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# Analysis of HSS Chisel Main Cutting Edge Angle and Feeding Depth of ST 60 Steel Cylindricity in Longitudinal Turning Process

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***Abstract*—This study aims to analyze the main cutting edge angle of HSS (high-speed steel) chisel and the depth of cut on the cylindricity of ST 60 steel workpiece in the longitudinal turning process. The material used is ST 60 steel with a specimen length of 200 mm and a diameter of 30 mm and turned along 200 mm using variations of the main cutting edge angle, Kr (30, 45, 60, 90°) and the depth of cut, a (0.5; 1; 1.5; 2.0 mm) and other variables are set at constant conditions. Based on the results of this study, it can be concluded that the variation of the SS chisel cutting angle in the turning process produces an average total cylindricity value at a cutting angle of Kr 30° = 0.95 mm, Kr: 45° = 0.65 mm, Kr: 60° = 0.45 mm. In other words, it can be concluded that the optimal cylindricity value occurs at a cutting angle of 90° = 0.15 mm. While the average cylindricity value at a cutting depth of a: 0.5 mm = 0.25 mm, a: 1 mm = 0.35 mm, a: 1.5 mm = 0.55 mm, a: 2.0 = 0.60 in other words, the optimal total cylindricity value is obtained at a cutting depth of 0.5 mm.

***Keywords—HSS chisel, cylindricity, main cutting angle, feed depth, ST 60 steel***

## I. Introduction

The effect of the main cutting edge angle of HSS (high-speed steel) tool and the depth of cut on the cylindricity of ST 60 steel in the longitudinal turning process is an important topic in the field of manufacturing engineering. Longitudinal turning is a machining process used to produce cylindrical workpieces by removing material from the surface of the workpiece using a rotating lathe tool. . ST 60 steel as one of the carbon steel materials widely used in the industry, has advantages such as high tensile strength, wear resistance, and ease of machining. However, the quality of the machining results, such as the cylindricality and surface roughness, is greatly influenced by the cutting parameters used, including the angle of the main edge of the cutting tool and the depth of the cut. In addition, although parameters such as surface roughness and tool life have been extensively discussed in the literature, the influence of these parameters on the cylindricality of the workpiece on ST 60 steel is still not fully understood. In-depth experimental studies to evaluate the relationship between prime edge angle, depth of cut, and quality of machining results on ST 60 steel are still very limited [1],

Overall, to achieve optimum cylindricity in ST 60 steel machining using a longitudinal lathe, it is important to choose the right combination of main cutting edge angle and depth of cut [2]. This depends on the workpiece material, cutting conditions, and the desired surface quality objective. The right combination will result in efficient and accurate cutting, minimize distortion, and maintain good cylindricity in the workpiece [3].

HSS chisel is a chisel material that is often used in the cutting process because of its high wear resistance at high cutting speeds [4]. This chisel has the ability to maintain its strength and sharpness even at high temperatures generated during cutting. HSS chisels are often used for longitudinal turning work because of their more economical cost compared to carbide-based chisels [5].

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The main cutting edge angle is one of the important factors in the cutting process. This angle plays a role in determining how the tool interacts with the workpiece during cutting [6]. Choosing the right cutting edge angle can affect cutting forces, cutting temperatures, and the quality of the final results, such as cylindricity and surface roughness. The optimal main cutting edge angle can help reduce cutting forces and improve process efficiency [7].

