Advanced Manufacturing

Technology & Prototyping

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Lecture 5_Part 2

Water Jet Machining

DR. Moustafa Mahmoud

Ph. D. Eng.

Design & Production Dept.,

Faculty of Engineering, Ain Shams University

m_m_sayed@eng.asu.edu.eg

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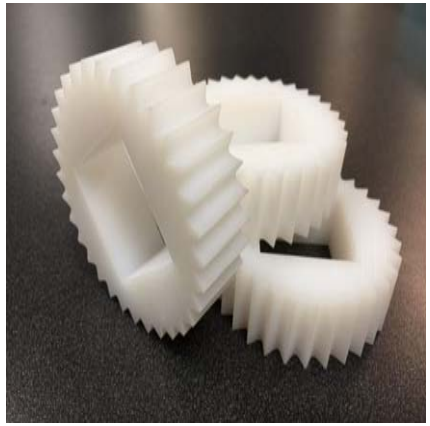
WATER JET MACHINING (WJM)

Introduction

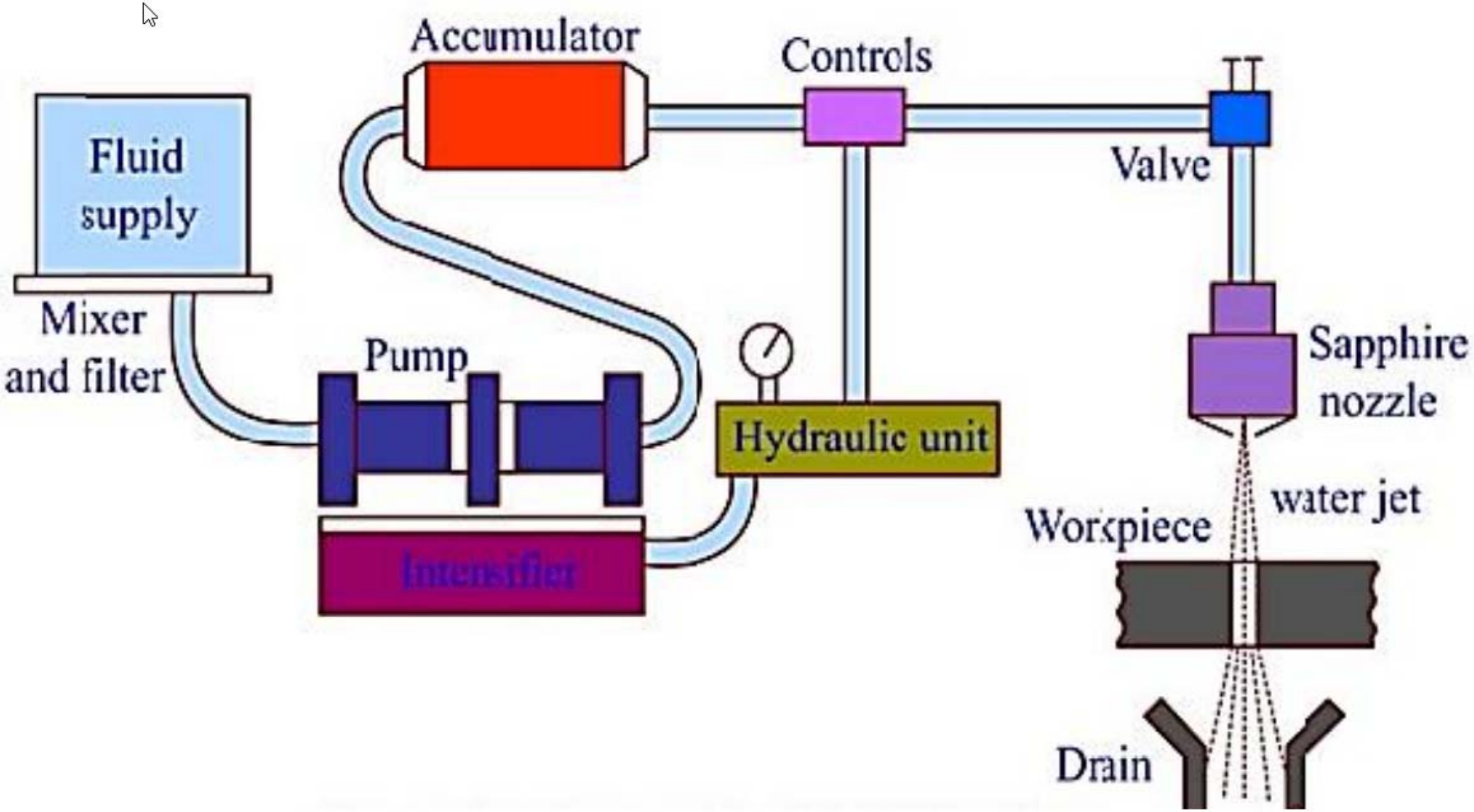
- Key element in WJM is a jet of water.
- Water jet travels at velocities as high as 900 m/s.
- When the water stream strikes a work piece surface, the erosive force of water removes the material rapidly.
- The water, in this case, acts like a saw and cuts a narrow groove in the work piece material.
- True cold cutting process – no HAZ (Heat Affected Zones), mechanical stresses or operator and environmental hazards.

