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The Effect Of Machining Parameters On Cost Production In The Drilling Process Using HSS And Carbide Tools

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(Use Times New Roman Font: 14 pt, Centered) (Names should be written in First Name Surname order)

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Abstract. In the manufacture of a product, there are several important things that need to be considered, such as the calculation of machining time, tool life and production costs. To know the machining time, you must know the type of work done on each component. The difference in cutting parameters is one of the factors that can affect the machining time and the rate of tool blade wear. The faster the tool blade wears out, the tool blade will be replaced so that the cost of the tool blade will be higher, and it will also affect the production cost. The purpose of this study was to determine the effect of cutting parameters on machining time and production costs by giving variations to these cutting parameters. and the limitation of the research in this study only discusses from the angle of drill cutting parameters, does not discuss break event points, does not discuss drill chisel geometry and does not discuss the materials used in more detail. From the results of the research and analysis carried out, it can be stated that the difference in cutting parameters greatly affects the machining time and production costs. In the type of chisel hss 1 to hss 3, the machining time is 114.17 minutes with a production cost of Rp. 844,900, 103.36 minutes with a production cost of Rp. 935,200, 95.87 minutes with a production cost of Rp. 1,033,900 and the type of chisel from carbide 1 to carbide 3, the machining time is 109.18 minutes with a production cost of Rp. 1,052,900, 93.33 minutes with a production cost of Rp. 1,105,000, 80.8 minutes with a production cost of Rp. 1,169,500.

Keywords. Drilling machine,Cutting parameters, Production cost, Machining time, Tool wear, Tool bits.

INTRODUCTION

In the machine tool industry, basically these tools can help complete a job related to metal or plate, in industry there are many kinds of machine tools, including: lathes, milling machines, milling machines, saws, grinders, and others. On the other hand, these machine tools must be able to produce a product or workpiece with high quality,[1] therefore in the process it must be carried out properly, precisely and correctly. In carrying out the machining process to produce a product, production costs and also the influence of machining parameters are factors that must be considered in making a product, such as cutting speed, feeding motion, and cutting time, [2] because every company certainly wants big profits. Therefore, it is necessary to have an understanding of the theory of production costs in order to be able to calculate the costs incurred to produce a product. In this study, primary data is used where the data is taken directly at the time of conducting the experiment. Research on the calculation of production costs uses two different types of chisels, namely HSS and Carbide, the material used is S 45 C steel which aims to determine the results of which tool has the best cutting parameter values and also the results of the most possible production costs.

METHODOLOGI

In this study, primary data is used where the data is taken directly at the time of conducting the experiment, where the data is taken directly through the CNC milling machining process. The parameters used can be seen in Table 1.

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TABLE 1. Cutting Parameters

Cutting Speed (m/menit)	Feed (mm/rev)	*Depht of cut* (mm)	*Spindle* (rpm)
20	30	16	910
25	38	16	1140
30	46	16	1365

The place where the research was carried out was at the Jakarta State Polytechnic's CNC Lab. In this study, the parameters used were varied into 3, namely with a cutting speed of 20 m/min, 25 m/min, 30 m/min, then feed 30 mm/rev, 38 mm/rev, 30 mm/rev, and a spindle rotation of 910 r. /min, 1140 r/min, 1365 r/min with a depth of cut of 16 mm, for the tools used are 3 HSS tools and 3 carbide tools with a size of 7 mm. Each tool uses predefined cutting parameters. Then to facilitate the calculation of time and production costs, it is assumed to be making 100 holes for each chisel.

The steps taken in this study were using HSS and carbide tools with a variety of predetermined parameters, then measuring tool wear with a digital microscope and using amcap and amscope applications to measure wear, every one try until the tool wears out.

The basic elements of the drill process are as follows [3]:

- Cutting speed:
  $v = \frac{\pi . d . n}{1000}$ m/min
- Feed:
  Fz = $\frac{Vf}{(n.z)} z$ = 2 mm/rev
- Depth of cut:
  a = d/2 mm
- Machining time:
  t_c = lt/vf min

TABLE 2. Drilling Parameter Catalog [4]

General Recommendations for Speeds and Feeds in Drilling

		Drill diameter			
	Surface speed	Feed, mm/rev		Speed, rpm	
Workpiece material	m/min	1.5 mm	12.5 mm	1.5 mm	12.5 mm
Aluminum alloys	30–120	0.025	0.30	6400–25,000	800–3000
Magnesium alloys	45–120	0.025	0.30	9600–25,000	1100–3000
Copper alloys	15–60	0.025	0.25	3200–12,000	400–1500
Steels	20–30	0.025	0.30	4300–6400	500–800
Stainless steels	10–20	0.025	0.18	2100–4300	250–500
Titanium alloys	6–20	0.010	0.15	1300–4300	150–500
Cast irons	20–60	0.025	0.30	4300–12,000	500–1500
Thermoplastics	30–60	0.025	0.13	6400–12,000	800–1500
Thermosets	20–60	0.025	0.10	4300–12,000	500–1500

