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WATER JET PROCESSING OF LIQUID WOOD PARTS OBTAINED BY INJECTION MOULDING

BY

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Abstract. The water jet processing process is part of the unconventional modern manufacturing processes, being able to be done with or without abrasive mixture and being a very good alternative for the other traditional cutting technologies. By water jet cutting, a wide range of composite materials can be processed, both with polymer and metal matrix, but also soft and flexible materials, precisely due to the generation of small cutting forces.

The paper deals with aspects related to the principle of water jet processing, the main parameters of the processing process, used machines and the proposal of an experimental plan in order to perform experimental tests.

Keywords: water jet; liquid wood; injection moulding.

1. Introduction

The water jet processing process is part of the unconventional modern manufacturing processes, being able to be done with or without abrasive mixture and being a very good alternative for the other traditional cutting technologies. By water jet cutting, a wide range of composite materials can be processed, both with polymer and metal matrix, but also soft and flexible materials, precisely due to the generation of small cutting forces.

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The material cut with water jet is not subjected to the heating process, due to the relatively short processing time, which also means the lack of changes in the structure of the material after processing.

The main advantages of water jet processing are (debitare-jet-apa.ro/):

– flexibility of production and wide variety of parts possible to process;

– lack of heating of the material after processing;

– high productivity and processing precision compared to other traditional cutting processes [Fig. 1 (Akkurt, 2015)];

– lack of defects resulting from processing;

– lack of pollution during the processing process;

– various materials can be processed such as: aluminum, stainless steel, steel, rubber, stone, plastics.

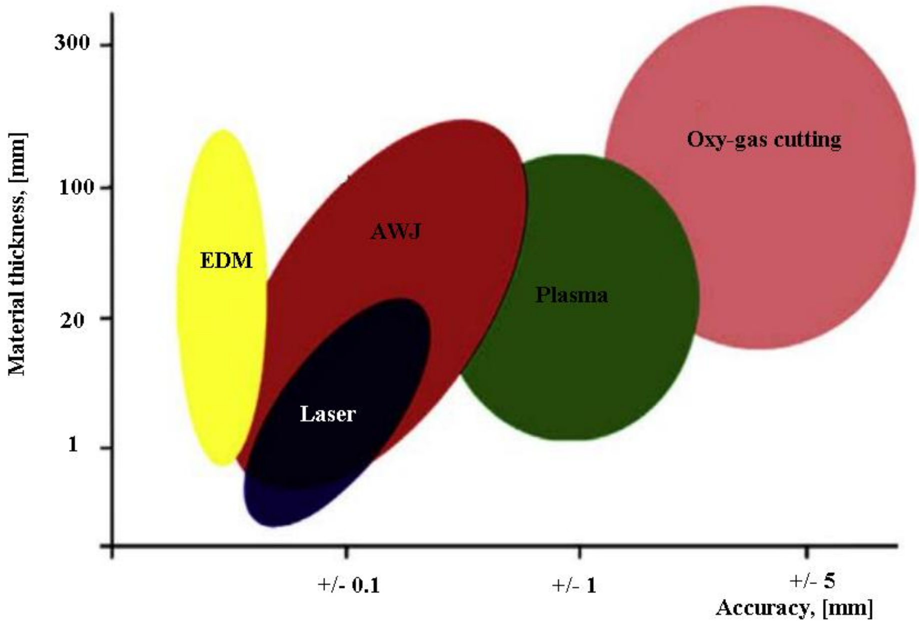

Fig. 1 – Precision processing by different processes (Akkurt, 2015).

2. The Principle of Water Jet Processing

The principle scheme of water jet processing (AWJ-Abrasive water jet) is presented in Fig. 2 (Grote and Antonsson, 2008). The water introduced under a pressure between (250-400) MPa is mixed with the abrasive particles, in a mixing chamber, after which, the elimination of the mixture through a nozzle, forms the processing jet. The distance between the nozzle and the surface to be processed can be established depending on the need for processing.