Introduction, cont.

- Nonconventional machining process in which high velocity jet of water is used to remove material from the surface of work piece or cutting it into two parts using the energy from high speed, high density, and ultra high-pressure water.
- It is used to cut and machine soft and nonmetallic materials like plastic, wood and rubber.



Schematic diagram



Principle

- The water jet machining involves directing a high pressure (150-1000 MPa) high velocity (540-1400 m/s) water jet (faster than the speed of sound) to the surface to be machined. The fluid flow rate is typically from 0.5 to 2.5 l/min
- The kinetic energy of water jet after striking the work surface is reduced to zero.

Principle, cont.

- The bulk of kinetic energy of jet is converted into pressure energy.
- If the local pressure caused by the water jet exceeds the strength of the surface being machined, the material from the surface gets eroded and a cavity is thus formed.
- Water is the most common fluid used, but additives such as alcohols, oil products and glycerol are added when they can be dissolved in water to improve the fluid characteristics.

Mechanism

- In these process (WJM), the mechanical energy of water phase are used to achieve material removal or machining.
- Fine, high pressure(1500-4000 MN/cm^2), high velocity (twice the speed of sound)of water jet is bombarded onto the work surface.
- High velocity water jet is directed at a target in such a way that the velocity is reduced to zero on striking the workpiece.
- K.E. of jet is converted into the high pressure.
- **Erosion if pressure > strength of material.**

