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Paper

TURNING OF BRITTLE AND VERY HARD MATERIALS WITH ABRASIVE WATER JET

Fuat KARTAL

Mechanical Engineering Department, Kastamonu University, Turkey
fkartal@kastamonu.edu.tr

Abstract

In this study, turning materials which are very difficult to be turned by conventional methods due to their geometry and mechanical properties have been turned with abrasive water jet. Two different turning mechanisms have been developed for turning with abrasive water jet. Three-phases motorized turning apparatus for turning long work pieces at low and high turning speeds, and a stepper motor driven turning assembly for three-dimensional operations were developed. As a result of the study, HSS tool, glass goblet, drill bit, glass rod, polyethylene, glass bottle, bevel gear, screw shaft materials with abrasive water jet turning operations have been performed successfully.

Key words: Abrasive water jet, turning, complex and brittle materials

1. INTRODUCTION

Abrasive water jet (ASJ) treatment is classified as hydrodynamic treatment [1-2]. Abrasive water jet treatment, which is one of the unusual manufacturing methods, has advantages over other processing technologies [2-3]. With abrasive water jet, brittle, ductile, composite and low melting materials can be easily processed [1-4]. Due to the longer service life and the cutting speed, water jet grinding is less expensive than conventional technologies for processing such materials [1-6]. Although in steel and other common materials, the cutting speed of water jet grinding is actually lower than in conventional turning. This cutting technology is well suited for difficult-to-process materials: composites, glass, ceramics, titanium alloys, etc. Profile grinding wheels are also one of the possible applications with abrasive water jet rotation [1-7].

In this study, abrasive water jet turning of the samples which are difficult to turn by traditional method due to their geometry and mechanical properties was performed.

2. MATERIALS AND METHODS

2.1. Turning Experiment

The Schneider Altivar-12 220V-380V speed control board is used to control the speed in a 0.37 KW three-phase asynchronous electric motor. The special feature of this board is that it makes constant torque and speed of the motor by making adjustments such as rotation direction and speed with the three-phase motor. When machining with water jet, the turning direction of the lathe chuck continues to be constant according to the set speed value as well as there is no such factor as increase-decrease in the lath rotation speed. A special USB connection cable coded TCSMCNAM3M002P is used for programming the Schneider Altivar-12 speed controller card. The direction of rotation is determined by the direction button on the SoMove Lite v1.9.4.1 program user interface installed on the computer. In Figure 1, there is a special lathe mechanism which provides speed control with 3-phase motor.

Figure 1: Asynchronous Motor Turning Test Assembly Image

The most important feature of the lathe test apparatus is that the electric motor is higher than the level of the water jet water collection pond and that the splashed water particles cannot reach the electric motor. In the test apparatus, the use of a moving tailstock and a lathe chuck housing have given the apparatus a different feature.

2.2. Stepper Motor Turning Device

Another method for machining with ASJT is to turn the turning chuck to which the work piece is connected to produce three-dimensional parts at an angle of rotation. This method is the most convenient method to perform the same operation on different parts of the CNC program without removing the work piece from the machine and distorting the work piece coordinates (zero). With this method, products with complex geometries can be produced on more than one machining surface with different rotation angles. In this study, Nema 24 step motor with 1.8 degrees step angle with 3.1 NM torque is used. The 3-axis Toshiba TB6560 control and interface board, which is commonly used as a driver board, is used. Parallel Port Laptop provides Mach3 Mill software for programming the movement of stepper motor. The non-turning test setup using a stepper motor and four-legged 100 mm turning chuck is shown in Figure 2.

Figure 2: Step Motor Turning Test Assembly Image

2.3. Test Samples

The test specimens, the HSS turning tool in 10x10 mm glass cup, 14 mm diameter drill bit 30 mm diameter glass rod and polyethylene, glass bottles, screw made of case hardened steel shaft and bevel samples were selected (Figure 3). In particular, the selection of these materials is that they are both brittle and hard.

Figure 3: Image of test samples

2.4. Test Conditions

In this study, parametric study was not performed on parts machined with ASJT. The parameters were fixed based on experience (Nozzle feed 100 mm / min, abrasive flow rate 500 g / min, Nozzle distance 2 mm, pump pressure 3600 MPa, Nozzle diameter 1.3 mm, turning speed 20 rpm). In this study, the turning ability of hard, brittle and ductile materials, which are difficult to be processed by traditional turning method, was carried out.