Tool Wear Criteria

Basically, the greater the frictional force between the tool and the workpiece, the greater the wear and tear and damage. If the tool is still used, it will have an impact on the tool itself, the machine tools used, the workpiece used and can also endanger the operator who runs it. To avoid unwanted things, a wear limit is set which is considered a critical limit at which the tool can no longer be used. In the cutting process, chisel wear can occur in the main plane of the chisel or what is then called flank wear and wear that occurs in the furious plane is called crater wear (creater wear). Edge wear is the wear that often occurs on the tool blade which is symbolized by VB. This edge wear is the side of the tool bit, which is located on the side of the main cutting edge. This edge wear occurs because the tip of the tool is in direct contact with the workpiece and resists cutting forces, this wear starts from the edge of the cutting edge and will continue to widen.[5]

TABLE 3. Maximum Wear Limit Of Tool Life

Chisel	**Materials**	**V_B (mm)**
HSS	Steel and Cast Iron	0,3 – 0,8
Carbide	Steel	0,2 – 0,6
Carbide	Cast Iron And Non Ferrous	0,4 – 0,6
Ceramic	Steel and Cast Iron	0,3

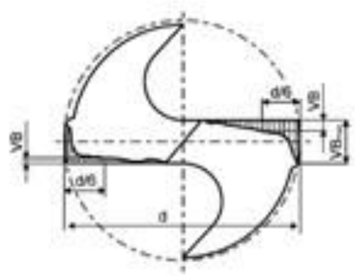

FIGURE 1. Flank Wear (VB) [6]

Machining Time

The machining process to be carried out can be calculated for each production cost to determine the cost comparison of the two different types of materials with varying machining parameters. To calculate the machining time, the thing that must be considered is the cutting parameter, after which the machining time can be calculated. Machining time consists of several parts, namely real cutting time (tc), non-productive time (ta), and machining time per product for the average (tm).

Tooling Cost

Tool Cost (Ce) In the tool cost there are various ways to determine it, namely by knowing the cost of the tool per piece and part of the tool life. To calculate the cost of the tool using the following formula:

Ce = ce . T [5]

Where ce is the tool cost per tool bit; Rupiah/tool bit and T is the age of the tool.

Machining Cost (Cm)

The machining cost can be calculated by the average machining time of the revenue per product such as per unit time; minutes which affects the rate of production speed. In determining the cost of machining formulas that can be used include:

cm = cm + tm [5]

Where in cm is a cost on machine operations such as operators; rupiah/product and tm is the time of the machining.; min/product.

Material Cost (CM)

Material costs include direct and indirect purchase prices (indirect / overhead cost of material) which are special costs for materials when they are still in the form of materials and after becoming a product, to calculate the cost of the material using the following formula:

CM = CMo + CMi [5]

CMo = purchase price; rupiah / product and CMi = is an indirect cost; rupiah / product.

RESULTS

Tool Wear Measurement Results and Cutting Time

Cutting Speed : 20 m/min
Feed : 30 mm/rev
Spindle : 910 r/min; Spindle Diameter : 7 mm

TABLE 4. Value of Wear and Cutting Time (HSS 1)

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
1	0,06	0,97
2	0,08	1,93
3	0,10	2,90
4	0,12	3,87
5	0,15	4,83

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
6	0,18	5,80
7	0,21	6,78
8	0,25	7,73
9	0,29	8,70
10	0,34	9,67
11	0,40	10,63
12	0,47	11,60
13	0,55	12,57
14	0,64	13,53
15	0,77	14,50

Cutting Speed : 25 m/min; Feed : 38 mm/rev
Spindle : 1140 r/min; Spindle Diameter : 7 mm

TABLE 5. Value of Wear and Cutting Time (HSS 2)

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
1	0,08	0,78
2	0,10	1,57
3	0,12	2,35
4	0,15	3,13
5	0,18	3,92
6	0,22	4,70
7	0,27	5,48
8	0,34	6,27
9	0,43	7,05
10	0,54	7,83
11	0,68	8,62

Cutting Speed : 30 m/min
Feed : 46 mm/rev
Spindle : 1365 r/min; Spindle Diameter : 7 mm

TABLE 6. Value of Wear and Cutting Time (HSS 3)

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
1	0,10	0,63
2	0,13	1,26
3	0,17	1,90
4	0,23	2,53
5	0,31	3,17
6	0,43	3,80
7	0,54	4,43
8	0,60	5,07

Cutting Speed : 20 m/min; Feed : 30 mm/rev
Spindle : 910 r/min; Spindle Diameter : 7 mm

TABLE 7. Value of Wear and Cutting Time (Carbide 1)