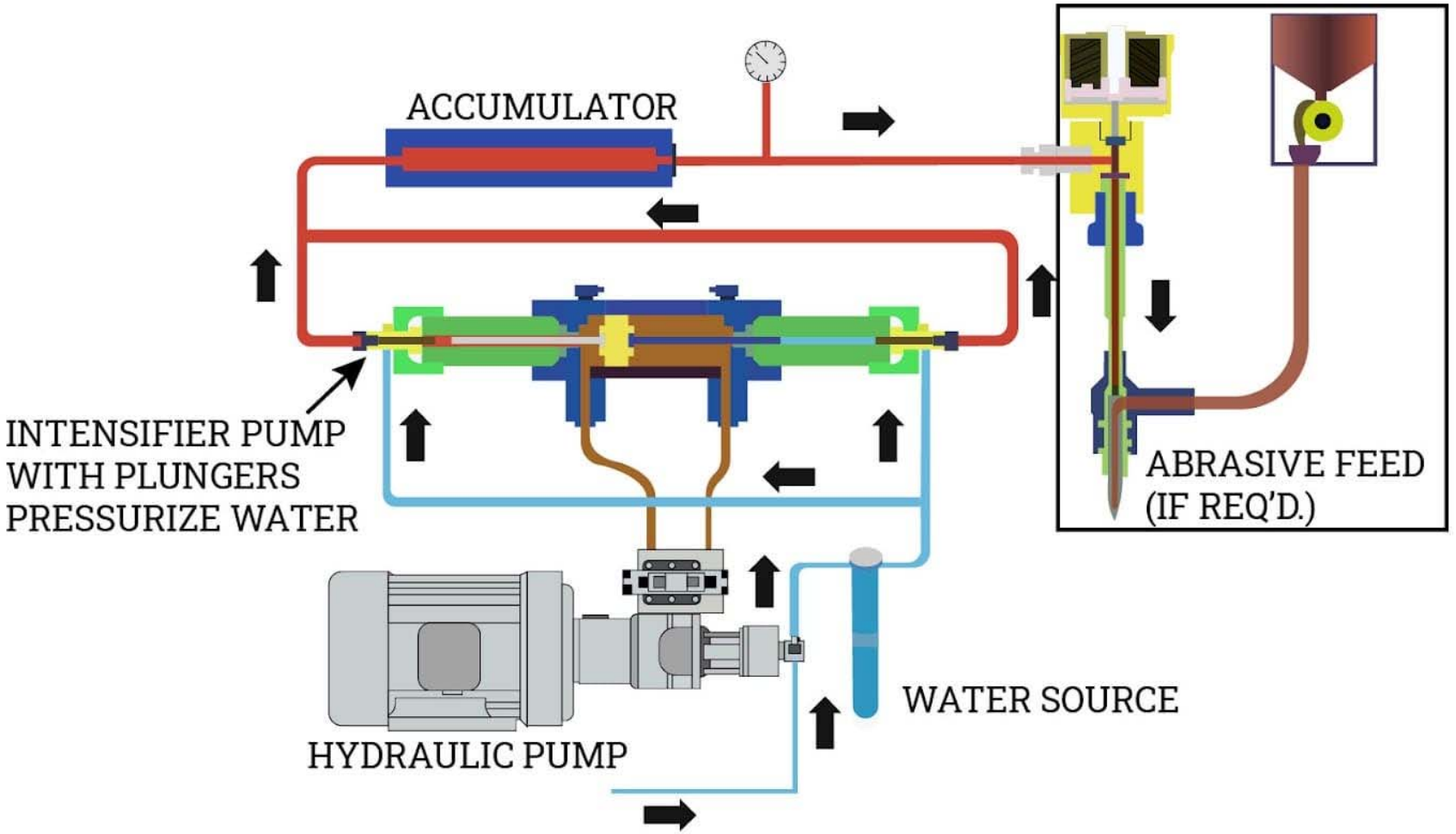
Mechanism, cont.

- Given amount of energy is concentrated onto a very small point to cause the material removal.
- On striking the K.E is converted into the pressure energy (stagnation pressure).
- Mechanism is erosion – localized compressive failure which occurs when the local fluid pressure exceeds the strength of the target material.
- Ductile – erosion due to shearing action.

The Machining System

- **Hydraulic Pump**
- **Intensifier**
- **Accumulator**
- **High Pressure tubing**
- **Jet Cutting Nozzle**
- **Catcher**

