



# Effect of Cutting Speed of Carbon Steel ST 41 on Cutting Temperature in Turning Process

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## ABSTRACT

The turning process is one of the most widely used lathe machining techniques in manufacturing, involving the interaction between the machine tool, workpiece, and cutting tool. During cutting, friction between the chisel and the workpiece generates excessive heat, with most cutting energy converted into heat. This study examines the effect of cutting speed on temperature in chisels, chips, and ST41 carbon steel workpieces at various lathe speeds. Using an experimental method, cutting speeds of 260 RPM, 560 RPM, and 800 RPM were tested. Data collected included lathe rotation speed, specimen temperature, chisel temperature, chip temperature, cutting depth, and chip mass. Results show that temperature increases with cutting speed. At 260 RPM, the chisel temperature was 38.46°C, the workpiece 36.83°C, and the chip 36.21°C. At 800 RPM, the highest tool temperature was 65°C, the workpiece reached 62.33°C, and the chip 48.56°C. This indicates that higher cutting speeds generate more heat, making the turning process more thermally intensive.

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## 1. INTRODUCTION

The rapid development of science and technology has made industry play an important role in it (Rochani, 2017) . With the existence of new industries, it will create new products that are more innovative and effective so that they can encourage the emergence of new discoveries both in the fields of science and technology and help human resources become more advanced. In the world of engineering, the turning process is one of the most widely used lathe machining processes in the manufacturing world (Abbas *et al.* , 2024) . With the increasing application of machining processes, especially in the lathe process, to be able to optimize the prediction of cutting forces and machining parameters (Akbar & Widiasih, 2022) .

According to Firstamarsyah (2019) , the role of lathes in the metal processing/working industry is very large because lathes can work on and shape cylindrical objects such as making shafts, *pulleys* , tapered objects, making holes, and making threads (Peni Dwi Purnomo, Johan Wayan Dika, 2021) . According to Li *et al.*, 2023) , basically, a lathe is a machine tool that functions for the metal cutting process. The main function of a lathe is to process cylindrical workpieces (Firdaus & Oleh, 2023) ; (Patel & Chauhan, 2020) .

In a lathe, the metal cutting process is generally an interaction between the machine tool, the workpiece, and the cutting tool (Pervaiz *et al.*, 2020) . The interaction here is influenced by parameters called cutting parameters, such as machine cutting speed, cutting depth on the object,

feed motion of an object, tool material, tool geometry and workpiece. The interaction between the workpiece and the tool can have an effect. One of the most important effects is the increase in temperature of both the workpiece and the tool (Aldio *et al.*, 2024). Rapidly increasing temperatures will accelerate the life of a tool, so prevention is needed if the temperature increases.

The friction that occurs between the chisel and the workpiece during cutting causes... excessive *temperature* (Ibrahim *et al.*, 2020). We can see that almost all cutting energy is converted into heat energy through friction during the cutting process. Due to the high pressure due to the cutting force and *high temperature*, the active surface of the chisel will experience wear (Grigoriev *et al.*, 2021).

Steel has characteristics from the softest to the hardest, from steel materials various forms of structures or metal forms can be made (Zayadi *et al.*, 2022). This is what makes steel referred to as a material that is rich in properties, where the main alloying element is carbon. According to Fachreza *et al.*, (2017), carbon is the main element to strengthen steel, so steel must contain carbon to a certain level. Based on its carbon content, steel can be distinguished into 3 types, namely: low carbon steel (C <0.3%), medium carbon steel (C 0.3-0.7%), high carbon steel (0.7-1.7%) (Prabowo *et al.*, 2021).

The temperature of the tool when cutting can be detected by means of a thermocouple of the cutting tool workpiece (Zhang *et al.*, 2018). Basically by utilizing the properties of a workpiece with a cutting tool. Because two different metal materials are in contact at high temperatures, according to the thermocouple principle, an electric voltage (emf) will arise if the circuit is closed.

One of the low carbon steels is ST 41 carbon steel which has a carbon (C) content of 0.10% (Gunawan, 2017). ST 41 steel is widely used for wire, nails, wire mesh, automotive equipment and coated electrode wire for welding purposes (Utomo & Yunus, 2021). The cutting speed of ST 41 carbon steel can affect the cutting temperature in the turning process (Peni Dwi Purnomo, Johan Wayan Dika, 2021). The higher the cutting speed, the lower the cutting temperature tends to be (Nistelroy *et al.*, 2024). Because high cutting speeds can reduce friction between the cutting tool and the workpiece, reducing the energy converted into heat. However, the cutting speed setting must be optimal to get good results, because cutting speeds that are too high can also produce negative effects such as faster cutting tool wear or decreased surface quality of the turning results. (Retyawan *et al.*, 2018).

## 2. RESEARCH METHOD

This research was conducted at the Oma Deli B-59 Complex, Artani Miduk Workshop, Tanjung Morawa, Deli Serdang Regency, North Sumatra. Implementation time June 2024 - July 2024. The research method used in this study is an experimental method. This is done to test the performance of the turning process using ST41 carbon steel specimens by seeing whether there is an effect of cutting speed on cutting temperature. Where some data are taken such as lathe rotation speed, specimen temperature, chisel temperature, and the resulting chip temperature, cutting depth, and turning chip mass. Then the collection of data and parameters will be used in the experiment and then the analysis of the results of the test will be carried out and make the necessary assumptions.

### 2.1 Data Analysis Techniques

After obtaining the parameters that have been measured during the research, the data that needs to be analyzed is as follows: Cutting Speed of Lathe Machine; Specimen temperature, chisel blade, and turning chips

Data processing and analysis begins with calculations on the required parameters using formula equations. Data processing and analysis will be presented in the form of tables and graphs then continued with conclusions.

