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Research paper

Machinability Study of Cast Iron in Small and Medium Enterprise

Abdul Haris Nasution, Muksin Rasyid Harahap, Suhardi Napid, Muhammad Rafiq Yanhar

Mechanical Engineering, Faculty of Engineering, UISU, Medan
**Corresponding author E-mail: aharisnst@ft.uisu.ac.id*

Abstract

Machining process or metal cutting process is a main activity practised by small and medium metal enterprise by using HSS tool. This machining process is directed to produce the mass products, such as components of machine or another equipment's, but often also the machining process is made inappropriately, or even in total false method, such as false selection of tool, thus the worn-out vastly, over cutting speed, thus surface is rougher, and etc. In this paper, the machinability on cast iron cutting is assessed (the material usually worked in small and medium metal industries), i.e., by making some experiment to obtain the most optimal cutting condition (v, f ,and a) to have the short cutting time, big cutting volume, lower surface roughness and longer tool life.

Keywords: *Cutting Condition, HSS tool, Cost Iron, Mass Products*

1. Introduction

Small and medium enterprise (SME) is one of real sector of Indonesian economic and this is a business opportunity able whithstanding on incondusive economic and political recently. The big number of SME can be categorized into some industrial sectors, and one of them is small and medium metal industry [1][2].

In general, small and medium enterprise has been satisfied of their achievement because they are oriented to local market. Therefore, the quality is not competitive to imported products. The error of machining process resulting in the problems include as reported by Stella [3] :

a. The lowest cutting rate, thus it will make the surface of product too rough. In several condition in which there is cutting interuption and sudden load occurs on lowest cutting rate, this condition will also make tool life shorter.
b. The lowest feed rate as an intention to obtain the smoth surface, more than need, thus it exceed the specification of technical drawing design.
c. Machining process producing refined chip (hair-shaped), thus the process become out of efficiency.
d. The application of tool is not suitable to work done, in perspective of both material and geometric (shape and angle of tool).
e. Inappropriate clamping of workpiece, it will demage the geometric of product exceeding the tolerance limit.
f. Inappriopriate calculation process for machining cost, thus enterprise will rely on miscalculation of product cost (abnormal cost, averestimated or underestimated).

To solve problems above, it is important to make restoration on machinability, including by using the suitable tool material to obtain the longer tool life and by making a test for cuting in various cutting condition (v,f and a)[4].

The products produce in small and medium metal enterprise in general are machine component produce as spare parts. For small and medium metal enterprise existing in North Sumatera, it is industry that pruduces spare parts made of cast iron material is most found[5]. This spare parts is usually used by several machines, including compressor, rice thereser, coffee mills, washing machine, and etc, therefore it is important to increase the productivity of small and medium metall enterprise as producer of the spare parts through increasing machinability of cast iron material as the main material.[6][7][8].

1.1. Formulation of Problem

The real condition in small and medium metal enterprise in which the preliminary study of machinability of cast iron material to produce spare parts was done, is as follows:

a. The type of tool used is High Speed Steel (HSS) on dry cutting is not appropriate because HSS has some limitation in term of strength and stiffness, and it is not reliable in high-temperature, thus tool life is lower[9]. This is evident in cutting process conducted, it is also observed that the operator always sharpens the tool after cutting five products or about 35 minutes.
b. The instable tool geometric because the sharpening is only on instinct and experience of operator, this make the surface roughness of product high variations. The research conducted by Y. Lin [10] on Ferro metal cutting has indicated, that surface roughness does not only depend on flank wear, but also on nose radius of tool, this also contributes to worse product surface roughness.
c. Inconsistent cutting condition include the depth of cut, tool geometry, cutting speed and feeding, contributes to inconsistency of product geometry produced, or in other word accuracy and precision of product produced is poor. The cutting condition also contributes to surface roughness as reported by Gafeer et al [11] in ferro metal cutting, that feed is very influential factor on surface roughness.

1.2. Purposes of Research

The general purpose of this research is to collect the data and analyze machinability of metal cutting process on Small and Medium Enterprise producing the spare parts from cast iron materials.

To give input and suggestions to Small and Medium Metal Enterprise to increase productivity in aspect of quality and quantity of product through study of machinability factor.

