International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Research Paper

The Optimal Condition of Cast Iron Dry-Cutting by the Use of Factorial 2^3 Method

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ABSTRACT

The metal industries (lathe workshops) usually carries out their activities of metal cutting by using coolant which aims to obtain a long tool life and to obtain the standarized level of surface roughness; however, the use of such coolant has negative impacts on the machine operators who can have lung and temporary skin problems as well ason the environment which can be polluted. All this is caused by the fact that the coolant is a synthetic material that cannot be decomposed in nature and for this reason scientists try to eliminate the use of coolant for metal machining. As a result, the operation cost can be minimized and no coolant disposal can be found in the environment. In this paper the dry machining test on cast iron has been carried out. After the test, some information on tool wear (VB), machining time (t), surface roughness (Ra), machining length (lm), machining volume (Vm) and material removal rate (MRR) was obtained. The data from the test results were analyzed and from five cutting conditions, the best conditions were obtained, which could be applied for environmentally friendly machining (or green machining).

***Keywords*:** Dry Machining, Coolant, Cast Iron, Green Machining

INTRODUCTION

Used coolant from the machining process is harmful to the environment and the human's health. Chemical substances that function as lubrication in the machining process are toxic to the environment if the cutting liquid is discharged to the ground and water. Chemical substances in refrigerants cause serious health problems for workers who are exposed to the liquid and mist refrigeration (Nasution, et al. 2018).

For high-speed machining, lubricants cannot penetrate into the chip-tool interface, so it does not affect the heat generated. In addition, non-environmentally friendly lubricants have the effects on tightening legal supervision and on limiting the use of coolant in the industry (Amini 2015).

Effects of Environment and Financing from Wet Machines

At present, coolant often remains to be used for some hard metal machining, for example for high speed steel and titanium alloys which, without refrigeration, are very difficult to machine. The cost of coolant use and removal is very significant and continues to increase. Regulations regarding the work and environmental safety are increasingly tightened because the coolant used by wet machining cause serious health problems for workers during metal machining workshops. Extreme pressure in lubrication usually contains paraffin which is transformed into dioxin by heat and high temperatures produced by the cutting process.In addition, many workers in industrialized countries are exposed to dangerous refrigeration (Education 2008).

Dry machining is needed for environmental sustainability and will be considered a future technology for manufacturing companies. For legal protection in terms of safety in the environment and health of workers, it will be emphasized that the machining carried out is dry machining. Benefits of dry machines include: non-polluting the atmosphere (or water); nothing is left on the dock which will be displayed in the reduction of disposal and cleaning costs; there is no threat to health; and it is not harmful to the skin and is allergic free, it also results in a reduction in costs in purchasing coolant and its disposal costs to nature, because the waste must be processed through several processes to be safe for the environment (Xirouchakis and Avram 2010, Jain and Kansal 2017).

RESEARCH AIMS

The aims to get the best cutting conditions for dry cast iron, the following things are to be applied:

Workpiece surface roughness meets the standards;

Chisel age meets the standard;

Speed produces good sound of growl.

MATERIALS, EQUIPMENTS AND METHODOLOGY

Materials

The materials 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)% (Source: As received from the casting industry).

Equipments

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

Methods

The method of data collection is done by doing some cutting of the workpiece with varying cutting conditions. The variation in cutting conditions given to the cutting of the workpiece using the factorial 2^3 method (Ojolo and Ogunkomaiya 2014). There are three variables tested (V, f and a), where each variable has a top value and a lower value. The cutting condition with factorial 2^3 method is as shown in table 1 below.

Table 1. Varitions of Cutting Condition

Cutting conditions	V (m/min)	f (mm/rev)	A (mm)
1	300	0,15	0,5
2	300	0,15	1
3	300	0,25	0,5
4	300	0,25	1
5	350	0,15	0,5
6	350	0,15	1
7	350	0,25	0,5
8	350	0,25	1

According to the provisions of ISO 36854, all cuts stop when the tool wear reaches 0.3 mm. The cut-out data is plotted in graphical form; from the graphs it will be clearly seen the effect of the combination of the cutting parameters.