Feed depth is a cutting parameter that refers to how deep the tool cuts the workpiece in a single pass. This parameter affects the number of cuts of the material and how much cutting force is applied. The main edge angle of the cutting tool has an important role in determining the distribution of the cutting force, the formation of flakes, and the life of the tool. Meanwhile, the depth of cut affects the rate of material removal as well as the force and temperature that occur during the machining process. However, until now, there are still limitations in studies that specifically study the effect of the combination of the main edge angle and the cutting depth on the turning process of ST 60 steel. Most previous studies have focused more on the analysis of cutting parameters individually or on other materials with different properties. In addition, although parameters such as surface roughness and tool life have been extensively discussed in the literature, the influence of these parameters on the cylindricality of the workpiece on ST 60 steel is still not fully understood. In-depth experimental studies to evaluate the relationship between the main edge angle, the depth of cut, and the quality of machining results on ST 60 steel are still very limited. A larger feeding depth generally results in a greater cutting force and can affect the cylindricality of the workpiece. Determination of optimal feeding depth is important to achieve stable and precise cutting results [8].

Cylindricity is a parameter that indicates the extent to which the workpiece surface approaches a perfect cylindrical shape. In the turning process, poor cylindricity can be caused by several factors such as cutting force, vibration and instability of the cutting tool.

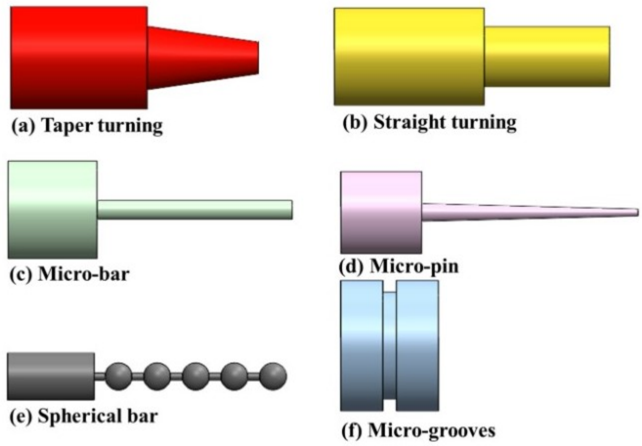


Figure 1. Schematic representation of turning process types and range of parts made by them: (a) Taper turning; and (b) Straight turning; (c) high-aspect-ratio micro-bar; (d) high-aspect-ratio micro-pin; (e) spherical bar; and (f) micro-grooves.

Analysis of the influence of the main cutting edge angle and depth of feed on cylindricity is very important to improve product quality and reduce product defects [9]. Feed depth is defined as the depth of the chip taken by the cutting tool. In rough turning, the maximum depth of cut depends on the condition of the machine, the type of cutting tool used, and the machinability of the workpiece [10].

This research aims to analyze how the variable angle of the main cutting of the HSS chisel and feed depth affect the cylindricity of ST 60 steel in the longitudinal turning process. By understanding the relationship between these parameters, it is hoped that optimal cutting conditions can be determined to produce products with good cylindricity and high process efficiency [11].

This study is relevant to the manufacturing industry that uses turning process to produce cylindrical components. Knowledge of optimal cutting parameters can help in designing more efficient production processes and producing high-quality products. It can also lead to cost savings and increased competitiveness in the market. Overall, a deeper understanding of the effects of the main cutting edge angle and depth of cut in the longitudinal turning process can provide useful insights for engineers and technicians in designing optimal process parameters for cutting ST 60 steel [12].

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## II. Research Methodology

### *A. Method*

This study is experimental with a quantitative approach to analyze the influence of the main cutting angle of the HSS tool and the depth on the cylindricality of ST 60 steel in the longitudinal turning process. In this study, the method used in laboratory experiments was used. This method is designed to provide a comprehensive understanding of the influence of cutting parameters on silliness, so that it can be used to improve the quality of the longitudinal turning process on ST 60 steels.

### *B. Material And Tools*

The material used in this study is ST 60 steel as a workpiece and high-speed steel for the tool material is HSS.

