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CAST IRON GREEN MACHINING

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Abstract

The main activity of the metal cutting industry is machining various kinds of metal materials to make various products such as bolts, couplings, gears, shafts, bearings, turning metal casting objects and other engine components for sale in the local market as well as for export needs. Cutting fluid (coolant) is often used for metal machining to obtain a long tool life and low machined surface roughness, but the use of such coolant has a negative impact on machine operators and environment. The negative impact on operators is cause lung disease and temporary skin disease while for the environment, it will cause environmental pollution because coolant from synthetic materials cannot be decomposed in nature. Due to this reason, scientists are trying to eliminate the use of coolant on metal machining. In this study, a dry machining test is performed on cast iron with 8 (eight) varying cutting conditions (2^3 factorial method), as follows V_1, V_2, f_1, f_2, a_1, a_2. In this test, some information can be collected such as toolwear (VB), machining time (t), surface roughness (Ra), machining length (L), machining volume (Q) and material removal rate (MRR). The test data are then analyzed to obtain optimum cutting conditions for the 8 (eight) cutting conditions to be applied to environmental friendly machining (green machining).

Keywords: Coolant, cast iron, green machining.

1. Introduction

Machining process or metal cutting process is the main activity carried out by small and medium metal industry by using conventional machine tools (Nasution, Ginting, Hamsi, & Harahap, 2005). This machining process is intended for manufacturing engine components or other equipment (Cerce & Pusavec, 2016; Nugroho & Senoaji, 2010)

Green machining is desirable for environment and it will be considered as a need in the upcoming future for manufacturing companies. For the protection of environmental laws and health regulations industries will be forced to consider dry machining. The benefits of dry machining includes: non-pollution of the atmosphere (or water); no left over on the swarf which will be displayed in reduced disposal and cleaning costs; no threat to health; and it is non-injurious to skin and is allergy free. And it also offers cost reduction in machining (Jain & Kansal, 2017; Nasution et al., 2005).

In high speed machining the coolant cannot reach the tool-chip interface, so it has no effect on the heat that occurs, in addition, the cooling liquid is not environmentally friendly, so it is necessary to make a law on machining that directs the metal cutting industry players to cut dry or green machining (Amini, Khakbaz, & Barani, 2015; Gaafer, Ghaith, Khalil, & Mostafa, 2015).

When cutting metal, coolant has an important function to remove chips on the workpiece. Thus, the use of coolant is very possible in high performance operations, while the function of coolant is not available in dry cutting, this means that there will be more friction and adhesion between the cutting tool and the workpiece. Cutting tool and Specimens will experience a higher thermal load. This can result in a high level of tool wear, for example the process of forming a crater wear on cutting cast iron using an uncoated carbide tool (Galanis, Manolakos, & Vaxevanidis, 2008; Nayyar, Kaminski, Kinnander, & Nyborg, 2012).

Basically, in a normal machining process, the process of dumping waste into the environment in a solid, liquid or gas condition, as a result of processes involving chisels, workpieces and coolasnt, While machining systems using cutting tools require a certain amount of power associated with machining activities as well as non-machining, usually, research studies are directed at cutting energy in the machining system, where a certain amount of energy is needed to remove a certain amount of material. However, from the point of view of green machining, the energy consumption used must be considered as a whole not limited to only cutting energy (Lee, Tarng, & Li, 2000; Nugroho & Senoaji, 2010).

2. Problem Statement

Generally, small-medium metal industry still uses coolant which has negative impact on lathe operators such as cause skin and lung diseases, as well as negative impacts on the environment because coolants are made from synthetic materials which are very difficult to be decomposit (Jain & Kansal, 2017). No use of coolant will reduce production costs (Amini et al., 2015).

However, dry cutting may also show positive effects such as thermal shock reduction and thus in the formation of comb-cracks. Higher machining temperatures influence also chip formation. This may results in both ribbon chips and snarl chips. When reliable control over chip formation is required, it may be necessary to use cutting inserts with especially adapted chip shaping grooves towards dry cutting (GLANIS).