RESULTS AND DISCUSSION

From dry machining results of workpieces with several variations of cutting conditions with method 2^3 it is obtained information about superior cutting conferences on several graphs produced.

Tool Wear

As we know, every industry always tries to reduce production costs as little as possible to get greater profits.

Tool wear is one of the factors that really needs to be considered, because in industries that produce components in bulk, tool wear needs to be pressed so that the tool life is longer; thus, the costs required to buy the tool can be economized (Jerard et al. 2001).

In Figure 1, it can be seen that each cut is done and stops when the tool wear is 0.3 mm and the tool that wears the fastest is chiseled on the cutting conditions of CC7 and CC8, while the CC2 and CC3 are the longest tool life, and the longest tool life on CC1.

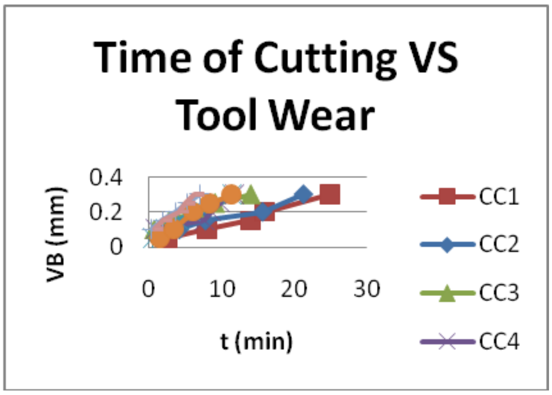

Figure 1. Link Curve between Machining Time with Tool Wear Chisel

From Figure 2 it can be seen that the superior machining length is in CC2, CC3.

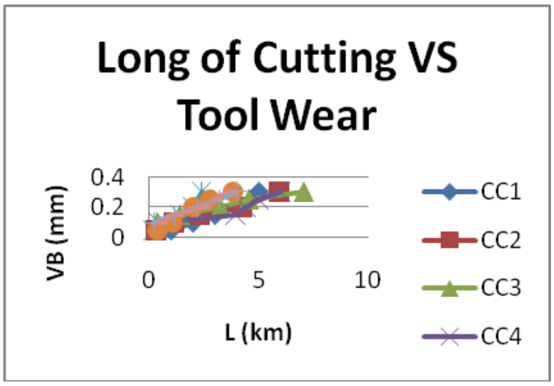

Figure 2. Link Curve Between Machining Length and Tool Wear

Surface Roughness

Surface roughness is one parameter that also determines the quality of the machined material. For this reason, a lot of research has been done so that the surface roughness produced by a machining process can meet the surface roughness specifications specified in the engineering drawings (Nasution et al. 2005) (Kir et al. 2016).

In this study the desired surface roughness limit is 2.4 µm, from the surface roughness graph in figure 3 that the cutting conditions that produce surface roughness as desired are CC2, CC5, and CC8, but CC5 and CC8 are eliminated due to age short chisel.

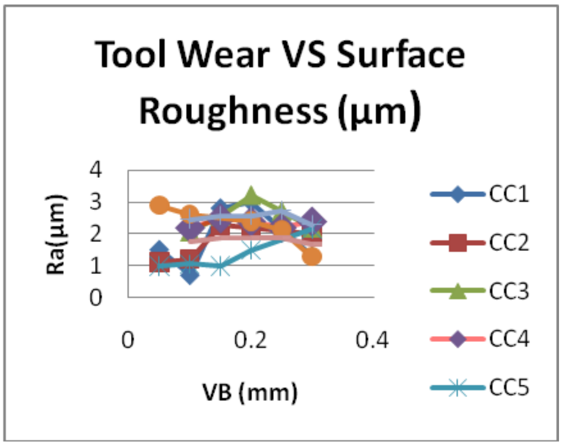

Figure 3. Link Curve Between Tool Wear Chisel and Surface Roughness

Volume of Waste Material (Q)

The volume of wasted material is the volume of material thrown away due to the process of cutting the metal or in other words the volume of waste material is the volume of chips or growl produced during the machining process of the material carried out. The more chips or growls that can be produced by a machining process, the higher the productivity in terms of the quantity of objects produced (Nasution, Napid, et al. 2018), (Nayyar et al. 2012).