Figure 2. ST 60 Steel Bar

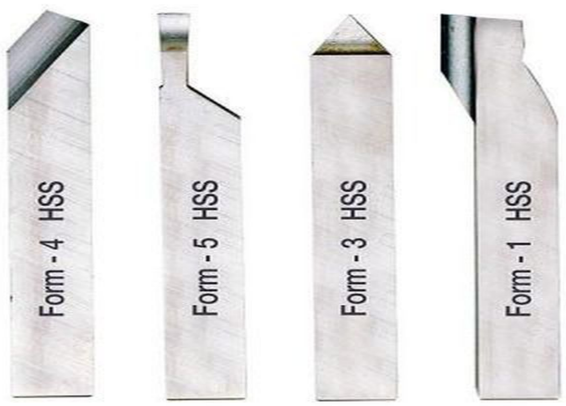


Figure 3. Types of HSS Chisels

Figure 4. The Workpiece Is Being Turned

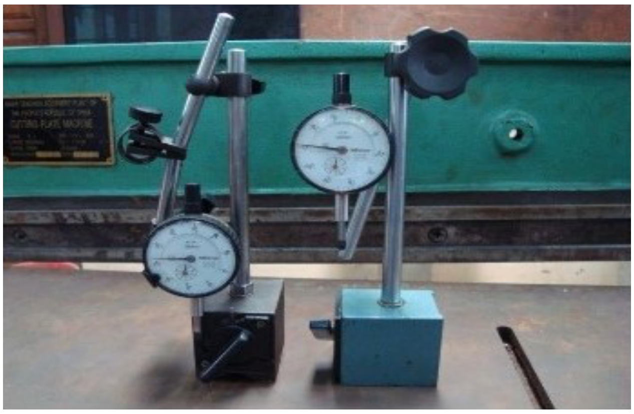

Figure 5. Dial Indicator

### *C. Research Procedure*

The steps in the turning process are carried out in a structured manner, starting with preparing the necessary tools and materials, including ensuring that the lathe is in optimal condition and that coolant is available to support the wet turning process, followed by the preparation of the workpiece to be turned, where the workpiece must be ensured to be firmly and securely positioned in the grip of the machine. Furthermore, the tool bit to be used is prepared by adjusting the main cutting bit angle (Kr) at angle variations of 30°, 45°, 60°, and 90°, and the feeding depth (a) is set at variations of 0.5 mm, 1 mm, 1.5 mm,

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and 2 mm, with the cutting speed (Vc) kept constant at 94.2 m/min for all applicable parameter combinations. Once all the settings are done, the process of turning the prepared specimen begins with a focus on the precision and quality of the final result, and once the turning is complete, the workpiece is carefully removed from the grip to avoid damage to the result, followed by the removal of the 1/2 x 8-inch HSS tool to be checked for condition or prepared for further use.

The cylindricality of the workpiece is measured using a special measuring instrument such as a sillinity measuring machine, or it can be calculated mathematically using the formula:

$$T_{cyl} = d_{min} - d_{max} \quad (3.1)$$

Where:
$T_{cyl}$ = totally cylindricity (mm)
$d_{min}$ = maximum diameter measured on the workpiece.
$d_{max}$ = minimum diameter measured on the workpiece.

The depth of feeding is defined as the depth of grunt taken by the cutting chisel, which can be calculated using the formula:

$$a = \frac{d_0 - d_m}{2} \quad (3.2)$$

Where:

a = depth of cuting (mm)

$d_0$ = initial diameter (mm)

$d_m$ = finally diameter (mm)

The maximum value of the cutting depth is affected by the condition of the lathe, the type of cutting tool used, and the machinability of the workpiece material being turned.

## III. Results and Discussion

### a) Results

The test results and calculation data in this research are displayed in table form, then a graph is made as follows:

Table 1. Calculation results of the influence of the main cutting edge angle, Kr (*30°*, *40°*, 60°, 90°) of the HSS tool on the totally cylindricity, *Tcyl* (mm) of the ST 60 workpiece:

| Main Cutting Angle, Kr(°) | Cutting Speed, Vc m/min) | Initial Diameter (mm) | Final Diameter (mm) | Totally Cylindricity, Tcyl (mm) |
|---|---|---|---|---|
| 30 | 94,2 | 50,00 | 50,05 | 0,95 |
| 45 | 94,2 | 50,75 | 50,10 | 0,65 |
| 60 | 94,2 | 50,51 | 50,06 | 0,45 |
| 90 | 94,2 | 50,20 | 50,05 | 0,15 |

