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Prevention Of Chips Formed İn Circular Cutting Of Glass Plates With Water Jet Cutter

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Abstract

In the water jet cutting method, breaking and burrs occur on the cutting edges while 8mm thick glass is cut circularly in two different sizes for the purpose of the Burner Plate (hearth). This not only causes loss of time due to the need for a second running-in process, but also increases the cost and causes an increase in the amount of scrap. In this study, it is aimed to improve the process by experimentally finding the parameters of the edge quality of the 8 mm thick glass material cut after correcting the squareness of a CNC water jet cutter to improve the circular cut. In tests performed at different pressures and different flow rates, with different nozzles, orifices and garnets, it was found that the most efficient and error-free cutting process will be by choosing the cutting speed of 1000 mm/min with 2000 bar, 0.4 kg/m abrasive flow rate, 0.76 nozzle, 0.25 orifice combination and 120 mesh garnet abrasive.

Keywords: Water Jet Cutter, Cutting, Glass, Chip.

1. Introduction

With the water jet cutting method, all artificial and natural materials are able to be cut with high efficiency without the effect of heat and without the need for tool change. Cutting could be done by conveying the water, which is sent from the pumps that produce high pressure water, to the material to be cut as plain or abrasive. During cutting, the distance between the conveyed water and the material and the speed of its progress must be maintained. Therefore, it is integrated with automatic speed-controlled cutting systems.

Water jet cutting technology was first discovered and used in the mining sector in the second half of the 1800s for pressurized water washing. In the early 1900s, rock cutting experiments were carried out with pressurized water and a 500 bar pressure water jet was provided. In the 1970s, an equipment producing 2750 bar pressure was developed and in 1972 the first industrial water jet cutting system was operated. In the systems developed later, hard materials were enabled to be cut more effectively by mixing cutting abrasive material into the sprayed pressurized water [1-5]. Presently, cutting systems with water jets up to 6,200 bar are used.

There are two basic types of cutting in water jet technology. These are plain water cutting and abrasive cutting. Cutting with plain water is made without mixing any auxiliary substances into the water sprayed on the material and is used to cut materials with relatively low hardness value. Abrasive cutting is applied by mixing abrasive (garnet) into the sprayed water. It is applied via the abrasive water jet of Cam [11].

In water jet cutting technology, every sector and cutting process of all kinds of complex shapes can be responded to. Very zigzag cutting, sharp corner, very narrow-angle cutting and very small radius cutting operations can be performed with water jet cutting systems integrated into CNC (Computer Numerical Controlled) systems and by using water jet software that includes automatic placement as in the example shown in Figure 1.1. [6].

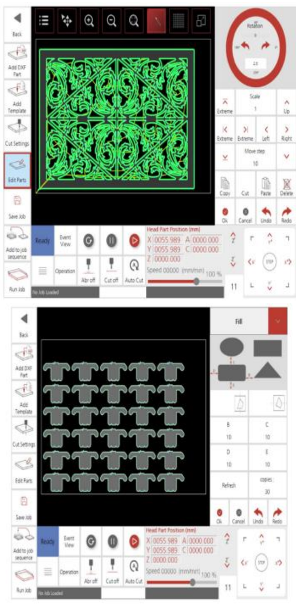

Figure 1.1. Water jet cutting software

The biggest advantage of water jet technology is that it has a cold-cutting process. Since mechanical and thermal stresses do not occur on the cut material during cutting, there is no need for post-cutting stress relief processes. All materials can be cut without temperature formation. Thus, unwanted hardening, burning, deformation, droplets, molten metal scraps and toxic gas are not formed on the cutting surface.

