Cutting with high-energy water-jet in industrial applications

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Although material processing with water-jet has been used in the mining industry since the early 40s, the first industrial applications came in 1975 with the cutting of paper and cardboard.

Today water-jet cutting is a fully developed alternative to mechanical and thermal cutting processes and there are only a few materials, such as diamonds, which cannot be cut by pure or abrasive water-jet.

Pure water-jet cutting

A water-jet unit consists basically of a high-pressure intensifier pump with a controller, a water filter and a cutting nozzle with high-pressure tubing, fittings and swivel joints (Fig. 1): equipment designed to give a narrow high-energy jet stream.

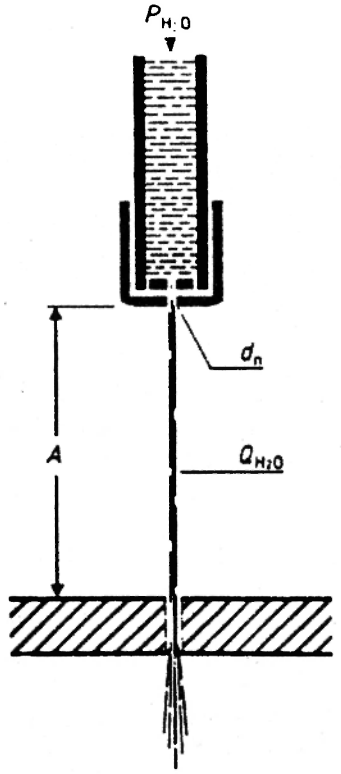

Fig. 1. *Pure water-jet system*
(P_{H2O} - high pressure water; d_n - outting nozzle; Q_n - high energy jet; A- nozzle distance).

The typical lifetime of the sapphire nozzle is between 200 and 500 cutting hours depending on the quality of the water. Unlike other cutting processes the distance from the nozzle to the workpiece is not a critical parameter and a height-control unit is therefore not generally required as far as 2-dimensional cutting is concerned.

Pure water-jet technology makes it possible to cut all soft materials such as:

- o Soft plastics and plastic foams.
- o Fibre glass and carbon fibre reinforced plastics.
- o Printed circuit boards.
- o Paper.
- o Diapers.
- o Rubber.
- o Leather.
- o Food.

Abrasive water-jet cutting

The machine configuration for abrasive water-jet cutting is based on the pure water-jet cutting unit, but the difference is that for this process an abrasive material is added to the jet stream in a special mixing chamber (Fig.2 and 3). Typical abrasives are silicate sand, garnet and silicate slag.

The lifetime of the sapphire nozzle is shorter than in pure water-jet cutting due to the reflection of abrasives in the mixing chamber.

Using an abrasive water-jet cutting system it is now possible to extend the range of materials which can be cut, to include:

- o Mild steel.
- o Stainless steel.
- o High-alloy steel.
- o Titanium.
- o Aluminium.
- o Glass.
- o Ceramics.
- o Stone.