Complete Water Jet Cutting Process



Machining system components

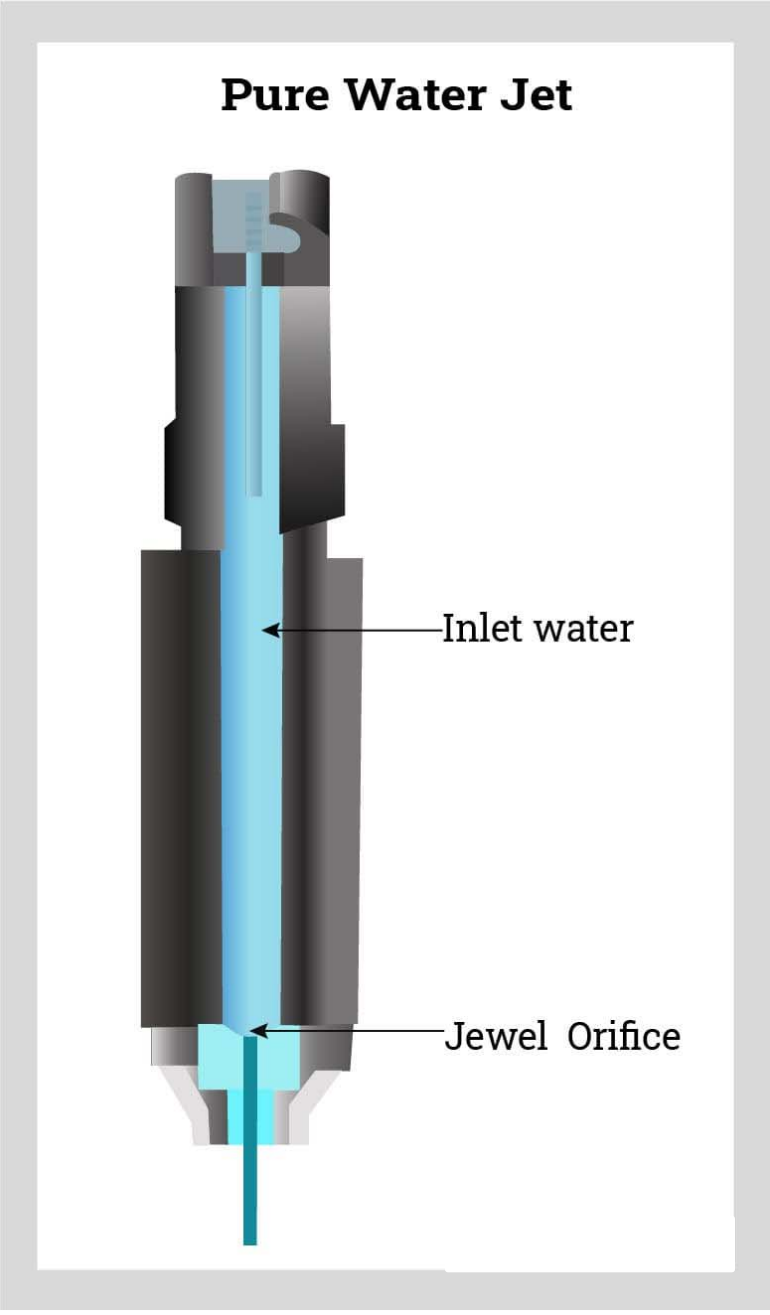
1- Pump:

- Water is pumped at sufficiently high pressure , 200 - 400 MPa (2000 - 4000 bar) using a intensifier technology.

2- Intensifier:

- Pressure amplification using hydraulic cylinders of different cross sections.
- Water is issued through a suitable orifice (0.2 to 0.4 mm dia.), the P.E is converted into K.E. resulting in high velocity jet (1000 m/s).
-

Machining system components, cont.