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
1	0,03	0,97
2	0,04	1,93
3	0,05	2,90
4	0,06	3,87
5	0,07	4,83
6	0,08	5,80
7	0,09	6,78
8	0,10	7,73
9	0,12	8,70
10	0,14	9,67
11	0,16	10,63
12	0,18	11,60
13	0,20	12,57
14	0,23	13,53
15	0,26	14,50
16	0,29	15,47
17	0,33	16,43
18	0,37	17,40
19	0,41	18,37
20	0,46	19,33
21	0,51	20,30
22	0,58	21,27

Cutting Speed : 25 m/min; Feed : 38 mm/rev
Spindle : 1140 r/min; Spindle Diameter : 7 mm

TABLE 8. Value of Wear and Cutting Time (Carbide 2)

Cutting Number	Flank Wear (mm)	Cutting Time (menit)
1	0,04	0,78
2	0,05	1,57
3	0,06	2,35
4	0,07	3,13
5	0,08	3,92
6	0,10	4,70
7	0,12	5,48
8	0,14	6,27
9	0,16	7,05
10	0,19	7,83
11	0,22	8,62
12	0,25	9,40
13	0,29	10,18
14	0,34	10,97
15	0,38	11,75
16	0,43	12,53
17	0,48	13,32
18	0,56	14,10

Cutting Speed : 30m/min; Feed : 46 mm/rev
Spindle : 1365 r/min; Spindle Diameter : 7 mm

TABLE 9. Value of Wear and Cutting Time (Carbide 3)

Cutting Number	Flank Wear (mm)	Cutting Time (minute)
1	0,05	0,63
2	0,06	1,26
3	0,07	1,90
4	0,09	2,53
5	0,11	3,17
6	0,14	3,80
7	0,17	4,43
8	0,20	5,07
9	0,24	5,70
10	0,28	6,30
11	0,32	6,97
12	0,37	7,60
13	0,42	8,23
14	0,48	8,87
15	0,54	9,50

- In table 4 HSS 1 the cutting time until the chisel reaches wear is 14.5 minutes with 15 holes, to make 100 holes it takes 96.67 minutes to cut with 7 chisels used.
- In table 5 HSS 2 the cutting time until the chisel reaches wear is 8.62 minutes with 11 holes, to make 100 holes it takes 78.36 minutes to cut with 10 chisels used.
- In table 6 HSS 3 the cutting time until the tool reaches wear is 5.07 minutes with 8 holes, to make 100 holes it takes 63.37 minutes to cut with 13 chisels used.
- In table 7 carbide 1 the cutting time until the tool reaches wear is 21.27 minutes with a total of 22 holes, to make 100 holes it takes a cutting time of 96.68 minutes with 5 tools used.
- In table 8 carbide 2 the cutting time until the tool reaches wear is 14.10 minutes with 18 holes, to make 100 holes it takes 78.33 minutes to cut with 6 tools used.
- In table 9 carbide 3 the cutting time until the tool reaches wear is 9.50 minutes with 15 holes, to make 100 holes it takes 63.3 minutes to cut with 7 tools used.

Machining Process Time Analysis

TABLE 10. Machining Process Time

No	Operator Job Type	Work Time (minutes)
1	Installing the chisel on the CNC machine	1
2	Chisel blade replacement	1,5

- In the HSS 1 cutting parameter, the total cutting time is 96.67 minutes, for 100 holes it requires 7 tools, the operator's work time for 7 tools is 17.5 minutes, so the total machining process time is 114.17 minutes.
- In the HSS 2 cutting parameter, the total cutting time is 78.36 minutes, for 100 holes it takes 10 tools, the operator's work time for 10 tools is 25 minutes, so the total machining process time is 103.36 minutes.
- In the HSS 3 cutting parameter, the total cutting time is 63.37 minutes, for 100 holes it takes 13 tools, the operator's work time for 13 tools is 32.5 minutes, so the total machining process time is 95.87 minutes.
- In the carbide cutting parameter 1, the total cutting time is 96.68 minutes, for 100 holes it takes 5 tools, the operator's work time for 5 tools is 12.5 minutes, so the total machining process time is 109.18 minutes.
- In the carbide cutting parameter 2, the total cutting time is 78.33 minutes, for 100 holes it requires 6 tools, the operator's work time for 6 tools is 15 minutes, so the total machining process time is 93.33 minutes.
- In the carbide cutting parameter 3, the total cutting time is 63.30 minutes, for 100 holes it requires 7 tools, the operator's work time for 7 tools is 17.5 minutes, so the total machining process time is 80.8 minutes.

Tooling Cost (Ce)

Based on the market price, the cost per tool for the HSS type is Rp. 40.000 and for the Carbide type it is Rp.100.000.