3. RESULTS AND DISCUSSION

In this study, materials with different geometric shapes and mechanical properties are processed with asynchronous motor lathe or stepper motor lathe according to their properties with ASJT. Long and cylindrical work pieces that need to be centered with tailstock are machined using asynchronous motorized lathe. The work pieces, which are suitable for connection with short and four-legged lathe chuck, are machined with ASJT by using stepper lathe. It has been found that stepper lathe assembly is suitable especially for short materials. Square and ellipse materials are easily connected using a four-leg mirror. Both test devices were insulated against water. Figure 4 shows the moment of cylinder ring removal in the fragile glass goblet with ASJT. Figure 5 shows the ASJT-treated samples.

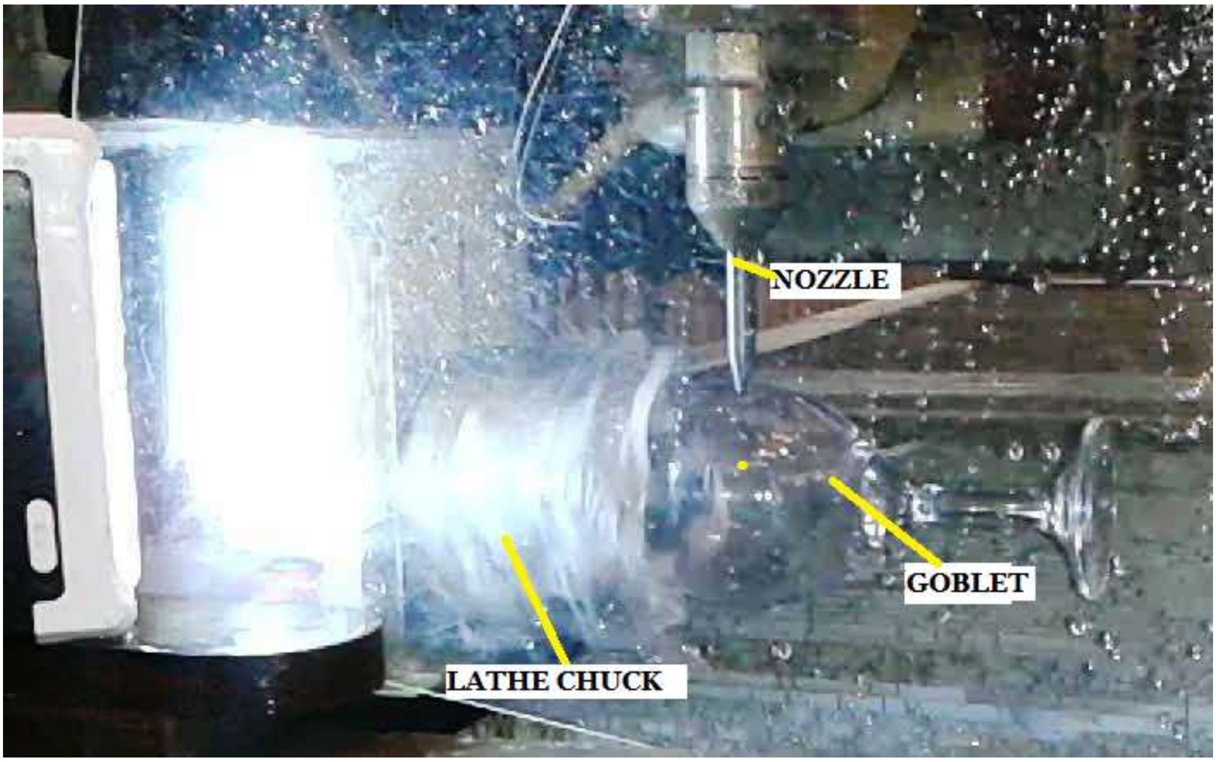

Figure 4: Image of Ring Extraction Process in Fragile Glass Goblet

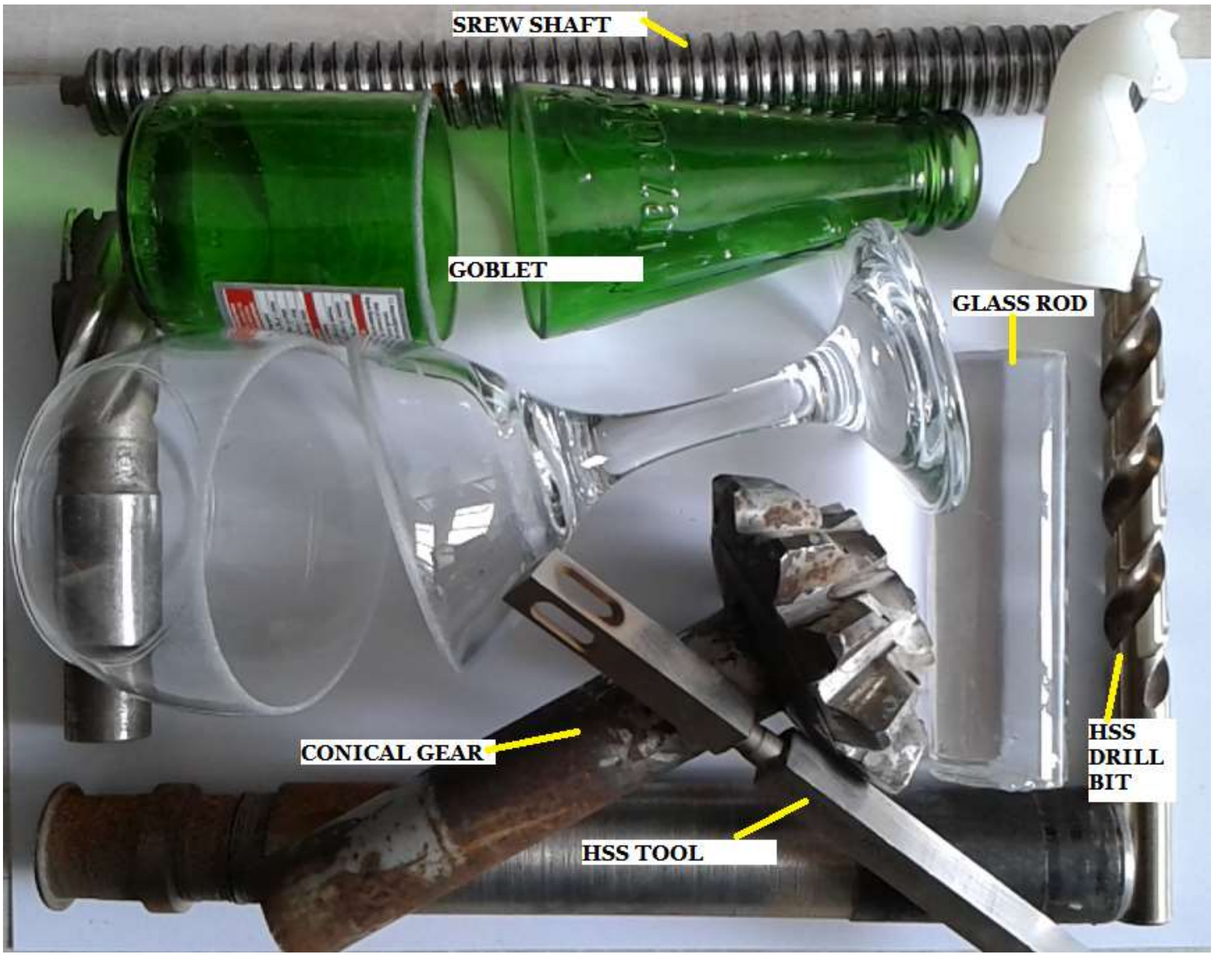

Figure 5: ASJT-Treated Test Sample Image

4. CONCLUSION

Within the scope of this study, work pieces selected from materials which can be difficult and even impossible to be processed by conventional manufacturing methods within the so-called limits have been successfully cut, diameter reduced, rough turning and forming processes with ASJT. In this study, no parametric study was performed. Findings obtained in this study;

• Different materials could be cut using the same nozzle.

• Square rectangles prism and ellipse geometry materials can be processed.

• The lathe chuck was rotated at 90 degrees to form a square, rectangular and prism sample surface without changing part coordinates.

• The ring was extracted from the very fragile glass.

• 14 mm diameter drill bit is reduced to 8 mm diameter.

• Bevel gear coarse turning process.

• Glass bottle cutting turning operation was performed.

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