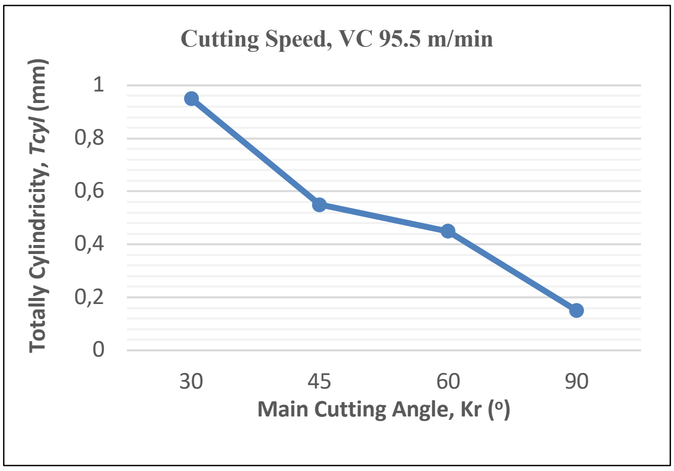


Figure 6. The effect of main cutting angle on totally cylindricity

Table 2. Results of calculation of the effect of feeding depth, a (0.5; 1. 0; 1.5; 2.0 mm) HSS tool on total silliness, *Tcyl* (mm) of ST 60 workpiece

| Feed Depth, a (mm) | Cutting Speed, Vc m/min) | Initial Diameter (mm) | Final Diameter (mm) | Totally Cylindricity, Tcyl (mm) |
|---|---|---|---|---|
| 0.5 | 94.2 | 50.25 | 50.00 | 0.25 |
| 1.0 | 94.2 | 50.45 | 50.10 | 0.35 |
| 1.5 | 94.2 | 50.85 | 50.30 | 0.55 |
| 2.0 | 94.2 | 51.05 | 50.45 | 0.60 |

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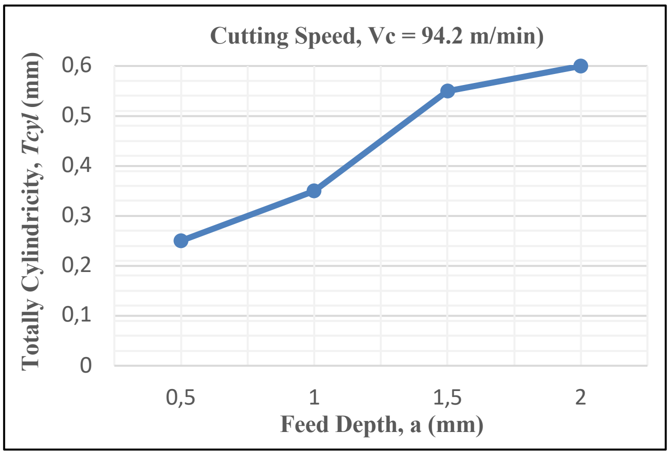


Figure 7. The effect of cutting depth on totally cylindricity

### b) Discussion

The results of the analysis show that increasing the main cutting angle of the HSS tool from 30°, 45°, 60°, to 90° progressively improves the total silindricity in the turning process of ST 60 steel. The 90° cutting angle results in better total silliness compared to smaller angles, due to its ability to cut more steadily and reduce cylindrical deviation in the workpiece [13]. An increase in the depth of cut from 0.5 mm to 2.0 mm negatively affects the total silency. A smaller cutting depth, such as 0.5 mm, results in better total silliness (0.25 mm), while a larger cutting depth, such as 2.0 mm, results in worse total silliness (0.60 mm). This is due to several factors, including:

**Cutting Force:** Greater feeding depth results in greater cutting force, which can cause vibration in the machine or cutting tool, resulting in deviations in cylindrical shapes [14].

