Application of CNC machine router 3-Axis for making of Engravired granite or marble

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Abstract. The development of a Computer Numerical Controller (CNC) machine specifically for the manufacture of creative product crafts needs to be encouraged to improve the variety and quality of the products. Manual engraving of natural stone (marble, granite) by relying on the skills of people and simple equipment will produce a product with a long time of processing. Competition in the business and industrial world is needed to increase effectiveness and efficiency with short manufacturing time indicators, low prices, more and more interesting design variations. The research objective is to find effective and efficient machining parameters, analyze factors that influence surface roughness, and enrich the variety of creative product designs of marble stone materials. This study uses an experimental method approach which is a study to find the effect of spindle rotation variables, infeed speed, infeed depth on the quality of surface roughness by operating the CNC Machine Router 3-Axis. It was found that the following parameters of the machine are cutting speed machining 30 (m / min), spindle rotation 12000 (rpm), and speed / feed rate 2000 (mm / min). Analysis of factors that influence the surface roughness of marble engraver the higher the speed / rate of infeed and the depth of infeed, the higher the surface roughness value of marble. Computer and engineering software applications are able to increase the variety of creative product designs.

1. Introduction

The progress of science and technology today is so advanced, but some people still use the method of making products in a conventional way. Conventional mold making has a lack of productivity, manufacturing time and minimal design variations so that it has not been able to meet consumer demands. The use of 3-axis router CNC (computer numerical controllers) machine is one of the options to meet the increasingly high demands of consumers, both in terms of quality and quantity [1]. Today's era of industrialization has increased the need and use of CNC machines along with the demand for creative products of granite or marble. CNC machines routers are machine tools used for cutting, engraving and marking workpieces with rotating chisels on their axes, and cut surfaces in the form of flat, angular or curved shapes [2,3]. Previous research, namely the manufacture of aluminum batik stamp with CNC Router 3-Axis Machine by applying mastercam software was successfully done to enrich national batik motives [4]. Another study, Ardiansyah [5] in his research resulted in the effect of machining parameters on the surface roughness of teak wood material. Patel K.P. [6] analyzed surface roughness experiments on CNC milling 3-axis machining process with aluminum material. The research objective is to find effective and efficient machining parameters, analyze factors that influence surface roughness, and enrich the variety of creative product designs of marble stone materials.

According to Salam, A. Rohman [7] CNC machines are classified according to shape, spindle position, number of axes and spindle speed. Based on the size of the shape, CNC machines can be classified into 2 types, namely plano and gantry. Based on the position of the spindle, CNC machines
can be classified into two types, namely horizontal and vertical types. The axis is a rotating shaft on the spindle and workbench. Based on the number of axes, the number of rotary shaft in CNC machines is divided into several types, namely 2 axis, 3 axis, 4 axis and 5 axis. Based on spindle speed, CNC machines can be classified into two, namely high speed machining and low speed machining [7]. The **CNC Machine Router 3-Axis** can be categorized as CNC machines with high spindle rotation speed or high speed machining.

The research objective is to obtain the optimal setting of CNC router machining parameters, analyzing the factors that influence the surface roughness of granite and marble stone. Optimal conditions for precise and time efficient machining parameters, surface roughness, security for cutting tools to enrich various creative gravired of the stone products in Indonesia. The CNC Machine Router 3-Axis machining parameters consist of cutting speed, spindle rotation, feed rate, and cutting depth. Cutting speed is a rotational speed of cutting tools expressed in meters per minute. The cutting speed depends on the workpiece material to be cut and the material from the cutting tools themselves. Spindle rotation is the ability to rotate the router CNC machine in one minute. The feedrate is the straight-distance feeding motion taken by the cutting tool at a constant rate relative to the workpiece in units of time (mm / min). Cutting depth (depth of cut) is determined based on the difference in thickness of the initial workpiece to the thickness of the final workpiece. The size of the depth of the cut is closely related to the speed of feeding and also the diameter of the cutting tool.

1.1. **Software of CNC machine router 3-axis**
The selected software is an important mean of operating the CNC Machine Router 3-Axis. The program implemented consists of various kinds of instructions from the software to carry out work orders. The things instructed by the software for breakout boards and drivers are the movement of stepper motors, spindles and relay settings, limit switches and emergency stops. The 3-axis CNC machine for making aluminum molds uses several supporting software before being executed by Mach3, namely CorelDraw, Aspire Vectric. Mach3 is a software found by Art Fenerty in 2001 and developed by ArtSoft. This software functions to implement all commands to the driver in running a 3-axis CNC router machine. This can be ordered by the Mach-3 software, namely the movement of the stepper motor (axis movement) in the form of G / M code, spindle rotation and speed, limit switch settings, relay settings and emergency stop settings. These commands are the basis for programming a 3-axis CNC router machine, making Mach3 software the main software in programming 3-axis CNC router machines [8].