As a result of the mechanical reaction occurring during cutting occurs in a micro/molecular structure, no deformation occurs on the material despite the high kinetic energy carried by the water jet, and if the appropriate parameters are selected with a precision positioning machine, a burr-free cutting process takes place. In this way, in water jet cutting, the cutting edges are surprisingly clean and there is absolutely no need for deburring, which means a second cost. Material losses are minimized thanks to the very narrow (maximum of 1.1mm) cutting track range. It is possible to cut very narrow and sharp corners depending on the beam diameter of the water jet, which is the cutting element. With the same cutting equipment, different thicknesses and different materials are ablo to be cut without making any changes, simply by changing the cutting speeds.

2. Working Principles and Application of Water Jet Cutting Systems

In the water jet cutting system, the pneumatic on-off valve located on the machine cutting head is opened and closed with compressed air through pipes with 1/4” and 3/8” outer diameter by the pump that produces high pressure water at the value of 1.500-6.000 bar, and pressurized water in the cutting head is mixed with abrasive. Afterwards, as seen in Figure 2.1, it firstly passes through the sapphire or diamond orifice and triples the speed of sound. Meanwhile, it is conveyed to the material to be cut over the nozzle by mixing the abrasive. [13-14-15-20-21]

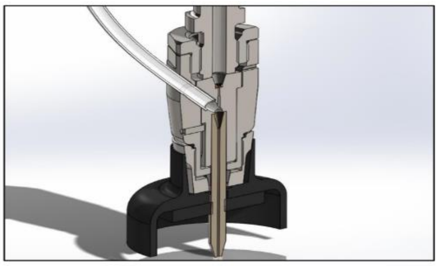

Figure. 2.1 – Cutaway view of cutting head consisting of sapphire/diamond orifice abrasive cut and nozzle [7]

Since the speed of the water passing through the orifice increases approximately 3 times the speed of sound, this process is called ‘water jet’. The inner diameter of orifice is usually between 0.20 mm and 0.35 mm. The delivery of pressurized water to the cutting head is provided by an on/off valve as shown in Figure 2.2.

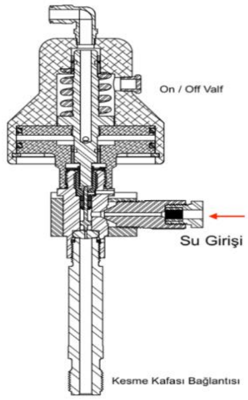

Figure 2.2. On / Off valve that provides the delivery of pressurized water

The orifice size to be selected depending on the pump capacity and the amount of water delivered is an important parameter for a quality cut. In figure 2.2, the relationship between orifice diameter and flow rate is shown. The water coming out of the orifice and garnet abrasive with 80-120 mesh sizes are generally conveyed in nozzles with an inner diameter of 0.60 mm to 1.02 mm. The material is cut with the water coming out of the nozzle by leaving an average of 2-3 mm distance between the nozzle tip and the material. Abrasive could be drawn by vacuuming with the water jet coming out of the orifice as well as abrasive propulsion systems are used for a more homogeneous flow. The abrasive mixed water jet sent from the nozzle must move at a constant speed while cutting the material.

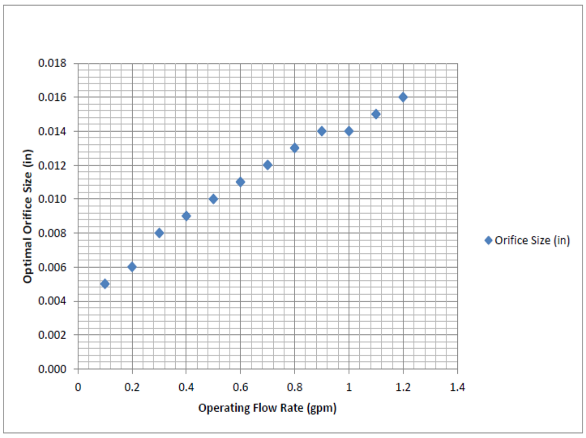

Figure 2.2 Relationship between orifice diameter and flow rate [7]

In order to adjust the garnet abrasive flow precisely, the abrasive dosage system seen in Figure 2.3 was used.

