Homepage Journal http://jurnal.polsri.ac.id/index.php/austenit
AUSTENIT VOL. 15 NO.2, OKTOBER 2023 ISSN : 2085-1286 E-ISSN : 2622-7649

OPTIMIZATION ROUGHNESS LEVEL OF TURNING FROM ALUMINUM SCRAP SMELTING RESULT USING SAND CASTING METHOD

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ARTICLE INFORMATION

Revised
25/09/2023

Accepted
10/11/2023

Online Publication
20/11/2023

doi:

10.53893/austenit.v15i2.7590

ABSTRACT

The Production Machinery Workshop at the Sriwijaya State Polytechnic are producing a lot of aluminum scrap left over from turning, where this waste is still thrown away. This will cause pollution to the environment and will be detrimental to the Sriwijaya State Polytechnic workshop. Casting is one way to deal with aluminum scrap, scrap be melted and then reshaped into a practical material that can be reused. The use of sand as a printing medium in recycling scrolls is not recommended because it is less effective and efficient in terms of long-term use. After research has been carried out, the resulting aluminum shaving waste can be reused as practical material provided that the shavings must be separated from other waste such as iron and steel. In the optimization process, the best value is obtained at the spindle speed factor of 900 rpm (A1), then the feeding depth at 0.5 mm (B1), and the feeding speed at 0.08 mm / put.

***Keywords**: Scrap, Sand Casting, Turning, Roughness*

1 INTRODUCTION

Aluminum is a non-ferrous metal material that is commonly found in the industrial world (Hidayat & Tamjidillah, 2016). Aluminum has the advantages of being lighter, corrosion resistant, low density, easy to form, and having high thermal and electrical conductivity (Azima et al., 2022). The widespread use of aluminum as a material or tool has resulted in an increasing amount of aluminum scrap which, if not processed properly, will harm the surrounding environment (Arjunanda et al., 2022). The advantage of utilizing aluminum scrap from an economic perspective is that it is more economical than mining aluminum ore, which also results in pollution (Jasman et al., 2018). Therefore, it is necessary to process aluminum scrap properly.

At the Sriwijaya State Polytechnic, aluminum is used as a practical material. The aluminum material used is initially in the form of cylinders, cubes, and squares which are then shaped according to the job sheet provided using a lathe, milling, or CNC machine. In this machining process, the material will be formed by feeding the surface of the material so that it is formed according to what is wanted. Feeding aluminum not only produces the desired product but also produces residual waste in the form of aluminum scrap.

Metal Casting is the process of making objects by melting metal. The liquid metal has poured into the base of the mold which consists of a casting pattern made according to the desired shape (Nafiuddin & Samsudi, 2022). The liquid metal is then allowed to harden and the product is formed according to the finished mold design (Adhi et al., 2017). Sand casting casting was chosen because it can print a variety of shapes and has low production costs.

Melting temperature is one of the factors that must be considered when making casting products to achieve better corrosion properties, excellent quality (Hermawan et al., 2013). The hardness test results were obtained at 44.98 HRB at a temperature of 6800^{o}C and 46.93 HRB at temperature of 750℃. The results of metallographic tests at these two temperatures showed that there were three dominant phases, namely the Al and Si phases and AlSiCu phase. Based on this research, changes in hardness and micro structure occur in the aluminum casting process (Lutiyatmi, 2022).

From the explanation above, further research is needed on the results of recycling aluminum scrap because the recycled practical material will be used as practical material again on the lathe. The value of the quality of the material produced needs to be known because the material will be reused as practical material, to produce quality products of course good materials are needed. Therefore, the research has the title Optimization Roughness Level of Turning from Aluminum Scrap Melting using Sand Casting Method.