3. Research Questions

In this study, coolant was not used, the research question (Galanis et al., 2008) are:

3.1. Will the tool wear according to standard be obtained?

3.2. Will surface roughness according to standard

3.3. Will good productivity be obtained?

4. Purpose of the Study

To obtain a cutting condition without coolant which has tool wear and roughness according to good standards and productivity.

5. Research Methods

5.1. Material

The material to be used in this study is the type of cast iron material with the mechanical properties of the following test results: 229 HB hardness, 396 mPa tensile strength and chemical composition as follows: Cr = (0.05 - 0.45)%; Cu = (0.15– 0.4)%; Mn = (0.5–0.9)%; Mo = (0.05-0.1)%; Ni = (0.05 - 0.2)%; P = Max 0.12%; C = (3.25-3.5)%; S = Max 0.15%; Si = (1.8-2.3)%.

The material used in this study is the type of Cast Iron material with a diameter of 75 mm and a length of 300 mm (see Figure 1):
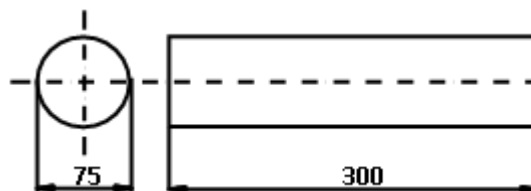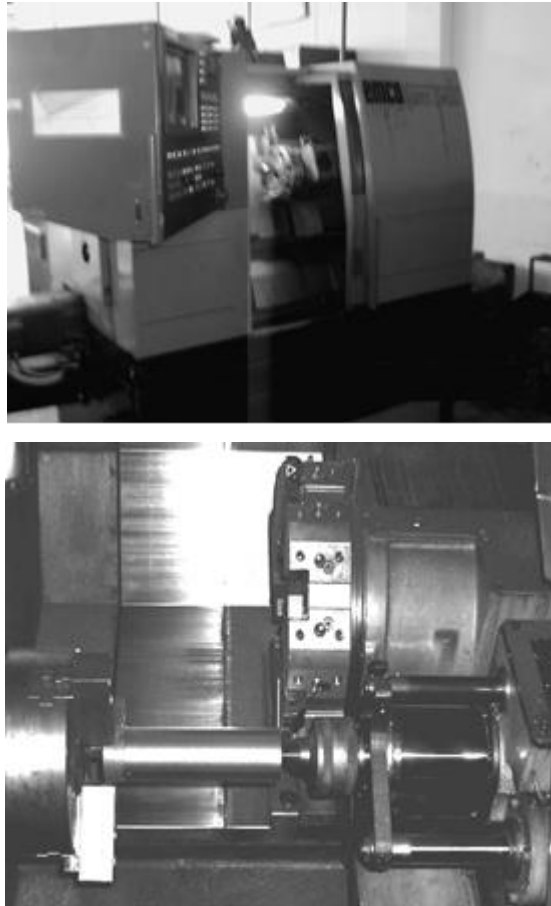

Figure 01. Material dimension

The lathe equipment used in the small and medium metal industry where the research was conducted was a CNC EmcoTurn-242 lathe.

5.2. CNC Lathe

The lathe equipment used in the small and medium metal industry where the research was conducted was a CNC EmcoTurn-242 lathe (see Figure 02).

Figure 02.   Equipment Setup: (a) CNC Lathe, (b) Workpiece Installed on the machine

Caption :
1.   Workpiece Clamp
2.   Tool
3.   Tool Holder
4.   Tool Post
5.   Center
6.   Workpiece

This CNC machine is used for cutting workpieces with cutting condition variations as in table 02.

Table 01.   Tecnilac Data of CNC Emcoturn

Power (N)	15 kwatt
Rotation (n)	450 Rpm
Maximum Clampng Diameter	158 mm
Distance between center	255 mm
Program memory	20 kilo byte
Input Speed	0,001 mm (0,0001 Zoll)
Threaded Range	0,01 – 10 mm
Starting Setting	(0 – 120) %
Setting The Main Axis Control	(50 – 120) %
Interpolation Level	± 9999,99 mm

In Table 01 can be seen the specifications of the CNC machine so that the performance of this machine is known whether it is feasible to use for cutting specimens.

