Effect of Machining Parameters On the Surface Roughness of Dolomite Cups

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Abstract. Natural Stones product from Indonesia frequently used as product of pottery and medical devices. However, characteristics variation and hardness divergence level of natural stone (dolomite) causes differences in the requirements of machine parameters on the manufacturing of it. Especially for the process of cylindrical shape of dolomite cups. The machinery parameters of dolomite that baffle. Consequently, the process of dolomite cups manufactures becomes not optimal and need to investigate about the effect of machining parameters to the process of dolomite cups, so that the surface of the dolomite cups products can be smoother to the maximum to reduce finishing time. The first step to investigate in this research is to test the material characteristics and hardness test on dolomite cups originating from Malang Regency, Indonesia. Based on the data of hardness and characteristic test, generated the value of cutting speed, Feed and deep of cut with 3 different parameter levels. The result of the machining process is further tested by surface roughness measurement, which then obtained the results of surface roughness values of each level parameter. From the data collected could be generated that the value of cutting speed is directly proportional to the level of surface roughness, on the other hand for feed and deep of cut inversely proportional to the level of surface roughness of the dolomite cups turning process. It can be concluded that to get the result of surface of workpiece of dolomite cups with low surface roughness can be done by choosing high cutting speed, while feed and deep of cut chosen as small as possible. By the data gaining from the research found that the optimal parameter which result of the smoothest surface occurs in the 900m/min cutting speed, 0,06mm/rev feed and 0,1mm deep of cut.

Keywords: machining parameters, surface roughness, cutting feed, turning, dolomite cups cup

1. Introduction

The process of machining dolomite cups is various, ranging from the cutting process, the type of tool used, also the cutting parameters. This is because elements/composition contained in natural stones also vary depend on weather, water absorption and other factors [1]. Weather and fractured effect on dolomite cups characteristics, moreover about the resistance capacity and stiffness to compression. Thus, it is needs to use non-destructive testing for characterization and gain information regarding the mechanical parameters of natural stones [1] [2]. The differences of weather caused the differences of water absorption values for all the stone types, which the higher water absorption is the higher pore shape factor and lower quality index values depend on the noticeable increase in effective porosity values [1],[3]. Natural stones in general show the fragility of the process, so it must be done with care...
and as much as possible determined the work from the right mechanical angle. [3]. Some types of natural stones need to be investigated in, geological and geomechanical properties for developing and encouraging of carbonate rocks operation. [4].

One of the ways to produce innovative products of natural stones need a treatment with Phase Change materials (PCMs) with thermal energy storage properties [5]. Another parameter that affect to the wear of the tool are cutting rate and another cutting condition. It was modified by the manufacturer of tool [6]. From the district of Malang Indonesia, there are more than 10 type of natural stones. However, of all existing machining processes, the most important measure of the quality of the surface during the machining process is the average surface roughness (Ra), and is thus largely due to many machining parameters, such as correct chisel angles and cutting edge angles, cutting speed, feed rate, cutting depth, nasal radius, machining time [7].

Engineering components need a good surface finish and it ensures a great reliability of sensitive usability. Therefore, for better surface finish it is required to optimize process parameters [8]. Machining needs strategy for reducing ecological impacts of the cutting processes [9]. One of the process of natural cups is dry turning, which most emerging machining technique with good quality and productivity. Temperature of machining influence of material property of workpiece[10]. Moreover, adjusting the cutting conditions by adjusting some parameters will affect the result of the lathe, where the quality of the cutting surface depends on the spindle speed, the cutting speed and the deep of cut [11] [12]. Surface Roughness increase with the process variables except the speed, speed made adverse effect on surface roughness. For that we need research about the effect of machining parameters to the process of natural stones, furthermore the surface of the products can be smoother to the maximum so as to reduce finishing time. [13] [14].

Natural Stones contain of many single compositions. Based on previous research mentioned that the hexac structure of composite material causes the failure of cutting tools during the composite machining mainly due to the presence of hard particles that cause the higher surface roughness value [15]. As for the technical way of cutting will be very influential. Deep of cut is one of the highest significant parameter that affect tool flank wear. [16] Therefore, it is necessary to conduct research and search for optimum machining parameters that are specially performed on the turning machine, so that the optimal parameter values will be obtained produces workpiece with minimum surface roughness level [17] [18].

Based on previous research mentioned that the hexac structure of composite material causes the failure of cutting tools during the composite machining mainly due to the presence of hard particles that cause the higher surface roughness value [19]. As for the technical way of cutting will be very influential. Furthermore, the optimum parameters which give minimum surface roughness are needed [20].

2. Research Methodology
This research using specific material of natural stone, which is come from area of Dampit Regency Malang Indonesia. It has done by laboratory-scale experimental study that aims to determine the effect of cutting parameters on the turning process on the level of roughness of the dolomite cups surface.

2.1. Material
Material used in this research is dolomite, which is from the data of test result of material characteristic with X-Ray Fluorescence spectrometry (XRF) hence known element from dolomite cups which come from area of Dampit Regency Malang Indonesia is pertained marble type with macro content as follows:

- C2 Ca Mg O6; Dolomite:88.6
- C Ca O3; Calcite:11.4

With the composition of elements as presented on Table 1.

**Table 1.** Dampit dolomite stone compositions
The results of characteristic tests have been able to find the elements of the existing dolomite cups and find material compound characteristics.

The cutting tool used is a kind of insert chisel (universal steel machining) with composition: Co 7.0%, mixed carbides 8.0%, dan WC Balance. Grain size 1-2mm and hardness: HV 1450. Coating specification: CVD TiCN-Al2O3.
Figure 3. Type of Insert used for cutting tool

The first stage of the research will be conducted at the Laboratory of Manufacturing and Metrology Laboratory of Mechanical Engineering Brawijaya University.