2. MATERIALS AND METHODS

2.1 Research Steps

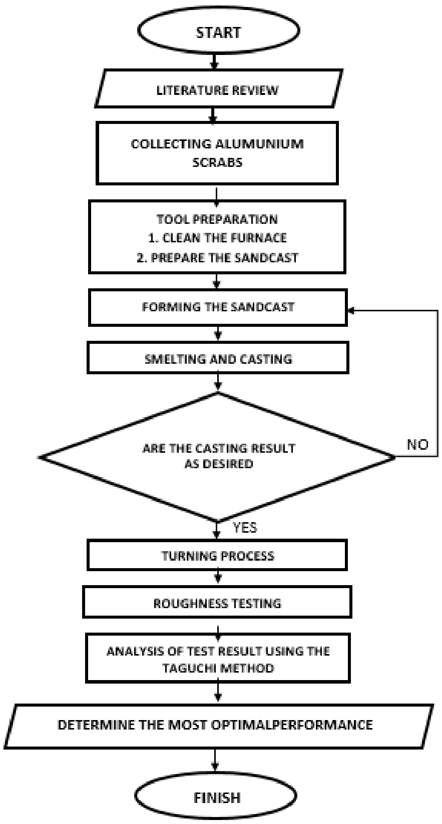

Figure 1. Research flow diagram

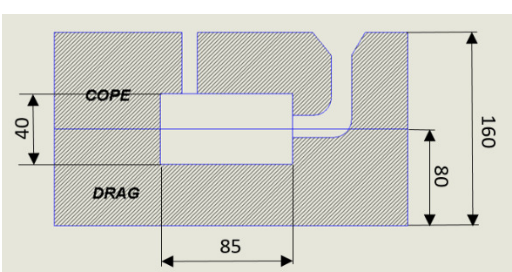

Figure 2. Sand mold design

The mold design in the sandcasting process is as follow:

With an initial diameter of the workpiece of 40 mm, the turning process will then be carried out in stages by adjusting the diameter of the object. The formula used is:

$$\eta = \frac{V_c.1000}{\pi.d} \quad (1)$$

Where;
η= Spindle rotation speed (rpm)
V_c= Cutting Speed (meters/minute)
d = Object Diameter (mm)

From these calculations it will be found that the turning process using an HSS chisel is 716.56 rpm. So, with the principle that the smaller the workpiece, the faster the spindle rotation speed will be, so it is necessary to determine a variable value of ≥ 716.56 rpm. Based on the table there are 3 parameters and levels that selected

Table 1. Experimental Factors

Parameter	Levels		
	1	2	3
Spindle Speed (Rpm) (A)	900	1230	1500
Depth of Cut (mm) (B)	0.5	1.0	1.5
Feeding Speed (mm/ref) (C)	0.1	0.08	0.07

After determining the spindle speed and these parameters, the material diameter value can be found to match that speed:

$$d1 = \frac{V_c \,.\, 1000}{\pi \,.\, \eta} \qquad d2 = \frac{V_c \,.\, 1000}{\pi \,.\, \eta} \qquad d3 = \frac{V_c \,.\, 1000}{\pi \,.\, \eta}$$

$$d1 = \frac{90 \,.\, 1000}{3.14 \,.\, 900} \qquad d2 = \frac{100 \,.\, 1000}{3.14 \,.\, 1230} \qquad d3 = \frac{110 \,.\, 1000}{3.14 \,.\, 1500}$$

d1=31.84mm d2=25.89mm d3=23.35mm

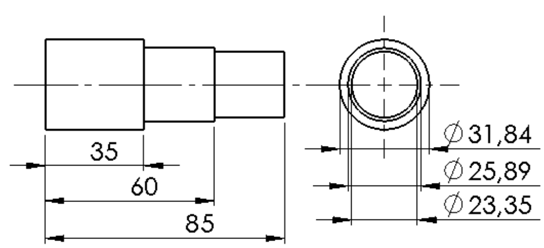

Figure 3. Result Turning Size

After the material has been adjusted to size, the next step is to finish it with the specified parameters