5.3. Data Collection Method

The data was collected on workpiece cutting using 2^3 factorial method. According to provisions of ISO 36854, all cuts stop at the time of tool wear (flank wear) have reached 0.3 mm. The cutting data is plotted graphically which will show the effect of cutting parameters combination (Cerce & Pusavec, 2016).

6. Findings

Cutting conditions without coolant carried out to obtain tool performance and machining productivity with 2^3 Factorial method. The cutting conditions were by varying cutting conditions with the lower limit (CC1) and upper limit (CC8), as shown in Table 02.

Table 02. Variations of Cutting Condition

| Power (N)	v (m/min)	F (mm/rotation)	A (mm)
1	200	0,15	0,5
2	200	0,15	1
3	200	0,25	0,5
4	200	0,25	1
5	400	0,15	0,5
6	400	0,15	1
7	400	0,25	0,5
8	400	0,25	1

6.1. Time Machining and Tool Wear

Based on tool wear and tool life, Figure 03 clearly show that all tools with various cutting conditions stop cutting when tool wear = 0.30 mm.The result is tools that works at cutting speed V = 200 m/minute (CC1 , CC2, CC3 and CC4) are better than at cutting speeds V=400 m / minute (CC5, CC6, CC7, and CC8).
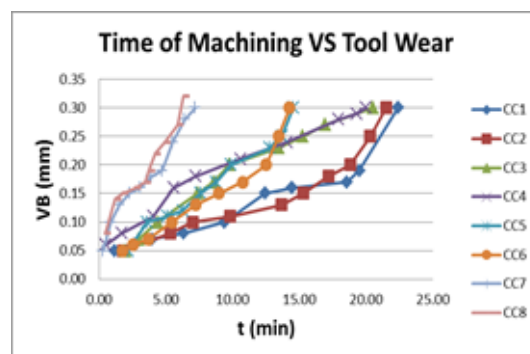
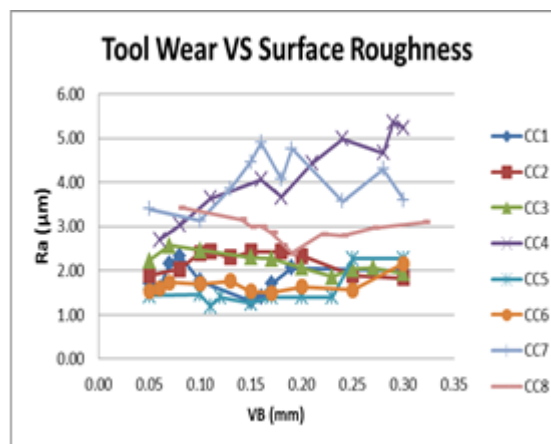**Figure 03.** Relationship between Machining Time and Tool Wear

Based on the relationship between cutting length and tool wear as shown in Figure 04, it can be seen that cutting length produced at each cutting condition is not much different, except for CC7 and CC8. This is because tool that works at cutting conditions 7 and 8 is wear out quickly.
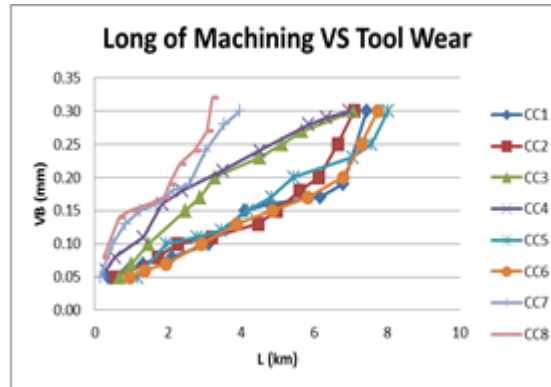
Figure 04. Relationship between Cutting Length and Tool Wear

6.2. Time Machining and Tool Wear

Figure 05 shows the value of surface roughness of a machined object produced by several cutting conditions. According to specification of work piece drawing, the desired surface roughness of the product is not greater than 2.5 μm. Thus, the cutting conditions included in the criteria for surface roughness are CC1, CC2, CC3, CC5, CC6. Meanwhile, CC4 which excelent in various ways is not included in the criteria for surface roughness.

