizing circuit is best from a functional point of view. A study of nozzle life gives that using de-ionized water gave a nozzle use life greater than 200 hours verses about 190 hours with water treated by reverse osmosis and 78 hours for softened water. These nozzle lifetimes compare with a life of the nozzle of 34 hours when tap water is used. As can be seen the best treatment of the water results in six-fold improvement in nozzle life verses use of tap water.

REFERENCES

[1] Hoogstrate A.M., van Luttervelt A.M.; Opportunitirs in Abrasive Water-Jet Machining, Annals of the CIRP Vol. 46/2/1997

[2] Janković P., Radovanović M., Parameters of Abrasive Waterjet Cutting Process, 6th International Conference ″Research and Development in Mechanical Industry″-RaDMI 2006, Budva, Montenegro, 2006, pp.343-346

[3] Janković P., Radovanović M., Vićovac N., Essential components of abrasive water jet cutting machines, Manufacturing and Management in 21st Century, Skopje, 2004