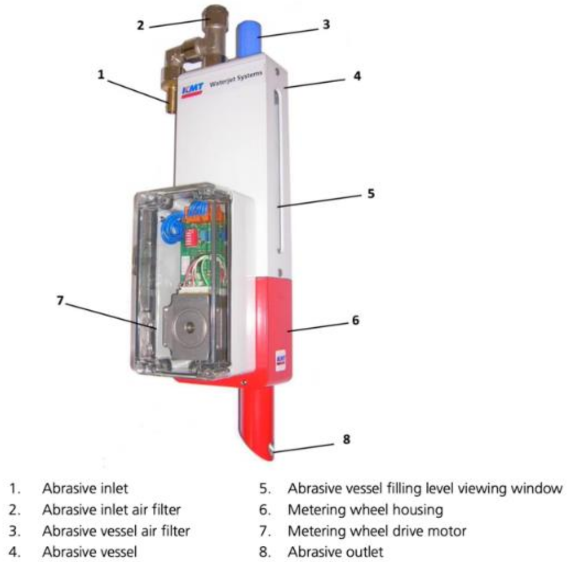

Figure 2.3 Abrasive dosage system [8]

The amount of abrasive according to the voltage value given by the water jet cutting software and CNC is also shown in Figure 2.4.

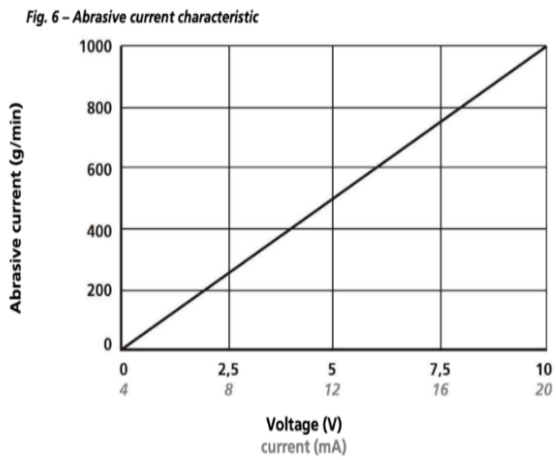

Figure 2.4 Abrasive dosage system voltage/flow rate graph [8]

3. Machine Squareness Precision

The squareness precision of the X and Y axes of the machine is very important for smooth circular cuts and minimizing the measurement errors and breakage errors. Before the experimental study, the squareness of the machine was measured and the errors were corrected parametrically via CNC control system and Y1 and Y2 motors. Squareness measurements before and after correction are described in Figure 4.1 and Figure 4.2.