2. Material, Equipment and Methodology

The material of workpiece is cast iron with chemical composition C = (3.25 - 3.5) %, Cr = (0.05 - 0.45) % , Cu = (0.15 - 0.4), Mn = (0.5 - 30.9) %, Mo = (0.05 - 0.1) %, Ni = (0.05-0.2) %, P = Max 0.12 %, S=Max 0.15%, Si = (1.8 - 2.3) %, and mechanical properties : Brinnel Hardness = 183 - 234 HB, Tensile Strength = Min 276 Mpa, Ultimate Compressive Strength = 1034 Mpa. Figure 1 shows the workpiece of cast iron and in figure 2 is the dimension of the workpiece.

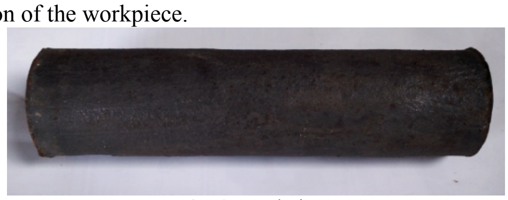

Fig. 1. Workpiece

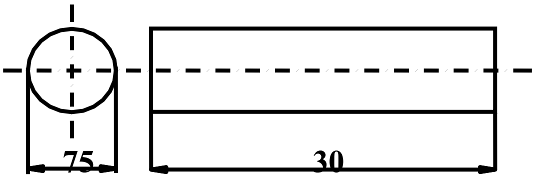

Fig. 2. Dimension of the Workpiece

The lathe used in Small and Medium enterprise in which the research was done is conventional lathe and the tools used by Small and Medium Enterprise in which preliminary study was done is HSS tools as shown in figure 3.

Fig. 3. HSS tool

The method of data collection was by collecting the data from 4 (four) variation of cutting conditions, i.e.: cutting time, surface roghness. The data collected was then analyzed to see the performance of Small and Medium Metall Enterprise from quality and quantity side by using conventional machine, and then a testing was made against several variation of cutting condition to obtain the data as follows: machining time (t), tool wear (VB), length of machining (L), material removal rate (MRR), surface roughness (Ra) of machining work piece. The obtained data was then processed to get machinability performance from quality and quantity side and to see extent to which increase in quality and quantity was gained by cutting condition recommended by the result of this research.

Cutting Condition toward 4 (four) variation of cutting condition variation, i.e :

CC1: v = 10 m/min ; f = 0.1 mm/rev ; a = 0.5 mm
CC2: v = 15 m/min ; f = 0.1 mm/rev ; a = 0.5 mm
CC3: v = 20 m/min ; f = 0.1 mm/rev ; a = 0.5 mm
CC4: v = 25 m/min ; f = 0.1 mm/rev ; a = 0.5 mm

3. Result and Discussion

3.1. Tool Wear

In figure 4 shown that each cutting process is done about five minutes, and the faster worn-out occur on the tool with cutting condition of CC3 and CC4, but the resulting worn-out is still under 0.3 mm, it means it is still in allowable condition.

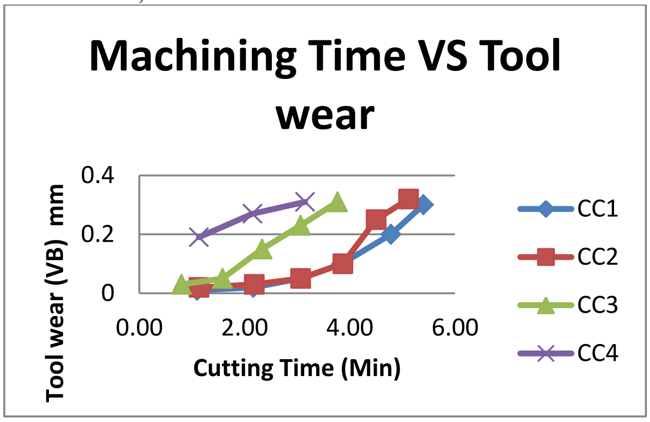

Fig. 4. Machining Time and Tool Wear

3.2. Length of Machining

From figure 5 shown that length of machining done on Small and Medium Enterprise , CC1, CC2, CC3, is very short, it means the productivity is very low compared to CC4.

