The Effect of Cooling Media Variation and Wet Process Turning Feed Speed on The Roughness of St 60 Steel on Locomotive Wheel Axle

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Abstract. This study aims to determine the effect of variations in cooling media and variations in feeding speed in wet process turning on the surface roughness of ST 60 Steel as a recommendation for the Yasa Locomotive Hall in turning wheel shafts. This research uses an experimental method on wet process turning of ST 60 steel material by controlling the independent variables and control variables. The independent variables include variations in cooling media (radiator coolant, dromus oil, and mineral water) and variations in feed speed (20 mm/rev, 50 mm/rev, and 275 mm/rev). Control variables include spindle rotation speed (765 rpm), depth of feed (2 mm), 90º cutting angle, and using VNMG160404 insert tool. It can be concluded that turning on ST 60 steel with coolant radiator cooling media has more optimal results. The higher the feed speed, the finer the surface roughness value produced. It is known that at a feed speed of 275 mm/rev, specimens with coolant radiator cooling media have a surface roughness value of 1.415 μm, specimens with dromus oil cooling media have a surface roughness value of 2.088 μm, specimens with mineral water cooling media have a surface roughness value of 2.461 μm. The surface roughness value is within the standard range of wheel axle turning roughness values.

Keywords: Surface roughness value (Ra), wet process turning of ST 60 steel, variation of cooling medium, variation of feeding speed.

1 Introduction

In railway facilities, machining is an important stage in efforts to repair or replace damaged engine parts, such as wheels, bearings, and shafts. One of the components in railway facilities that undergo the machining process is the locomotive wheel shaft which is generally made using St 60 steel material. This machining process is routinely carried out on a scheduled basis during the four-year maintenance period (P48) and six-year maintenance (P72) at the Yogyakarta Locomotive Yasa Hall.

According to Rugayyah (2020), in wheel axle turning results, it is important to pay attention to the level of surface roughness [1]. This is related to the function of the

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interrelated components of the wheel shaft and wheel puck. The finer the surface roughness value on the locomotive wheel shaft, the smaller the friction that occurs between the two components.

According to Sugiyanto & Prabowo, the surface roughness value of the wheel shaft is below the standard, which can cause several negative impacts, such as excessive friction problems, wear, and fatigue resistance [2]. These negative impacts result in a decrease in the performance and service life of the wheel axle due to uneven pressure due to excessive friction. Thus, the wheel shaft experiences structural damage which causes wear to become faster [3].

According to Budiana et al, one aspect that can be used as a guide in evaluating metal quality is testing the roughness of its surface [4]. The results of surface roughness testing can be used to determine the surface quality of objects, identify defects on the surface, and ensure compatibility between two surfaces that rub against each other.
In the study conducted by the author, there are some specific variations compared to previous research. The research conducted the work process was carried out on a conventional lathe while in this study the work was carried out on a CNC lathe used in the wheel shaft turning process at the Yogyakarta Locomotive Yasa Hall [5]. In the research conducted by (Arsana et al., 2019) the material used was St 37 steel while in this study the authors used St 60 steel material. In the research conducted by (Rohman et al., 2023) the types of tools used were HSS tools and carbide tools while the type of tool used in this study was a carbide insert tool type VNMG160404 based on tool usage data in turning wheel shafts at the Yogyakarta Locomotive Yasa Hall. In the research conducted the cooling media used were SAE-20W oil, soybean patra, and pure coconut patra, while in this study using mineral water cooling media, dromus oil, and radiator coolant [3], [6], [7]. In previous research conducted [8]–[10]. The feeding speeds used were 25 mm/rev, 75 mm/rev, 150 mm/rev, and 250 mm/rev, while in this study the feeding speeds used were 20 mm/rev, 50 mm/rev, and 275 mm/rev.

2 Method

2.1 Desain

This research uses an experimental method on wet process turning by varying the cooling medium and the speed of the cutting on the St 60 steel material. The following is a test specimen design to determine the cutting that will be carried out on the specimen.

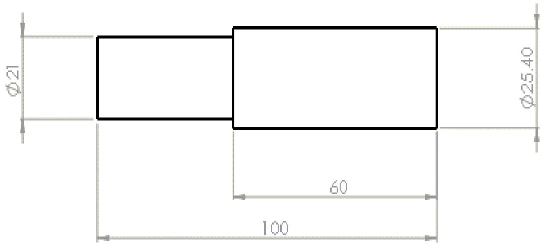

Fig. 1 Specimen Design

2.2 Tools and Materials

The use of CNC lathes aims to carry out the machining process to produce objects that are in accordance with the pre-entered programme. The following are the specifications of the LTC-200 CNC lathe machine.

Table 1 Specifications of CNC LTC-200

Model	LTC-200
Type	CNC lathes
Swing	497,84 *mm*
Machining length	299,72 *mm*
Chuck size	203,2 *mm*
Bar capacity	50,8 *mm*
Max rpm	4,500 *rpm*
Turning diameter	299.72 *mm*

Specifications and drawings Surface roughness testing using surface roughness tester 6210 is shown in table 2 and figure 3.