### 2.2 Procedure Testing Tools Testing

Before do testing need know the necessary parameters measured during testing ongoing. There are several testing parameters is as following: Speed round machine (n); Depth cut (a); Eating movement (f); Cutting Length object work (l); Temperature in specimen, eyes chisel and on the growl results process turning.

To obtain data from the results of testing lathe machine specimens Here, there are several stages of testing, namely: testing the machine rotation speed, temperature, and mass of chips produced from the turning process.

**3. RESULTS AND DISCUSSIONS**

From the results of the flat turning test using a conventional lathe, the results of the study on the effect of rotation speed and flat lathe feed speed on ST41 steel material with a diameter of 20 mm and a length of 100 mm using variations in rotation speed of 260 rpm, 560 rpm and 800 rpm can be concluded in table 1 below.

**Table 1. Test Result Table ST41 Carbon Steel Lathe**

No	Round	Temperature Cutting			Furious Mass (gr)	Turning Time (Seconds)
		Chisel	Specimen	Furious		
1	260	37	36.5	35.3	67	315
		37.4	36.7	36.3	76	
		41	37.3	36.7	94	
2	560	42.8	47.9	42.4	70	125
		49.6	49.5	48.7	80	
		55.7	54.7	51	85	
3	800	62.2	52.5	43.4	75	90
		64.2	62.6	44.6	82	
		68.6	71.9	49.7	82	

Based on from data results in the table on can concluded that results testing from the eating process steel carbon ST41 with using different rpm start from lowest speed until with speed highest round. At a speed of 260 rpm, the feeding process object Work walk with slow and results fiber his Still seen rough

Then at speed next namely 560 rpm, the feeding process object Work seen more fine than speed of 260 rpm. While at a speed of 800 rpm, the process feeding object very fine work than speed of 260 rpm and 500 rpm.

From the table above is also visible that the more fast variation speed round machine lathe so temperature produced in the specimen, the eye chisel and result furious the more increased. This is due to Because the more fast rotation on the engine lathe so eye chisel will the more fast rubbing with specimen and will cause improvement the resulting temperature.

**3.1 Turning Results at 260 Rpm Variation**

In the flat turning process at a speed of 260 rpm, the turning process runs slowly so that in the flat turning process on the ST41 carbon steel specimen with a specimen diameter of 20 mm and a cutting depth of 5 mm, the fibers are rough and the results are not good.



Figure 1. Test results at 260 rpm variation

In the image above, the results of the turning test on carbon steel st41 with a speed variation of 260 rpm, the test results are seen to be less smooth and rough. This test takes 315 seconds from the initial turning process to the completion of the turning.

**3.2 Turning Results at 560 Rpm Variation**

In the flat turning process with a speed of 560 rpm, the turning process runs faster than the speed variation of 260 rpm, then in the flat turning process on the ST41 carbon steel specimen with a

specimen diameter of 20 mm and a cutting depth of 5 mm produces finer fibers and the specimen results are shinier. The specimen results of turning at a speed variation of 560 rpm can be seen in the image below.



**Figure 2.** Test results at 560 rpm variation

In the image above, the results of the turning test on carbon steel st41 with a speed variation of 560 rpm, the test results are smoother than the test results at a speed of 260 rpm and the specimen looks shinier. This test takes 125 seconds from the initial turning process to the completion of the turning.

Almost all of the cutting energy changed becomes hot. This heat is mostly carried away by the chips, some of it propagates through the tool and the rest flows through the workpiece towards the surroundings.

### **3.3 Turning Results at 800 Rpm Variation**

In the flat turning process at a speed of 800 rpm, the turning process runs faster than the speed variations of 560 rpm and 260 rpm, then in the flat turning process on the ST41 carbon steel specimen with a specimen diameter of 20 mm and a cutting depth of 5 mm produces finer fibers and the specimen results are shinier. The specimen results of turning at a speed variation of 800 rpm can be seen in the image below:



**Figure 3.** Test results at 800 rpm variation

In the picture above the results of the turning test on carbon steel st41 with a speed variation of 800 rpm and, it can be seen that the test results are smoother than the test results at a speed of 560 rpm and the specimen looks shinier. This test only takes 90 seconds from the initial turning process to the completion of the turning.

Almost all of the cutting energy changed becomes hot. This heat is mostly carried away by the chips, some of it propagates through the tool and the rest flows through the workpiece towards the surroundings.

## **4. CONCLUSION**

Figure 2. Test results at 560 rpm variation Based on the objectives of this study, machining tests on ST41 carbon steel have been carried out using a conventional lathe. Experimental tests were carried out by varying the spindle rotation speed of the lathe and analyzing the effect of temperature on the

variation of the speed. The results showed that increasing the cutting speed in the turning process caused an increase in the temperature of the tool, workpiece, and chips produced. The temperature increase in the tool was higher than the workpiece due to continuous friction between the tool and workpiece, which generated heat. Meanwhile, the temperature of the workpiece was lower due to natural cooling due to the rotation of the workpiece exposed to the surrounding air. Chips that were released from the workpiece also caused an increase in temperature, but after being separated, the temperature was no longer higher than the temperature of the workpiece and tool. Future research can continue the test with several developments, such as: Additional Materials and Lubricants: Using various types of materials other than ST41 steel or applying lubricants to reduce friction and temperature generated during the cutting process; Long-Term Analysis: Testing the effects of long-term cutting on the durability of the tool and workpiece, as well as how temperature affects overall machine performance; Wide Range of Speed Testing: Adding a wider range of rotational speeds to determine the sweet spot between performance and temperature; and Real Industry Testing: Conducting field tests to test lab results under more realistic operating conditions and see if they are consistent.

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