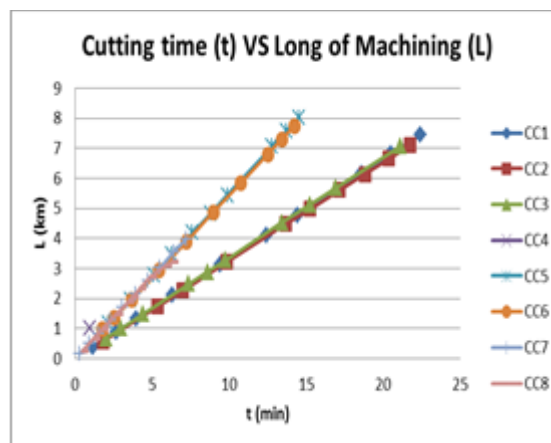**Figure 05.** Relationship between Cutting Length and Tool Wear

6.3. Cutting Volume (Q)

Figure 06 show that cutting volume produced by various cutting conditions to time limit of the tool varies greatly from the lowest 501.545 mm^3 to the highest 1782990 mm^3. The tools work from new conditions until the wear of each tool is 0.3 mm (figure 4). Based on the ability to produce cutting volume, tool that works on the cutting conditions of CC2 and CC6 has good performance, while the best is CC4, but it has been eliminated in surface roughness.
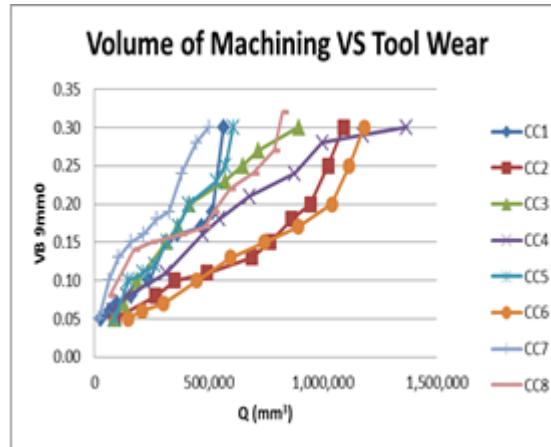
**Figure 06.** Relationship between Cutting Volume and Tool Wear

Based on the relationship between cutting length with cutting time (see Figure 07), each cutting condition can produce almost the same length of cut which is around 7.5 to 8 km exceptCC7 and CC8 around 3 to 4 km.

Figure 07. Relationship between Cutting Length and cutting Time

6.4. Material Removal Rate

From Figure 08, it can be seen that the most prominent MRR is in CC4, CC6, CC7 and CC8, but all of these cutting conditions have been eliminated due to the above factors, so even though the MRR on CC2 is not very prominent but the MRR in CC2 is included in the medium scale.
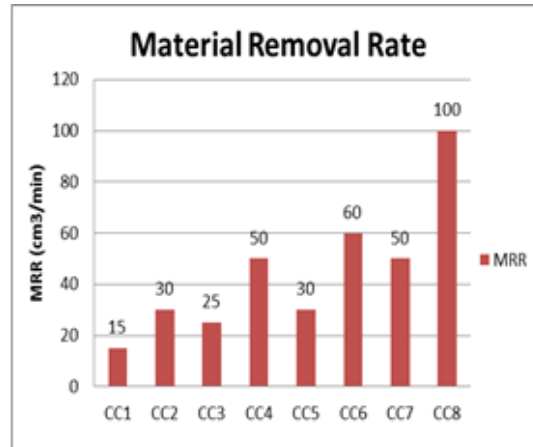
Figure 08. MRR in each Cutting Condition

7. Conclusion

After analyzing all graphs generated from the experiment, the optimal cutting conditions to beapplied at green machining (without coolant) is cutting condition -2 (CC2) with v = 200 m/minute, f = 0.15 mm/rotation and a = 1 mm. Material Removal Rate is 30 cm^3/minute. This is caused by:

- The tool life generated is included in the standard criteria.
- Surface roughness produced according to standards.
- Superior from side Machining length and machining volume
- The resulting MRR falls into the middle criteria.

Acknowledgments

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