Jekran CNC Waterjet Cutting Systems.mp4

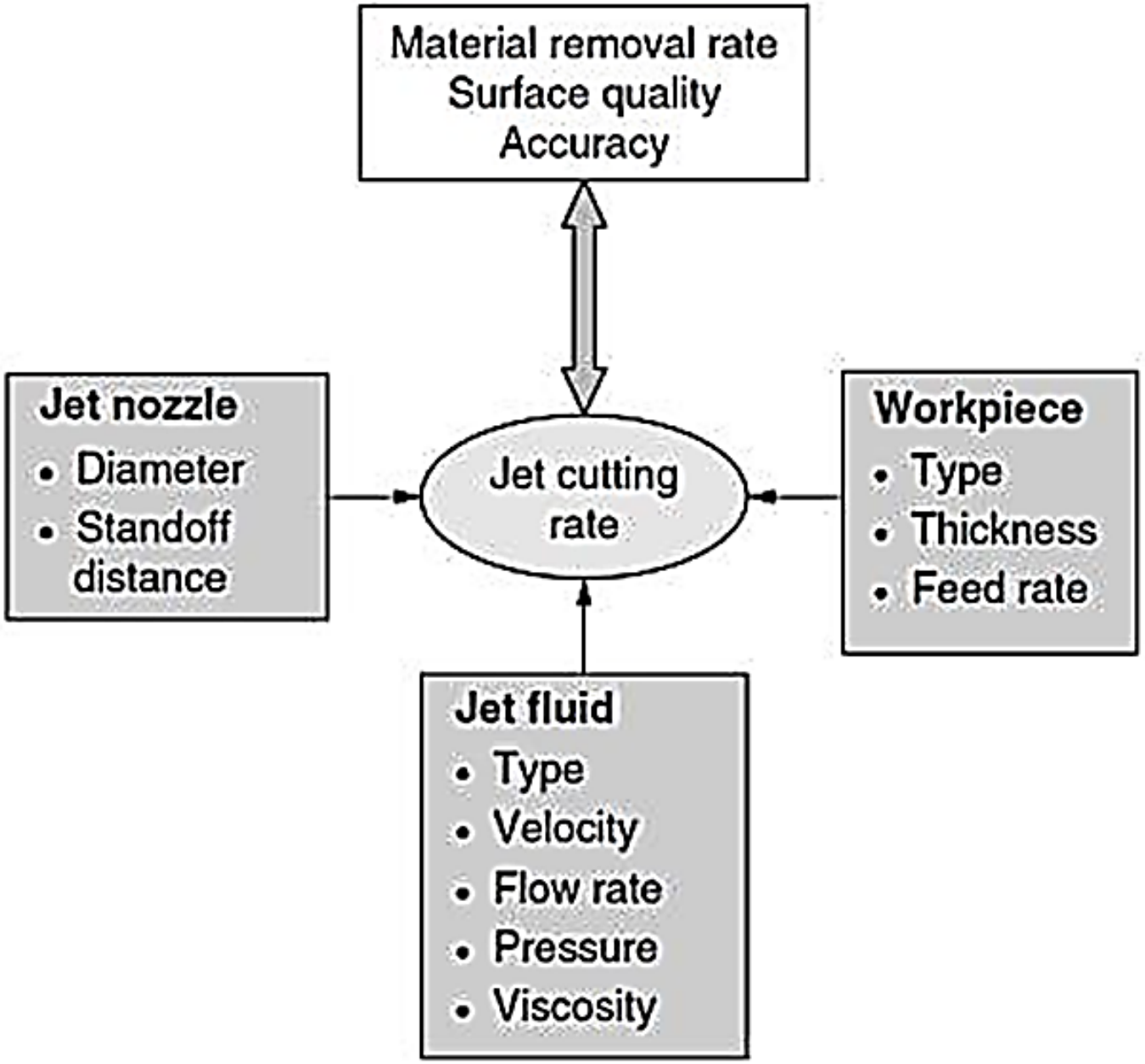
Process parameters

- **Standoff distance** is small to minimize dispersion of the fluid stream
- **Nozzle operating diameter**-affects precision of the cut-smaller opening for finer cuts on thinner materials-for thicker stock, thicker stream + higher pressure
- **Water pressure**
- **Cutting feed rate:** typical feed rates: 5mm/s to more than 500mm/s depending on the work thickness

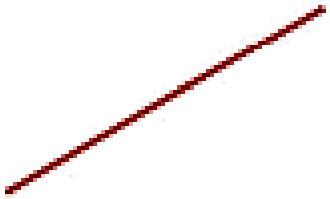
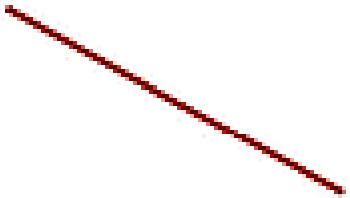
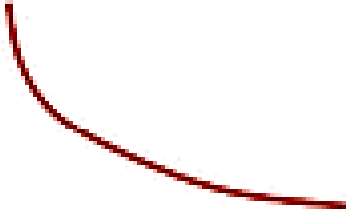
Process parameters, cont.

- Orifice: Sapphires – 0.1 to 0.3 mm
- Focusing Tube: WC – 0.8 to 2.4mm
- Pressure: 2500 to 4000bar
- Abrasive: garnet and olivine
- Abrasive flow: 0.1 to 1.0 Kg/min
- Stand off distance: 1 to 2mm
- Machine Impact Angle: 60^{o} to 90^{o}
- Traverse Speed: 100 mm/min to 5 m/min
- Depth of Cut: 1 mm to 250 mm

Process parameters, cont.