From Figure 4, it can be seen that the volume of the most wasted material is on CC2 and CC3, but CC3 has been eliminated at a low tool life and high machining surface roughness value.

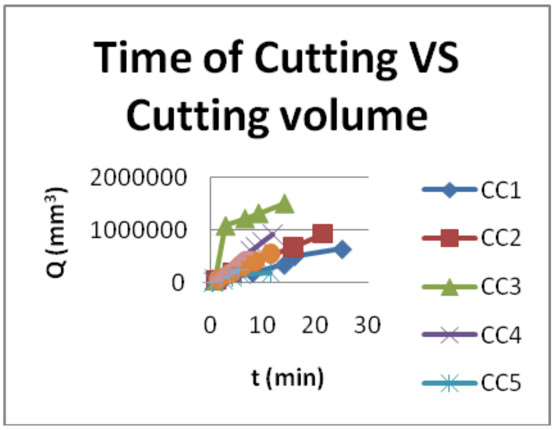

Figure 4. Link Curve between Cutting Time and Cutting Volume

Material Removal Rate

One of the measures of productivity level in terms of quantity is the material removal rate, the higher the rate of speed of growling income a cutting condition has, the higher the quantity of production it produces. But even though the rate of furious income obtained by a cutting condition is very high, it does not mean that it is the best cutting condition, because many other parameters need to be considered, including: whether the surface roughness that is produced is good enough, whether the tool life is long or whether time to machine a product is quite short, and so forth. If from the MRR side a cutting condition is very good but on the other hand it does not qualify, then such cutting conditions cannot yet be said to be optimal cutting conditions.

In terms of furious income (Material Removal Rate / MRR) as shown in Figure 5, the MRR on CC8 is more prominent while the MRR on CC2 belongs to the middle category.

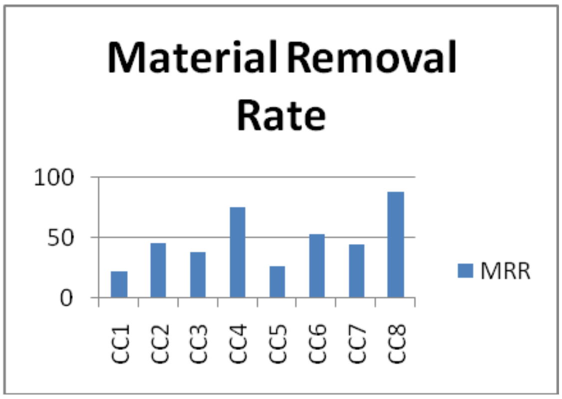

Figure 5. MRR Bar Diagram in Each Cutting Condition

CONCLUSIONS

After looking at the overall analysis above, the most optimal cutting conditions that can be used in cast iron dry machining are CC2 cutting conditions with v = 300 m / min; f = 0.25 mm / rev ; a = 0.5 mm, this is based on several things including:

The tool life is about 20 minutes long;

Superior in terms of Cutting Length and Cutting Volume;

The surface roughness value produced on machining workpieces is below 2.4 µm.

ACKNOWLEDGEMENTS

The authors wished to acknowledge the Directorate of Research and Community Service, Directorate General of Research Strengthening and Development at the Ministry of Research, Technology and Higher Education. The authors also thank Muhammad Ali Pawiro for his assistance in the translation, formatting, and editing of the earlier version of manuscript.

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How to cite this article: Nasution AH, Harahap MR, Napid S. The optimal condition of cast iron dry-cutting by the use of factorial 2^3 method. International Journal of Research and Review. 2019; 6(8):375-379.

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