CorelDraw is a computer program that performs editing on vector lines. This program was created by Corel, a software company headquartered in Ottawa, Canada. CorelDraw has uses for processing images. Therefore it is widely used in work in the field of publication or printing or work in other fields that require a visualization process. The superiority of CorelDraw mamou produces images produced with vector or vector based. CorelDraw is used as a tool for designing with higher quality results in collaborating between writing and drawing, especially when dealing with curves, lines or angles [9]. Aspire Vectric software is one of the programs used in CAD / CAM to provide creative industrial product manufacturing solutions by highlighting decoration and artistic. This combination of artistic features is often used in making products with 3-axis CNC router machines. The materials used make various kinds of creative products made from aluminum, copper, brass, wood, and acrylic resulting good products [8].

2. **Methods**

2.1. **Location and time of research**
The research location was conducted at Mechanical Engineering Laboratory of Semarang State Polytechnic, workshop of CV Retro Kreasi Machine in Semarang, and Erriesa Griya Print Pekalongan from April - October 2018.
2.2. Research materials and machinetools

The main research material: granite and marble obtained at Stone Gallery Semarang with various types of granite and marble available. Machine tool for this research is: CNC Machine Router 3-Axis with the following specifications: machine dimension: 1540x1005x1500 (mm); working area:

600x400x150 (mm); spindle motor: 3 (KW) 18000 (rpm); axis drive: stepper motor X = 8.7 (Nm), Y = 8.7 (Nm), Z = 7.7 (Nm), tool holder: ER20 collet, max tool he. 13 (mm); Power: AC220V / 50 Hz, 3.5 (KW); Computer: Dualcore 2GB RAM, 15 "Touchscreen LCD Monitor; software: Mach-3 CNC control (www.machsupport.com). The machine completed with cooling system, clamping system, cutting tools for carbide type Engraving bits of 600 Tip angle of 6 mm diameter, and surface roughness tester. The implementation of granite and marble engraving with CNC router machines to improve the variety of creative products consists of stages, Figure 1:

- Identification of the needs of natural stone engraving (marble / granite) craft.
- The design of marble / granite stone engraving motifs is done using a computer with some coreldraw, aspire vectric, and mach-3 software.
- The granite / marble material is prepared at the CNC router working table clamped to the edges so that it does not move towards the X axis, Y axis, and Z axis.
- The 3-Axis router CNC machine used by local production.
- Machining tests are carried out with granite / marble stones measuring 300x250x10 (mm) with machining parameters to produce the best graphical recommendations.
- Evaluation to obtain information about the best machining parameters (spindle rotation, feed rate, cutting depth, type of cutting tools) is correlated with the quality of marble engraving and the safety of the CNC router equipment and machines.
- Application of machining parameters study for the manufacture of creative marble stone engraving products from the design of the Polines logo, the Higher Education Research and Technology Logo, and the Garuda Logo using materials measuring 300x250x10 (mm). Granite and marble engraving products are painted to show attractive products.

Figure 1. Research design.

This activity includes smoothing sharp corners, and the coating process on the engraved groove with paint. The final stage of the activity of marble stone engraving is compared with conventional methods.
starting from preparation, execution, to finishing stage. Figure 1 research design of marble stone engraving with CNC router machine.

3. Results and discussion
The experimental data collected in Table 1 was then analyzed to determine the effect of CNC milling machining parameters on the characteristics of optimal quality and condition from a combination of machining parameter levels. The higher the spindle speed, the lower the surface roughness value. Conversely, the lower the spindle speed, the higher the surface roughness value will be. The higher the feed speed / rate, the higher the surface roughness value will be. Conversely, the lower the speed / rate of feeding, the smaller the surface roughness value will result. Experiments were carried out with 300 x 250 x 10 (mm) marble type Ornamental marble using carbide type cutting tools, collant water cooling systems and CNC router machines. Machining parameters for 12000 spindle rotation (rpm), feed speed / rate 2000 (mm / min), plunge 480 (mm / min), pass depth 0.5 (mm), step over 0.12 (mm) produce fine quality marble stone engraving functional and security cutting CNC router machine tools.

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4. Conclusion
The results of the research that have been carried out can be concluded:
- Machining parameters of the CNC Machine Router 3-Axis for engraving granite and marble stones are: cutting speed 30 (m / min), spindle rotation 12000 (rpm), and feedrate / feedrate 2000 (mm / min).
- Analysis of the factors that influence the surface roughness of the first marble engraving is the speed / rate of infeed, the depth of infeed means that the higher the value, the higher the surface roughness value of marble.
- Security of selected cutting tools of cutting tools of carbide type: Engraving bits of 60° tip angle, 0.5 mm diameter capable of finishing the marble logo polines at the time 01:36:22, logo ristekdikti 01:54:53, garuda logo 01:40:26 without replacing the cutting tool (of which a continuous liquid dromus cooler to keep cutting tools working optimally).
- Enrichment of creative marble engraving products can inniciatated with the input design of various photos on the corelDraw page into silhouettes, followed by setting Aspire vectric and Mach3 executions on CNC Machine Router 3-Axis.

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