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Paper

DEVELOPMENT OF A NEW METHOD IN ORDER TO DO SILENT ABRASIVE WATER JET TURNING PROCESS APPARATUS

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ABSTRACT

This study aims to reduce the high level of noise generated during the machining process using abrasive water jet turning from a range of 100~130 dB(A) to a range of 70~85 dB(A). Moreover, this study also focus on a new method to be developed and applied in order to remove the ripple effect occurring in the water jet pool and to eliminate the abrasive water jet splash. This new method developed in the current study proved successful for the machining of polymer based plastics using abrasive water jet below the surface of water levels.

Keywords: Abrasive water jet machining, abrasive water jet turning, worker health and safety awareness, Noise.

1. INTRODUCTIONS

Abrasive Water Jet (AWJ) cutting has been used as an efficient method for machining of any material, especially the ones hard to cut, in line with the developments in the materials used for industrial purposes. Water jet technology with its structural differences from traditional machining techniques has found a place for itself in developed countries for the operational and economic advantages it offers [1,2].

It is possible to machine rotating workpieces using water jet along with machining and cutting flat surfaces. In this respect, water jet serves as a tool bit. However, there is an essential difference between water jet and the traditional tool bit. It utilizes the manufacturing of rotating symmetry out of hard-to-machine metals such as complex metal composites, tough alloys, and ceramics. Operation of the water jet involves the movement of the jet in x, y, and z coordinates while the workpiece rotates. The system is shown in Figure 6. An important advantage brought in by AWJ machining is that it offers very low cutting power which allows for machining of brittle bars with very small diameters and made of hard-to-machine materials [3].

The literature scan showed that there are several experimental studies which involve cutting and erosion using a milling device [4-13]. However, it was found that all the milling mechanisms used in these studies were similar and that the mechanism most of the times did not involve an enclosure in order to protect against pressure water and abrasive particles while the process was conducted above water level. Using a lathe chuck without any enclosure makes the machining process even harder to perform. The noise produced by the abrasive water jet nozzle when used above water level is rather high and may reach up to 110 dB(A) . Available two-dimensional abrasive water jet cutters machine the workpiece below the water level in order to reduce the noise produced and the splatter of the materials (Figure 1). Exposure to loud noises (> 80 dB(A)) for an extended period (months and years) can cause irreversible hearing loss . This hearing loss may be permanent or temporary, or both. Temporary hearing loss, also known as auditory fatigue, loses its effect when the subject leaves the environment with loud noise (often within 2 hours) [14-16].
Permanent hearing loss depends on the following;

- Personal Sensitivity,
- Level of noise (sound energy level),
- Frequency distribution of the noise-sound,
- Daily total exposure duration,
- The length of the duration one is exposed to loud sound,
- The nature of the sound, i.e. continuous, intermittent, or pulsed.

Figure 1. Two-dimensional cutting process below the water level of abrasive water jet,

Being exposed to continuous sound above 85 dB(A) causes significant hearing loss for many people and the damage is increased with the increasing sound level. The permitted exposure duration for unprotected ears should be decreased by half for every 5 dB(A) increase in the noise level. For example, the exposure duration for 90 dB(A) should be limited with 8 hours while this number should be 4 hours for 95 dB(A) and 2 hours for 100 dB(A) . The permissible maximum noise level for the protected ear is 115 dB(A) for 15 minutes.

2. MATERIALS AND METHODS

Machining parameters of the abrasive water jet cutter used in the experimental study are shown in Table 1.

Table 1. The parameters used in the turning operation by abrasive water jet.

PARAMETERS	VALUE
Pressure, MPa	300
Traverse rate, mm/min	30
Abrasive mass flow rate, g/min	55
Orifice diameter, mm	0.33
Focusing tube, mm	0.76
Focusing tube length, mm	72
Stand-off distance, mm	2
Number of passes	1
Cutting head angle. Degree °	90°
Abrasive	Barton Garnet
MESH	80

Figure 2 shows the experimental turning mechanism used for abrasive water jet cutting below water level and the water jet lathe used. Figure 3 shows the computer assisted design of the turning mechanism used for abrasive water jet cutting below water level in this study.

Figure 2. The water jet machining machine used in the experiment.