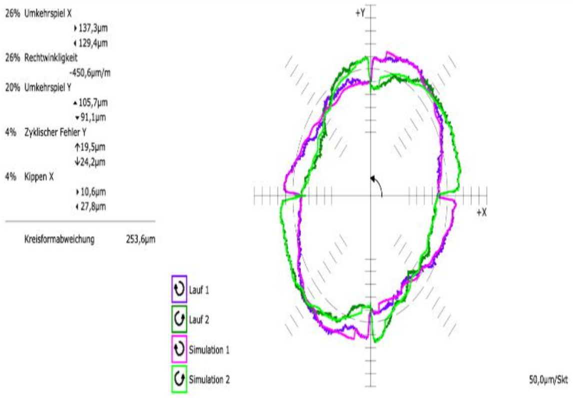

Figure 4.1. Squareness before correction

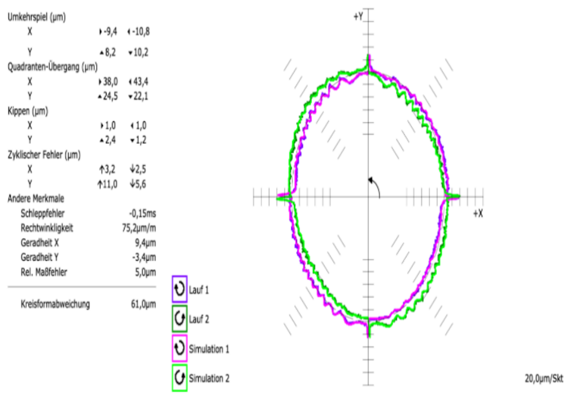

Figure 4.2 Squareness after correction

4. Cutting Speed Selection Experiments

The cutting quality decreases during process if the precision of the CNC Machine X and Y axes is not sufficient, the parameters are not selected appropriately, the garnet flow is not homogeneous, the garnet size is not homogeneous and the appropriate nozzle-orifice combination is not selected. First of all, machine positioning precision and squareness settings were adjusted [12-18].

Cutting with appropriate parameters

• increases cutting quality
• reduces the cost (garnet consumption decreases, energy cost decreases)
• reduces time loss
• increases cutting speed.

Moreover, the nozzle-orifice combination used while cutting and the abrasive flow rate of the abrasive used, and the parameters given in Table 4.1 for this application, it has been determined that the combination that will give the desired quality at the most optimum cutting speed has been obtained by experiment no. 14 [10-16-17-19].

Experiment	Pressure (BAR)	Abrasive (gr/min)	Nozzle (mm)	Orifice (mm)	Garnet (mesh)	Cutting speed (mm/min)
1	3500	500	1,02	0,35	80	1200
2	3500	400	1,02	0,35	80	1000
3	3500	300	1,02	0,35	80	800
4	3500	200	1,02	0,35	80	600
5	3000	500	1,02	0,35	80	1200
6	3000	400	1,02	0,35	80	1000
7	3000	300	1,02	0,35	80	800
8	3000	200	1,02	0,35	80	600
9	2500	500	0,76	0,25	120	1200
10	2500	400	0,76	0,25	120	1000
11	2500	300	0,76	0,25	120	800
12	2000	200	0,76	0,25	120	600
13	2000	500	0,76	0,25	120	1200
14	2000	400	0,76	0,25	120	1000
15	2000	300	0,76	0,25	120	800
16	2000	200	0,76	0,25	120	600

Table 4.1 Experiment Matrix

The best result obtained with the experimentally found parameters in cutting 8mm thick glass with water jet cutter was obtained with Experiment 14, and the comparison with the quality of the cut edge with Experiment 6 and Experiment 10 is shown in Figure 4.1.

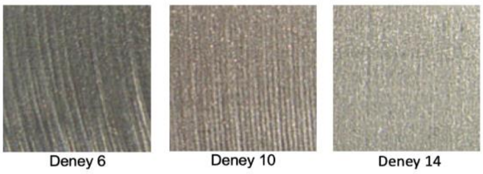

Figure 4.1 Impact of cutting speed on the cutting surface

The best results were gathered in the cuts made with the Experiment No. 14 parameters and it was found that the chips were prevented on the edges of the circularly cut 8mm glass and a smoother edge quality was observed. Examples of clean cuts and chipping in two different circular sections with diameters of 100 mm and 30 mm are shown in Figure 4.2.

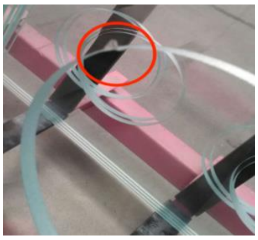

Figure 4.2 Experimental results of the cuts made with inappropriate and appropriate parameters respectively

5. Conclusion

In addition to the quality and precision of CNC water jet cutting machines, the quality of the high pressure pump and the homogeneous pressure and water flow, the appropriate selection of other parameters also increases the performance and quality of the water jet cutting machines as they become functional. In this study, it is aimed to obtain the most efficient results with the experimental studies carried out with the aim of eliminating the chipping problem in a water jet cutting machine used in the glass industry.

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