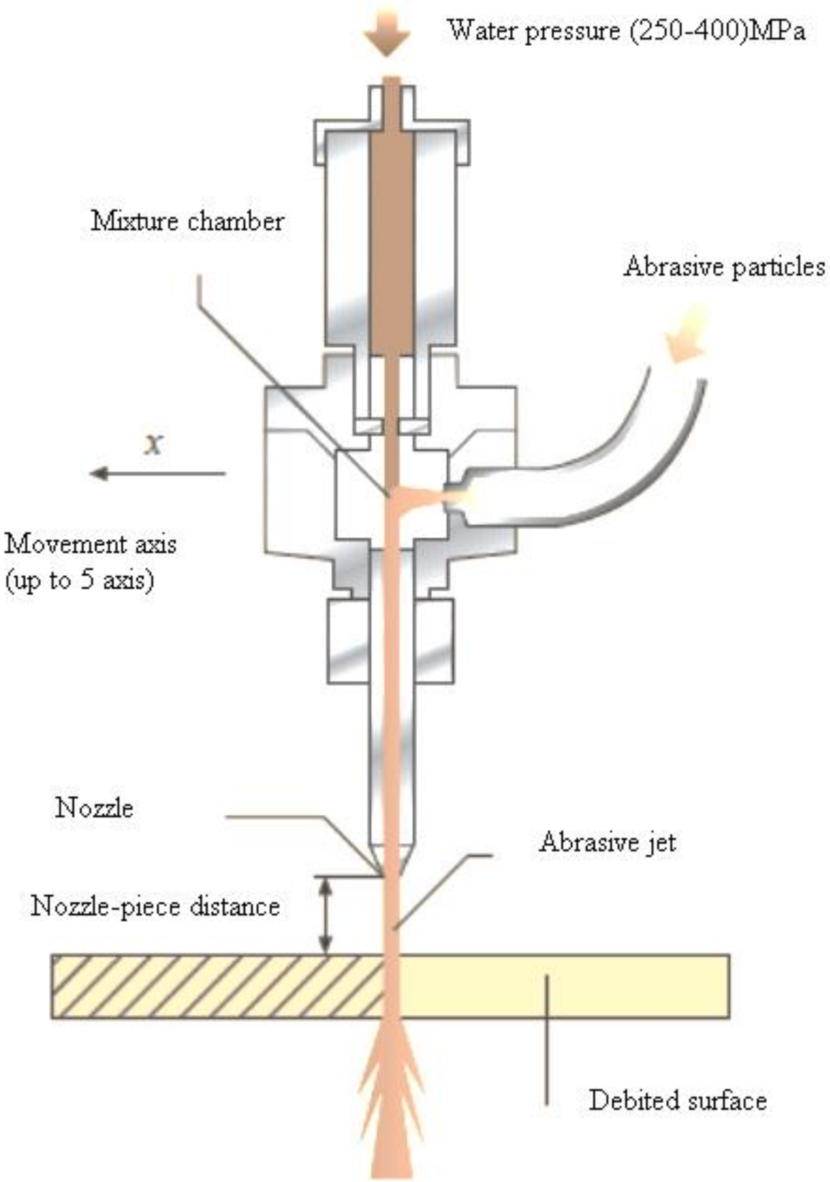

Fig. 3 – General scheme of the AWJ procedure
(Grote and Antonsson, 2008; Pătîrnac and Rîpeanu, 2017).

The main components of water jet cutting machines are: water supply unit, pressure supply unit, pressure amplifier, pulsation damper, cutting head, mixing tube and abrasive supply tank. The general scheme of the installation is presented in Fig. 4 (Pătîrnac and Rîpeanu, 2017; Pătîrnac, 2020).