2.2 Taguchi Method

In conducting experiments, the Taguchi concept is used to produce optimal performance. The Taguchi experimental strategy is more effective because it allows research to combine a large number of variables and numbers (Gunawan et al., 2022). Apart from that, it can also reduce costs and time so that the process becomes more efficient (Fanya & Haruman, 2022) The data processing method for this method is:

a) Determining quality character

There are three quality characteristics grouped based on target value, including: Nominal the Better; Smaller is Better; Larger is Better (Bustami et al., 2014). The type of characteristic of the SN Ratio value used in finding reductions is Smaller is Better (Zamheri et al., 2020). Because small amount of the roughness value is better.

b) Determining the Type of Orthogonal Matrix

Selecting an appropriate or sufficient orthogonal matrix requires an orthogonal matrix equation that represents the number of components, the number of levels, and the number of observations collected (Apriansyah et al., 2022).

Degrees of freedom = (factors) x (levels– 1)
= (3) x (3-1)
= 6

To determine the type of Orthogonal Matrix, the value that is ≥ of the freedom value is selected, so for the Orthogonal Matrix the L9 type is selected:

L9 value = L x value (number of factors – 1)
= 4 x (3-1)
= 8

Table 2. Orthogonal Matrix

Sample	Spindle Speed *(Rpm)*	Depth of Cut (mm)	Feeding Speed (mm/put)
1	900	0.5	0.1
2	900	1.0	0.08
3	900	1.5	0.07
4	1230	0.5	0.08
5	1230	1.0	0.07
6	1230	1.5	0.1
7	1500	0.5	0.07
8	1500	1.0	0.1
9	1500	1.5	0.08

c) SN ratio analysis

Analysis of Varian Signal to Noise (SN) is used to determine which factors are most influential on the expected response (Wang et al., 2019).

Data analysis using Minitab 19 then obtained the response values for SN ratios and means using smaller is better with the following equation:

$$SN = -10 \log\left(\frac{(\Sigma y^2)}{n}\right) \quad (2)$$

Where;
y = response for the given combination
n = Number of responses

3. RESULTS AND DISCUSSION

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3.1 Smelting and Turning Results

The following is the result of smelting that called smelting waste which was carried out using the sandcasting method by casting using sand with a composition of 86% sand, 8% clay, 5% water. The melting of the chips itself is carried out using an induction kitchen at a temperature of 750oC and cooled to room temperature.

Figure 4. Smelting Result

After cutting the waste is formed into a specimen, the next step is to carry out turning with variables that have been determined for each part of the specimen. The image above is the result of the turning process of aluminum chip waste.

Figure 5. Turning Results

3.2 Roughness Test Results

After carrying out the turning process on the material using the specified factors and levels, the next step is to carry out a roughness test on the specimen that has been made. The following are the results of the roughness test:

Table 3. Roughness Testing Results

Sample	Roughness Test Results		ΣRa (μm)
	Test Point	Ra (μm)	
1	1	1,260	1,370
	2	1,279	
	3	1,452	
	4	1,310	
	5	1,552	
2	1	2,302	2,280
	2	1,891	
	3	2,702	
	4	2,185	
	5	2,322	
3	1	1,508	1,781
	2	1,652	

	3	1,907	
	4	2,140	
	5	1,699	
4	1	1,047	1,093
	2	1.07	
	3	1,052	
	4	1,160	
	5	1,139	
5	1	2,685	2,488
	2	2,775	
	3	2,613	
	4	2,157	
	5	2,210	
6	1	1,972	2,113
	2	2,159	
	3	2,242	
	4	2,149	
	5	2,047	
7	1	1,953	1,834
	2	1,830	
	3	1,999	
	4	1,626	
	5	1,762	
8	1	2,512	2,377
	2	2,699	
	3	2,585	
	4	2,111	
	5	1,979	
9	1	2,386	2,320
	2	2,448	
	3	2,887	
	4	1,911	
	5	1,972	

After inputting data using the Minitab application, the mean and SN Ratio values obtained from the test are as follows table 4 and Figure 6.