2.2. Material
Experiments on this research process can be seen in the Figure 4. From the Figure 4 explains the research scheme of the characteristic test process that started by taking some of the stone from the district of Malang Regency, then tested the material characteristics, from the test of the material characteristics obtained the results about the dolomite stone. From the existing sample forwarded by testing the hardness of the hardness level can be used as a reference to find the cutting parameters.

From Table 2, the average hardness of dolomite cups from Dampit area is around 82,307 VHN, which is closes to the hardness of pure iron. The hardness test is performed on the natural stones to find the cutting parameter according to the hardness level of the stone. Subsequently performed the turning process of selected 3 parameters of cutting, namely cutting speed, feed and deep of cut. From the turning process is obtained surface of the cup which is then tested surface roughness. The outcome of roughness test obtained data about the difference in surface roughness due to the difference of parameters that have been selected and then analyzed.
**Table 2.** Dolomite cups Hardness test result

| Number | Dolomit/ Dampit Dolomite cups(VHN) |
|--------|-----------------------------------|
| 1      | 85.07                             |
| 2      | 79.66                             |
| 3      | 82.19                             |
| **Average** | 82.30666667 |
3. Result and Discussion

3.1. Characteristic of Material

| No | Cutting Speed (m/min) | Feed (mm/rev) | Depth of Cut (mm) | Ra (µm) |
|----|----------------------|---------------|------------------|---------|
| 1  | 300                  | 0.06          | 0.1              | 1.503   |
| 2  | 300                  | 0.06          | 0.15             | 1.567   |
| 3  | 300                  | 0.06          | 0.2              | 1.604   |
| 4  | 300                  | 0.12          | 0.1              | 1.592   |
| 5  | 300                  | 0.12          | 0.15             | 1.698   |
| 6  | 300                  | 0.12          | 0.2              | 1.756   |
| 7  | 300                  | 0.18          | 0.1              | 1.852   |
| 8  | 300                  | 0.18          | 0.15             | 1.865   |
| 9  | 300                  | 0.18          | 0.2              | 1.872   |
| 10 | 500                  | 0.06          | 0.1              | 1.334   |
| 11 | 500                  | 0.06          | 0.15             | 1.322   |
| 12 | 500                  | 0.06          | 0.2              | 1.412   |
| 13 | 500                  | 0.12          | 0.1              | 1.449   |
| 14 | 500                  | 0.12          | 0.15             | 1.454   |
| 15 | 500                  | 0.12          | 0.2              | 1.534   |
| 16 | 500                  | 0.18          | 0.1              | 1.565   |
| 17 | 500                  | 0.18          | 0.15             | 1.702   |
| 18 | 500                  | 0.18          | 0.2              | 1.809   |
| 19 | 700                  | 0.06          | 0.1              | 1.172   |
| 20 | 700                  | 0.06          | 0.15             | 1.241   |
| 21 | 700                  | 0.06          | 0.2              | 1.342   |
| 22 | 700                  | 0.12          | 0.1              | 1.435   |
| 23 | 700                  | 0.12          | 0.15             | 1.354   |
| 24 | 700                  | 0.12          | 0.2              | 1.564   |
| 25 | 700                  | 0.18          | 0.1              | 1.456   |
| 26 | 700                  | 0.18          | 0.15             | 1.534   |
| 27 | 700                  | 0.18          | 0.2              | 1.637   |
3.2. Effect of Cutting Speed on Surface Roughness

From the data in table 3 can be made graph of the relationship of cutting speed to surface roughness. The above data is processed so that for deep of cut is calculated on average.

![Figure 7](image)

**Figure 7.** Graph the effect of cutting speed on surface roughness

From figure 7 it can be concluded that the value of cutting speed inversely proportional to the value of surface roughness obtained, where the greater the cutting speed then the level of surface roughness is reduced. From the graph can be shown that the highest surface roughness generated by 300m/min cutting speed.

![Figure 8](image)

**Figure 8** Dolomite cup surface with variation cutting speed a. 300m/min, b. 500m/min, c. 700m/min

3.3. Feed Effect on Surface Roughness

Data is processed by calculating the average deep of cut obtained, then obtained 9 data which draw into the graph as shown on Figure 9. The size of the feed is directly proportional to the level of surface roughness obtained, from the graph shown that the feed with a value of 0.05 produces the lowest surface roughness.
Figure 9. Graph the effect of Feed on Surface Roughness

3.4. Deep of Cut Effect on Surface Roughness
Surface roughness test data were calculated by using average for feed values, from 9 existing data created graphs to determine the effect of deep of cut on surface roughness values. From Figure 10 it can be concluded that the greater the deep of cut causes the level of increased surface roughness. From these results it can be concluded that deep of cut level is directly proportional to the level of surface roughness. From the graph shown that the lowest surface roughness generated by 0,1mm deep of cut.

Figure 10. Graph the effect of feed on surface roughness

4. Conclusion
From the graph and data collected, this research could be concluded as follows:

1. The value of cutting speed in dolomite cups machinery is inversely proportional to the surface roughness value obtained, it could be happened because of in a high cutting speed affected to high engine vibration, so that vibration affects the machining process which increase surface roughness. It could be conclude that the greater the cutting speed lead to reduce surface roughness rate.

2. The amount of feed is directly proportional to the level of surface roughness obtained, from the graph shows that the smaller the value of the feed used, it will result in a lower level of surface roughness.
3. The depth of cut is directly proportional to the level of surface roughness, where the deeper the cut will result in a greater degree of surface roughness.

4. To produce machining product with material/work piece of dolomite cups with low level of surface roughness hence needed high cutting speed value, otherwise low of feed and deep of cut.

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