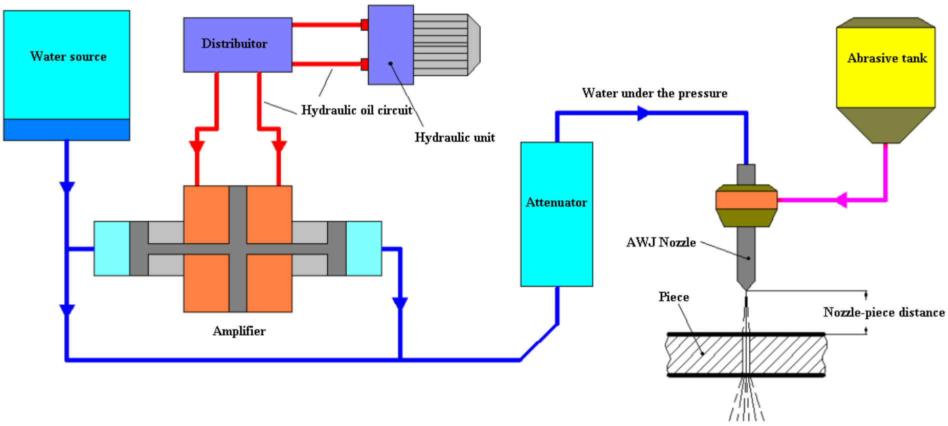

Fig. 4 – General scheme of the water jet cutting installation
(Pătîrnac and Rîpeanu, 2017; Pătîrnac, 2020).

3. The Main Parameters of the Processing Process

In general, the main parameters of the water jet cutting process are: water pressure, water flow and the amount of abrasive material. In the case of using only water, it under very high pressure is released through a sapphire nozzle, which transforms water into jet, the speed can reach values of even 850 m/s (debitare-jet-apa.ro/). Water-only cutting is used for soft sealing materials, rubbers and foams. When cutting with abrasive, the mixture between water and the amount of abrasive material introduced takes place, being used to cut very hard materials.

Besides the mentioned parameters, which belong to the category of hydraulic parameters, the diameter of the nozzle and the speed of the water in the nozzle can be mentioned.

From the point of view of the parameters of the cutting process, these are: the distance from the nozzle to the cutting material, the cutting speed and the cutting width.

When using the abrasive cut, the abrasive flow rate and the diameter of the abrasive supply nozzle must be mentioned as parameters.

The following parameters can have an influence on the quality of the cut:

– the length of the focusing cannon, when the cutting thicknesses are higher than 45 mm, it is recommended to use long cannons (75-100) mm;

– the diameter of the focusing cannon in close connection with the type of abrasive used;

– the abrasive flow, can lead to an accelerated wear of the focusing cannon if it has high values, for long processing periods of time;

– the nature and granulation of the abrasive, the reduction of its hardness can lead to the decrease of the cutting quality;

– nozzle-piece distance, increasing this distance to values greater than 5 mm can lead to an increase in the width of the cut and an increase in the angle of deviation of the cut at the exit of the jet from the material.

4. Water Jet Cutting Machines

Water jet processing equipment is classified according to working pressure, number of axes and others.

In terms of working pressure, water jet cutting machines can be:

a) Machines that can process with pressures up to 400MPa

Fig. 5 (Herghelegiu, 2011; flowcorp.com) shows the WMC2 car with the following main characteristics:

– length and working width: two variants of (2x2) m or (4x6) m;

– displacement on the Z axis: 250 mm is made pneumatically;

– accuracy: 0.08 mm.

Fig. 5 – Water jet cutting machine WMC2/ Waterjet Machining Center (Herghelegiu, 2011; flowcorp.com).

Fig. 6 shows the water jet cutting machine OMAX model 55100 (Herghelegiu, 2011; omax.com).

The main technical characteristics of the machine are the following:

– displacement on X - Y (2540x1397) mm;

– accuracy 0.08 mm;

– standard speed of 4572 mm/min;

– working pressure: it is set optionally and has values of 200 MPa or 400 MPa.

Fig. 6 – Water jet cutting machine OMAX (Herghelegiu, 2011; omax.com).

b) In terms of the number of processing axes.

Fig. 7 shows the 5-axis water jet cutting machine Primus 184 INTERMAC, Italy (abitare.com), and Fig. 8 shows a 6-axis water jet processing robot (Herghelegiu, 2011; flowcorp.com).