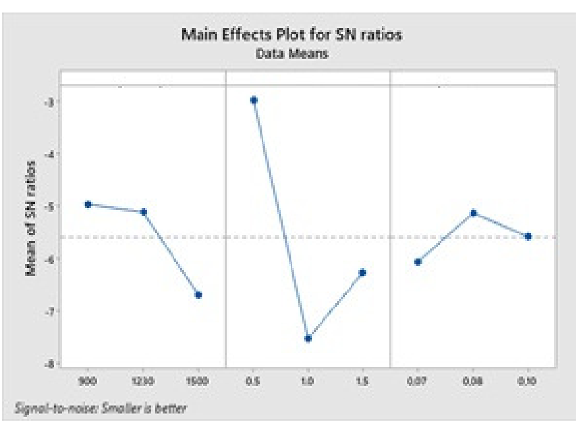

Figure 6. Main Effects Plot for SN Ratio

Table 4. Response for Signal to Noise Ratios

Levels	Spindle Speed	Depth of Cut	Feeding Speed
1	-4,971	-2,980	-6,066
2	-5,118	-7,533	-5,136
3	-6,701	-6,276	-5,587
Delta	1,730	4,553	0.931
Rank	2	1	3

From the results of the analysis on SN ratios shown on table 4, the best value was obtained, namely the spindle speed factor (A1) of 900 rpm. then depth of cut (B) 0.5 mm, and feed speed (C) 0.08 mm/put. Then the average value of each determining factor is also obtained.

Table 5. Response Table for Means

Levels	Spindle Speed	Depth of Cut	Feeding Speed
1	1,811	1,439	2,034
2	1,905	2,382	1,905
3	2,177	2,072	1,954
Delta	0.367	0.942	0.129
Rank	2	1	3

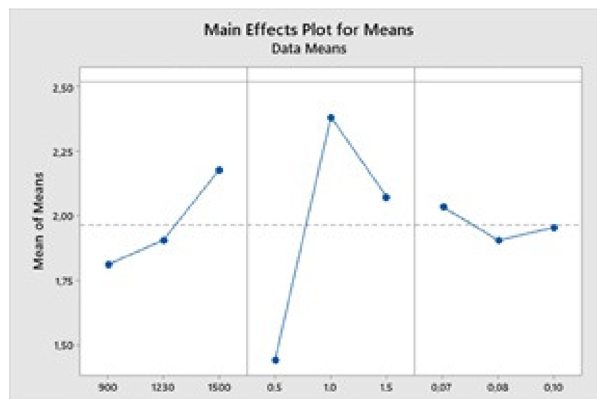

Figure 7. Main Effects Plot for Means

From the table 7 and Figure 7 that the value with the smallest means can be obtained, namely at spindle speed 900 rpm (A1), depth of cut 0.5 mm (B1), and feeding speed 0.08 mm/put (C2), it can be concluded that the optimal value in process testing turning of recycled aluminum scrap using the sandcasting method, namely the turning factor [A1B1C2].

4. CONCLUSION

From the research conducted, we can conclude that the smelting of aluminum scrap can be done provided that the scrap is free from steel or iron content. Based on the result of the roughness measurement were found that after the turning process, the result of the roughness value at N7 with average roughness result was 1.964 µm. In the optimization process, the best value is obtained at the spindle speed factor of 900 rpm(A1), then the feeding depth at 0.5 mm (B1), and the feeding speed at 0.08 mm/ref.

5. ACKNOWLEDGMENT

Thank you to all parties who have helped us in carrying out this research. To the Directorate General of Learning and Student Affairs, Ministry of Education, Culture, Research and Technology for providing funding for our research. Thank you to Sriwijaya State Polytechnic for providing facilities to support us. Next to the Deputy Director for Student Affairs at Sriwijaya State Polytechnic supervisor, Head of Department, and other lecturers who have guided and supervised us in completing various activities related to PKM-RE. And also thank you to the RECALT POLSRI TEAM who have worked hard and worked sincerely to complete every activity needed from start until finish.

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