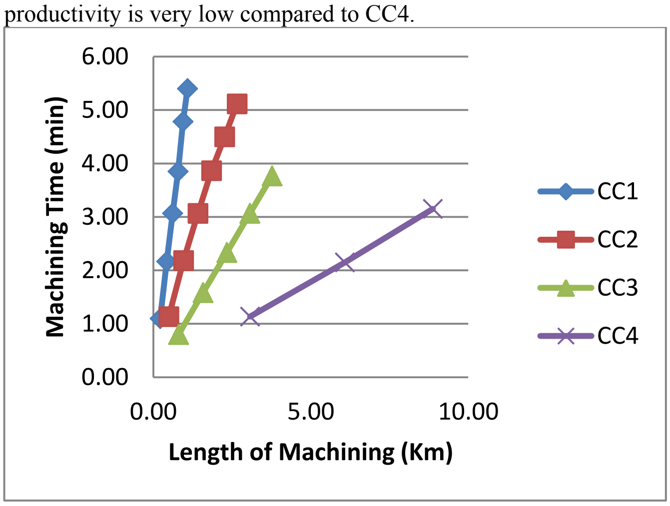

Fig. 5. Machining Length and Machining Time

3.3. Surface Roughness

The expected limit of Surface Roughness is 2.4 µm, from graph of Surface Roughness in figure 6 that cutting conditions of CC3 and CC4 obtained the suitable surface roughness as expected, while roughness at cutting conditions on CC1 and CC2 is more rough.

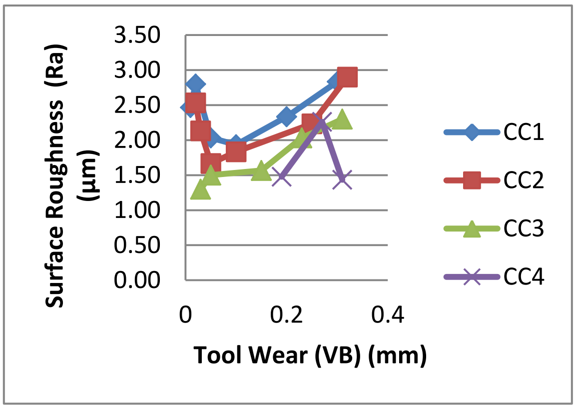

Fig. 6. Tool Wear and Surface Roughness

3.4. The Machining Time

From figure 7 in perspective of machining time, it can be seen that the fastest machining is in CC4, with v = 25 m / min, f= 0.1 mm/ rad ; a = 0.5 mm.

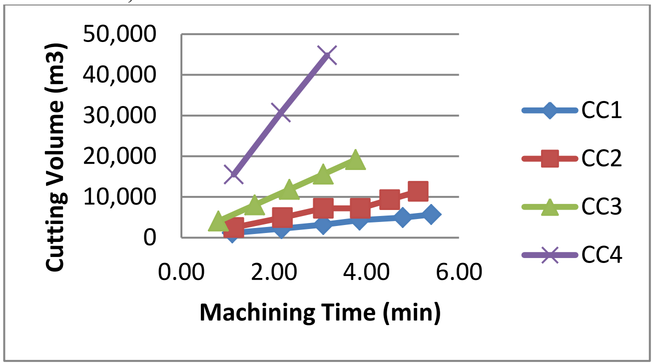

Fig. 7. Cutting Time and Machining Volume.

3.5. The Cutting Volume

In perspective of cutting volume, it can seen clearly in figure 8 that cutting volume obtained of CC4 is higer than CC1, CC2 and CC3.