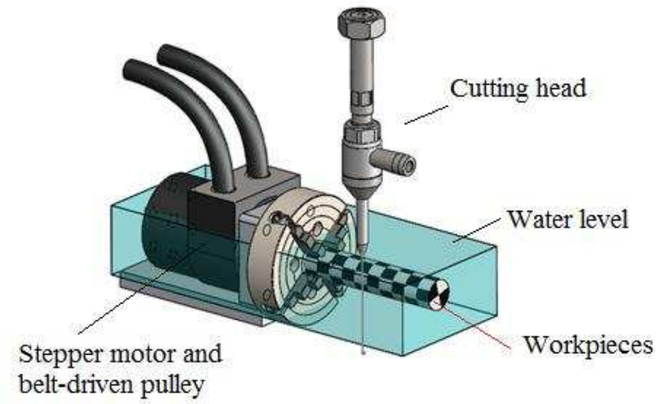

Figure 3. The three-dimensional image of the experimental setup model that is designed to make turning with abrasive water jet under the water level.

Custom experimental machining workpiece holder was tried for speeds under 50 rpm. It was only aimed to give circular motion to the workpiece in the same direction with the abrasive water jet. As low speed was preferred, lathe chunk did not cause ripples in the water. Nevertheless, water chuck and bearings were made of waterproof stainless material and polymer plastics. Figure 4 shows the prototype model developed experimental setup to make turning with abrasive water jet under the water level. DT-8852 digital sound / noise level meter data logger used in this study is shown in the Figure 5 below. Specifications of this device are given in Table 2.

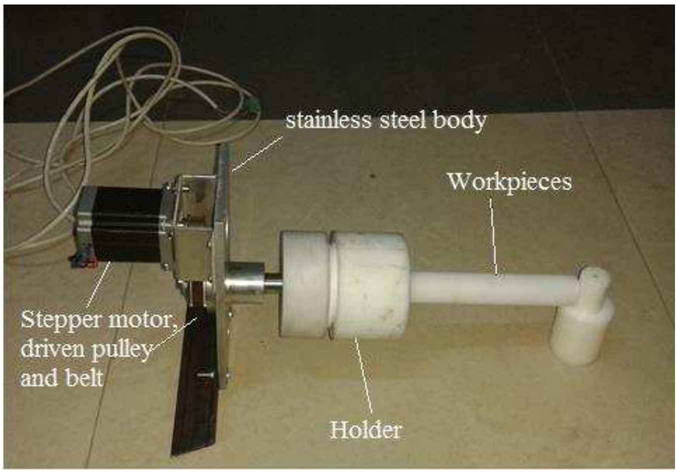

Figure 4. The image of the prototype model developed experimental setup to make turning with abrasive water jet under the water level.

Figure 5. DT-8852 sound level meter [17].

Table 2. DT-8852 sound level meter characteristics [17].

Standard applied	IEC61672-1 Type 2, ANSI
Accuracy	±1.4 dB(A)
Level ranges	Auto:30 dB(A) ~130 dB(A)
Frequency range	31.5 HZ ~ 8 KHZ
Dynamic range	50 dB(A)
Time weighting:	125 mS,
Microphone	1/2 inch electret condenser microphone
Resolution	0.1 dB(A)
Display Update	2 times/sec
Analog output	AC/DC outputs, AC=1Vrms, DC=10mV/ dB(A)

3. RESULTS AND DISCUSSION

Abrasive water jet processes in which the water jet nozzle operates below and above the water level have resulted in different outcomes. The noise level obtained from the nozzle which was placed 2mm above water level where the meter was placed 1 meter away from the mechanism was recorded as 108,9 dB(A) (see Figure 6 (a)). The noise level obtained from the nozzle which was placed 2 mm below the water level, on the other hand, was recorded as 85,4 dB(A) (see Figure 6 (b)). Noise level decreases by 27.51% when the machining is performed when the nozzle is located 2mm under water. This is a significant difference which cannot be ignored.

Figure 6. (a) Turning with abrasive water jet over the water level, (b) turning with abrasive water jet under the water level.

4. CONCULISONS

It is possible to reduce the noise level at its source, to reduce it on the way the energy of sound diffuses, and to protect the exposed personnel in order to reduce the noise produced by the water jet and the pump during the abrasive water jet machining process. This study found that it was possible to reduce the noise level by 27% by machining the workpiece under water where nozzle is also located underwater. According to the occupational health and safety standards, a noise level of 85.4 dB(A) is in the acceptable range for 8 hours daily work. This is a significant number in terms of occupational health and safety. Nevertheless, machining where workpiece and nozzle are placed under water eliminates the unfavorable conditions such as ripples in the water jet pool and water splash. It allows for a safer and orderly working environment. It is expected that the findings of this study will contribute to the future research in the field of abrasive water jet cutting.

5. ACKNOWLEDGMENT

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