TABLE 11. Tooling Cost

Chisel Type	Cutting Parameters	Amount Chisel (pcs)	Tooling Cost (Rp)
HSS 7 mm	1	7	280.000
HSS 7 mm	2	10	400.000
HSS 7 mm	3	13	520.000
Carbide 7 mm	1	5	500.000
Carbide 7 mm	2	6	600.000
Carbide 7 mm	3	7	700.000

Machining Cost (Cm)

- Operator Fee
  The operator's monthly fee for the operation of this machine is Rp. 4,500,000. So the operator's daily cost for this machine is (Rp.150.000)/(8 Hours) = Rp. 18,750, /hour
- Indirect Cost
  The costs required for warehouse costs and electricity costs, these costs are taken from 5-15% of administrative operational costs, warehouses, electricity.
- Electricity cost
  In calculating the cost of electricity, the load used is 200 V x 79 A = 15.8 kW, then 15.8 kW x 8 hours = 126.4 kWh. The price per kWh of load costs is Rp. 1.445 (1.300 VA). Then the total cost of the load is: Rp. 1.445 x 126.4 kWh = Rp. 182.700
  The amount of indirect costs is 15% x Rp. 182,700 = Rp. 177.405

The chisel hss 1 to make 100 holes the machining time required is 114.17 minutes = 1.91 hours, the machining cost for the HSS 1 chisel is Rp. 177,405 x 1.91 hours = Rp. 338,900

- The chisel hss 2 tool to make 100 holes the machining time required is 103.36 minutes = 1.72 hours, the machining cost for the HSS 1 chisel is Rp. 177,405 x 1.72 hours = Rp. 305,200.
- The hss 3 tool to make 100 holes the machining time required is 95.87 minutes = 1.60 hours, the machining cost for the HSS 1 chisel is Rp. 177,405 x 1.60 hours = Rp. 283,900.
- Carbide tool 1 to make 100 holes machining time required is 109.18 minutes = 1.82 hours, machining cost for carbide tool 1 is Rp. 177,405 x 1.82 hours = Rp. 322,900.
- Carbide chisel 2 to make 100 holes the machining time required is 93.33 minutes = 1.55 hours, the machining cost for carbide chisel 2 is Rp. 177,405 x 1.55 hours = Rp. 275,000.
- Carbide chisel 3 to make 100 holes machining time required is 80.8 minutes = 1.35 hours, machining cost for carbide 3 chisel is Rp. 177,405 x 1.35 hours = Rp. 239,500.

Cost Production (Cp)

To get the results of production costs, it can be calculated the cost of the tool plus the machining time = production costs.

TABLE 12. Cost Production

Chisel Type	Cost Production
HSS 1	Rp. 618.900
HSS 2	Rp. 705.200
HSS 3	Rp. 803.900
Carbide 1	Rp. 822.900
Carbide 2	Rp. 875.000
Carbide 3	Rp. 939.500

Cost Material (CM)

CM = CMo + CMi
= Rp. 150,000 + Rp. 80,000
= Rp. 230,000
So for the price of Rp. 150,000 is the capital price to buy materials and the price is Rp. 80,000 is an indirect cost that includes operational costs, electricity costs, costs for worker services and others.

TABLE 13. Cost Production Material

Chisel Type	Cost Production (Rp)
HSS 1	848.900
HSS 2	935.200
HSS 3	1.033.900
Carbide 1	1.052.900
Carbide 2	1.105.000
Carbide 3	1.169.500

So for each type of chisel the total production cost obtained is added to the material cost of Rp. 230,000 and the results can be seen in Table 13.

CONCLUSION

1. Varied machining parameters have an influence on machining time and machining process costs, the HSS 1 tool has a machining time of 114.17 minutes with a machining cost of Rp. 844.900, the HSS 2 tool has a machining time of 103.36 minutes with a machining cost of Rp. 935.200, the HSS 3 tool has a machining time of 95.87 minutes with a machining cost of Rp. 1.033.900, the carbide tool 1 has a machining time of 109.18 minutes with a cost for the machining process of Rp. 1.052.900, on the carbide tool 2 has a machining time of 93.33 minutes with a cost for the machining process of Rp. 1.105.000, on the carbide tool 3 has a machining time of 80.8 minutes with a cost for the machining process of Rp. 1.169.500.
2. From the results of the research, the type of carbide chisel has a more efficient machining time compared to the HSS type of tool, it can be seen on the type of carbide chisel that has a machining time of 109.18 minutes, 93.33 minutes, 80.8 minutes and the type of HSS tool 114.17 minutes, 103.36 minutes.
3. The production cost of the HSS chisel is cheaper than the HSS chisel, it can be seen that the production cost of the HSS chisel is Rp. 844.900, Rp. 935.200, Rp. 1.033.900, and on the type of carbide chisel Rp. 1.052.900, Rp. 1.105.000, Rp. 1.169.500.

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