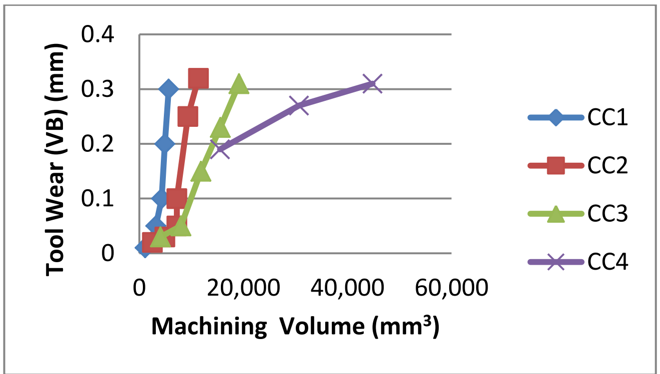

Fig.8. Cutting Volume and Tool Wear

3.6. Material Removal Rate (MRR)

From Figure 9 it can be seen that the highest Material Removal Rate (MRR) is at CC4 with 1.25 cm^3 / min. It shows that the productivity of CC4 is better than the others.

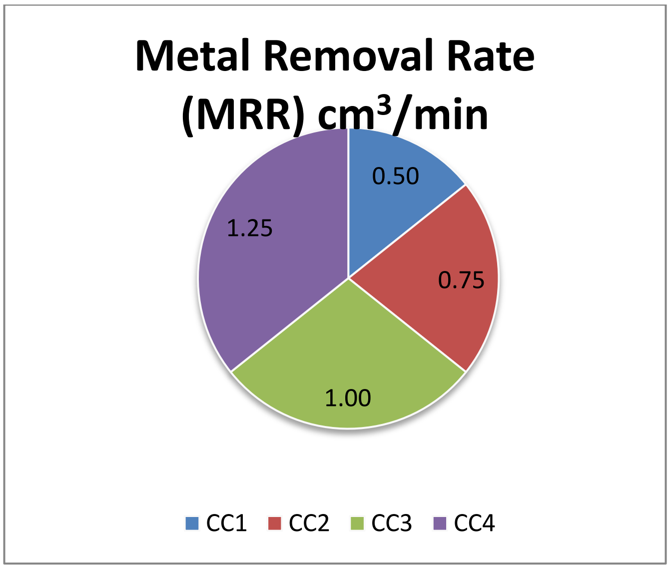

Fig. 9. Material Removal Rate per Cutting Condition.

4. Results and Suggestion

4.1. Results

Based on the data analysis above it can be drawn conclusion as follows:

a. From the tool wear side, CC1 and CC2 are better because the life of the tool is longer than CC3 and CC4.
b. From the length of machining side, CC4 is better than the others because it can machining the workpiece a long 8.8 km in 3.15 minutes
c. In term of surface roughness CC3 dan CC4 falls into the criterion with a roughness of the surface below 2.4 µm
d. In terms of cutting volume, CC4 is better than other cutting conditions, as it can produce cutting volume of 4.807 mm^3 in 3.15 minutes even though the life of the tool is shorter.
e. The highest Material Removal Rate (MRR) is at cutting condition 4 (CC4) which is 1.25 cm^3/minute. This shows the best productivity of the four cutting conditions is in CC4
f. The best cutting condition of the four cutting conditions above is CC4, where V = 25 m / min, f = 0.1 mm / rev.
g. When compared to the productivity produced between cutting conditions commonly used by small and medium industries is CC1 with the condition of cutting the results of this research is CC4, then the result can show on table (1).

Table 1. Comparison of CC1 with CC4

	CC1	CC4
Tool wear	5.40 min	3.15 min
Average Surface Rougness Value	2 µm	1.73 µm
Length of Mach-ining	1.08 km	8.88 km
Cutting Volume	5.657 mm^3	44.8 mm^3
Material Removal Rate (MRR)	0.5 cm^3/min	1.25cm^3/min

From the table above, it is clear that the productivity in aspec of quality and quantity of the small and medium industries can be improved by changing the cutting condition from CC1 (v = 10 m/min ; f = 0.1 mm/rev ; a = 0.5 mm) to CC4 (v = 25 m/min ; f = 0.1 mm/rev ; a = 0.5 mm), but for industries that produce mass products, the performance is still considered less, because the age of tool is low despite using cutting fluid. In terms of safety and environmental use of cutting fluid considered very bad impact.

4.2. Suggestion

Based on the findings above, in order to obtain better quality and quantity for better machining, longer tool life and more environmentally friendly, it is necessary to research about new technology of environmentally friendly machining on cast iron using uncoated carbide tool with 2^3 factorial method.

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