Process parameters effect on MRR

Pressure  MRR	Orifice size  MRR	Mix. tube diameter  MRR	Mixing tube length  MRR
		Stand off distance  MRR	Material hardness  MRR
Material toughness  MRR	Material thickness  MRR	Underwater shallow water MRR	Forward angle  MRR

Applications of WJM

- Water jet machining is used in various industries like mining, automotive and aerospace for performing, cutting, shaping and rimming operations.

- The materials which are commonly machined by water jet are rubber, textiles, plastics, foam, leather, composites, tile, stone glass, paper and much more.

Applications of WJM, cont.

- Water jet machining is mostly used to cut soft and easy to machine materials such a thin sheets and foils, wood, non ferrous metallic alloys, textiles, honeycomb, plastics, polymers, leathers etc.

- Besides the machining process, the high-pressure water jet is used in paint removal, surgery, cleaning, peening to remove residual stress etc.

Applications of WJM, cont.

- Paint removal
- Cutting soft materials
- Cutting frozen meat
- Textile, Leather industry
- Mass Immunization
- Surgery
- Peening
- Cutting
- Pocket Milling
- Drilling

Advantages of WJM

- It can produce complex and intricate cuts in materials.
- The machining area in this machining process remains clean and dust free.
- It has low operating and maintenance cost because it has no moving parts.
- The thermal damage to the work piece is negligible due to no heat generation.
- It is environment friendly as it does not create any pollution or toxic products.

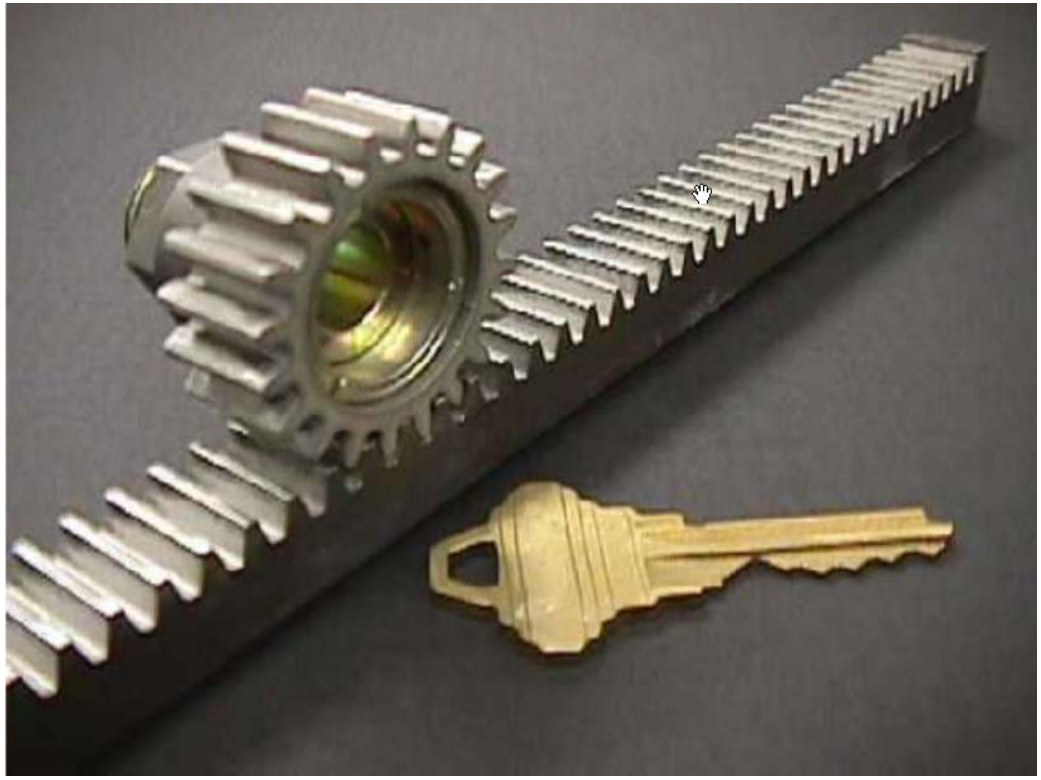
Disadvantages of WJM

- Very thick material cannot be machined by this process.
- The initial cost of water jet machining is high.

Products

Water Jet Cut Auto Parts

Products, cont.



QUESTIONS?

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