Fig 2. Surface roughness testing

Table 2 Specifications of 6210

Model	**SRT - 6210**
Display	4 digits, 10 mm LCD, with blue backlight
Parameter measurement	Ra, Rz, Rq, dan Rt

Measuring Range	Ra, Rq: 0.005-16.00um/0.020-629.9u inch Rz, Rt: 0.020-160.0um/0.780-6299u inch
Store memory	7 groups of measurement
Data output	communicate with PC through RS232C interface
Accuracy	≤±10%
Resolution	Not more than 6%
Maximum driving stroke	17.5mm/0.7inch
Cut off length (l)	0.25mm / 0.8mm / 2.5 mm optional
Evaluation length	1-5 L
Driving speed	Sampling length=0.25mm Vt=0.135mm/s sampling length = 0.8mm Vt=0.5mm/s sampling length = 2.5mm Vt=1mm/s returning Vt=1mm/s
Profile digital filter	Filtered Profile: RC Filtered Profile: PC-RC Filtered Profile: Gauss Non-Filtered Profile: D-P
Resolution	0.001 μm if reading ＜10μm 0.01 μm if 10μm≤reading＜100μm 0.1 μm if reading ≥100μm

The surface roughness tester tool is used to measure the roughness value of the ST 60 Steel material after experiencing various cooling media variations and variations in the feed speed during the turning process. Furthermore, the data from the surface roughness test of each test specimen was analysed in the form of graphs on Origin lab software to determine the effect of parameter variations used in wet process turning on the surface roughness value of ST 60 Steel material.

3 Result

The surface roughness tester tool is used to measure the roughness value of the material for three repetitions at the testing point at an angle of 0º, 120º, and 240º for each test specimen. The following are the results of surface roughness testing carried out on each test specimen.

Table 3 Radiator Coolant Surface Roughness Value

Cooling Media	**Feeding Speed (mm/ rev)**	**Ra 1 (μm)**	**Ra 2 (μm)**	**Ra 3 (μm)**	**Average (μm)**
Radiator Coolant	20	2,850	2,782	3,055	2,895
	50	2,238	2,072	1,916	2,075

	275	1,269	1,423	1,553	1,415

Table 4 Dromus Coolant Surface Roughness Value

Cooling Media	Feeding Speed (mm/ rev)	Ra 1 (μm)	Ra 2 (μm)	Ra 3 (μm)	Average (μm)
Dromus Oil	20	3,775	3,892	3,636	3,767
	50	3,324	3,021	3,089	3,311
	275	2,275	2,029	1,960	2,088

Table 5 Water Coolant Surface Roughness Value

Cooling Media	Feeding Speed (mm/ rev)	Ra 1 (μm)	Ra 2 (μm)	Ra 3 (μm)	Average (μm)
Water	20	4,301	4,561	5,101	4,654
	50	3,175	3,004	3,124	3,101
	275	2,457	2,356	2,571	2,461

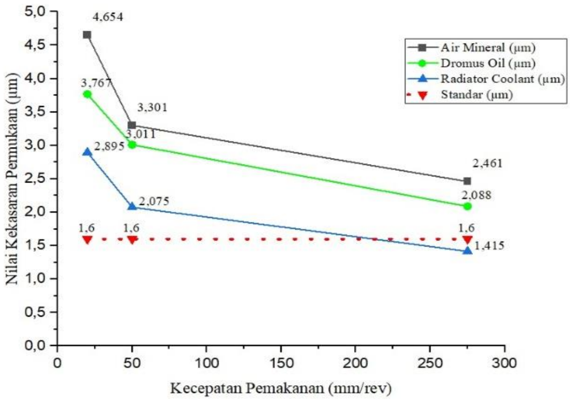

Fig. 3 Relationship between Speed and Surface Roughness Value

It can be seen that at a feed speed of 20 mm/rev. Test specimens with mineral water cooling media have a surface roughness value of 4.654 µm. Test specimens with dromus oil cooling media have an average surface roughness value of 3.767 µm. Test specimens with coolant radiator cooling media have an average surface roughness value of 2.895 µm.

It is known that at a feed speed of 50 mm/rev each test specimen has a decrease in surface roughness value. Test specimens with mineral water cooling media have a surface roughness value of 3.301 µm. Test specimens with dromus oil cooling media have a surface roughness value of 3.011 µm. Test specimens with coolant radiator cooling media have a surface roughness value of 2.075 µm.

It is also known that at a feeding speed of 275 mm/rev each test specimen again experienced a decrease in surface roughness value. Test specimens with mineral water cooling media have a surface roughness value of 2.461 µm. Test specimens with dromus oil cooling media have a surface roughness value of 2.088 μm. Test specimens with radiator coolant cooling media have a surface roughness value of 1.415 μm.

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