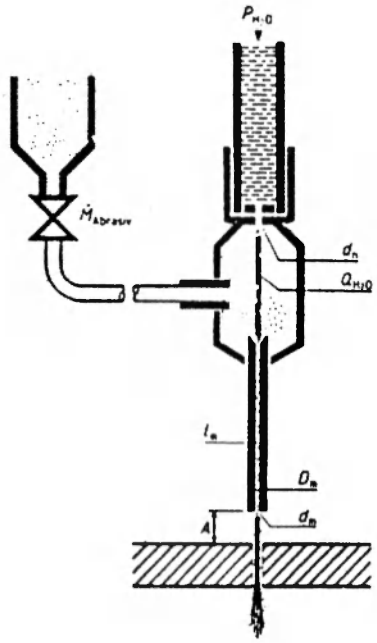

Fig. 2 *Abrasive water-jet system*

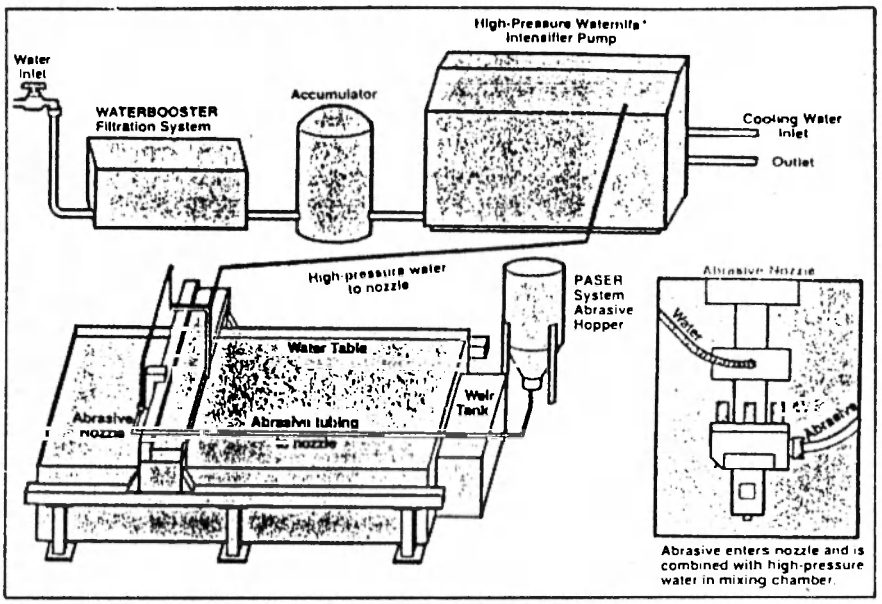

Fig. 3 *Abrasive water-jet cutting system*

Table 1. Typical cutting parameters

Material	Thickness (mm)	Cutting speed (mm/min)
Mild steel	1 - 70	3300 - 20
Stainless	1 - 50	2500 - 25
Aluminium	1 - 60	3500 - 30
Copper	2 - 30	2500 - 60
Brass	1 - 30	5000 - 70
Titanium	1 - 60	3000 - 25
Granite	10 - 150	200 - 20
Glass	4 - 50	5000 - 200
Rubber	5 - 100	8000 - 200
Acrylics	15 - 100	2000 - 120
Glassfibre	3 - 60	9000 - 200
Carbonfibre	1 - 40	20000 - 300

Advantages of water-jet cutting

Compared with thermal cutting methods, like oxy-fuel cutting, plasma and laser cutting and the traditional mechanical cutting technologies, water-jet cutting is superior because of the following features:

- Max. process temperature 100°C, no heat distortion.
- Dustfree (pure water-jet).
- Narrow kerf independent of material thickness.
- No material deformation.
- Very little contamination of air and water.
- Retroactive force during hole piercing <6 kp.
- Easily attachable to ESAB standard cutting machines.

The typical cutting parameters are given in Table 1.

Fields of application

Pure water-jet cutting is used in the automotive industry to cut carpets, plastic foil, textiles and fibre glass reinforced body parts. In the electronics industry it is used for the machining of printed circuit boards. The most established installations can be found in paper, cardboard, and diaper manufacture.

Abrasive water-jet cutting systems are frequently used in the military and aircraft industry for the machining of high-alloy metals, titanium, armoured glass, and carbon fibre reinforced plastics.

The natural stone and glass processing industry is now introducing the water-jet process in order to take advantage of its manufacturing advantages.

In future it is expected that other industries will also realize the benefits of water-jet cutting technology. This will be strongly supported by ecological aspects which will become more and more important as a result of increasingly stringent environmental requirements.

Problems

The high-energy water-jet is accelerated to a very high speed and a noise level of up to 120 dB must therefore be expected. Furthermore, the energy of

the jet stream after it passes the workpiece must be dissipated in a special "catcher" device. In abrasive water-jet cutting in particular the remaining jet energy must be dispersed by using a layer of steel balls or river stones in a water tank. This also creates considerable noise.

The clamping of the workpiece creates problems when smaller parts are going to be cut with abrasive water-jet.

Conclusion

Water-jet cutting is highly suitable for the increasing number of special cutting problems which cannot be solved by traditional methods.

Editor's note: ESAB-Hancock, West Germany, have formed a specialist department which is responsible for the coordination of water-jet cutting applications in Europe and the Far East, while ESAB Automation, USA,are covering the American continents. Both of them are working with the market leader Flow Systems who manufacture the water-jet equipment.

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