Fig. 7 – 5-axis water jet machine Primus 84 INTERMAC (abitare.com).

The main technical characteristics of the machine are the following:

– maximum surface of a semi-finished product: 2100 mm x 4200 mm;

– very high pressure amplifier (420 Pa-60.900psi) with 50Hp (37 kw);

– maximum flow rate: 3.8 l/min;

– continuous pressure adjustment from 50 MPa to 400 MPa.

– the overall dimensions of the table: length-5.690 mm; width-2.420 mm; height-2.050 mm; weight-3.800 kg;

– working surface: transverse axis X = 1.860 mm; longitudinal axis Y = 4,000 mm; vertical axis Z = 250 mm.

Fig. 8 – Robot in 6 axes of processing with water jet (Herghelegiu, 2011; flowcorp.com).

The main features of the robot in Fig. 8 are the following:

– length and working width: two variants of 1.8 m x 2.3 m or 2.5 m x 17 m;

– displacement on the z axis: from 36 to 120 inches, depending on the type, model and orientation;

– accuracy: 0.254 mm to 0.305 mm.

5. Planning for Water Jet Processing

The parts that will be processed with water jet were obtained from liquid wood by injection in the mold from two materials, Arboblend V2 Nature and Arbofill Fichte, of dimensions' l = 45 mm, L = 70 mm and thickness g = 10 mm. The research team within the "Gheorghe Asachi" Technical University of Iași, Department of Machine Manufacturing Technology, has conducted numerous studies and research on determining the mechanical, thermal, and structural properties of liquid wood parts obtained by injection molding (Nedelcu *et al*., 2013; Nedelcu, 2013; Nedelcu *et al*., 2016; Nedelcu and Comaneci, 2014; Nedelcu *et al*., 2015; Broitman *et al*., 2018; Nedelcu and Paunoiu, 2015; Mazurchevici *et al*., 2018; Plavanescu et al., 2015; Nedelcu *et al*., 2019; Plavanescu *et al*., 2016; Broitman *et al*., 2020; Nedelcu *et al*., 2014). These properties need to be known to carry out the water jet processing in good condition.

Finally, the two levels for the three input factors are shown in Table 1, which shows the complete factorial plan used to cutting both materials with water jet.

Table 1
Full Experimental Plan

Nr. Exp.	Input parameters		
	Speed	Distance between head and piece	Machine Quality Level
1	–1	–1	–1
2	–1	–1	+1
3	–1	+1	–1
4	–1	+1	+1
5	+1	–1	–1
6	+1	–1	+1
7	+1	+1	–1
8	+1	+1	+1

5. Conclusions

The water jet cutting process is used in various industrial fields such as automotive and aerospace, due to the flexibility of production and the large number of parts that can be processed. The water jet cutting process is environmentally friendly, being an ecological processing process, an aspect that compensates for the lower productivity and the relatively high costs of abrasive and exploitation materials. The quality of the processed surfaces is divided into 5 categories from Q1 to Q5, *i.e*. from a low surface roughness to one with high roughness. Machines used for water jet processing are classified according to the pressure that can be developed for water and the number of axles.

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PRELUCRAREA CU JET DE APĂ A REPERELOR DIN LEMN LICHID OBȚINUTE PRIN INJECTARE

(Rezumat)

Procesul de prelucrare cu jet de apă se încadrează în procesele neconvenţionale moderne de fabricaţie, putându-se realiza cu sau fără amestec de abraziv şi fiind o alternativă foarte bună pentru celelalte tehnologii tradiţionale de aşchiere. Prin tăiere cu jet de apă se pot prelucra o gamă mare de materiale compozite, atât cu matrice polimerică cât şi metalică, dar şi materiale moi şi flexibile, tocmai datorită generării unor forţe mici la tăiere.

Lucrarea tratează aspecte legate de principiul prelucrării cu jet de apă, principalii parametri ai procesului de prelucrare, maşini utilizate şi propunerea de plan experimental în vederea realizării încercărilor experimentale.