**Material removal:** With a greater depth of feeding, more material is removed in a single pass, which can affect the stability of the cut and cause fluctuations in diameter size [15].

**Effect of Vibration:** High feeding depth tends to increase vibration in the cutting process, which can lead to unevenness in the cutting yield and improve silencing [16].

## IV. Conclusion

The results of the data calculation show that the cylindricity at the main cutting edge angle Kr (30°, 45°, 60o) each total cylindricity is not good, while at the main cutting angle Kr (90°) the totally cylindricity is very good.

Cutting depth a (0.5 mm, 1 mm, 1.5 mm, and 2.0 mm), it can be seen that the greater the cutting depth, the worse the total cylindricity. Based on these results, it can be concluded that:

The main cutting edge angle, Kr (90°) produces better total cylindricality (0.15 mm) compared to the smaller main cutting angle. This is due to the ability of the 90° main cutting angle to cut more stably, thus reducing the deviation of the cylindrical shape of the workpiece.

The cutting depth, a (0.5 mm) produces better total cylindricality (0.25 mm) when compared to the larger cutting depth. This shows that the smaller cutting depth reduces cutting force and vibration, thus producing a more precise cylindrical shape.

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## References

[1] David, J. 2018. “Analysis of The Effect of Depth of Cut and Feeding on The Roundness of Cylindrical Turning Results”. National Seminar on Technology Innovation, UN PGRI Kediri, February 24, 2018.

[2] Ibrahim and Gusri Akhyar. 2017. “Tool Wear Analysis on Magnesium Az31 Drill Machining Using Taguchi Method.” Indonesian Journal of Mechanical Engineering 12(1): 29–35.

[3] Chendri, J. 2019. “Characteristics of HSS Tool Wear on St 60 Steel Machining.” Mechanical Engineering Science (Mes) 1(1).

[4] Chaubey, S.K. 2022. “Review on Fabrication of Cylindrical and Rotating Parts by Thermoelectric-Erosion Based Turning Processes”. Metals 2022, 12, 1227. https://doi.org/10.3390/met12071227.

[5] Patiran Fransiskus. 2019. “Comparative Analysis of Surface

Roughness Results Between HSS Tools and Carbide Tools on Lathes." Voering Journal 4(1): 8–14.P.

[6] Pratama Mardica Nala. 2019. "The Effect of Feeding of Turning St 41 Material with Various Cooling Media on Surface Roughness."

[7] Prayogo Wahyu Tri. 2022. "Bushing Manufacturing Process on Cooling Spare Parts at Purnama Teknik Mandiri Lathe Workshop." Sigmat Journal of Mechanical Engineering 2(1)

[8] Prijono. 2021. "Production Process Practicum."

[9] Rochim, T. 2007. Machining Process Theory, Jakarta.

[10] Sastal Angga Zeptiawan. 2018. "The Effect of Cutting Speed on Tool Temperature Changes and Lathe Tool Wear in Medium Carbon Steel Turning Process." Enthalpy-Jurnal Ilm. Mhs. Tek. Mesin 3(1): 1–11.

[11] Sidebang. 2020. "Experimental Study of the Effect of Hot Machining Method on Aisi 4340 Lathe Machining Process on Cutting Specific Energy and Surface Roughness."

[12] Wandiro, and Joko. 2018. "Analysis of the Effect of Chisel Angle Variation and Cutting Speed, on S45c Material to Obtain Chisel Life with Cooling Media."

[13] Gutakovskis, V., Bunga, G., Pikurs, G., Brutans, V., Ratkus, A., 2012, An experimental study of the cutting forces in the metal cutting process, Tallinn, Estonia.

[14] Baldoukas, A.K., Soukatzidis, F.A., Demosthenous, G.A., Lontos, A.E., 2008. Experimental Investigation of The Effect of Cutting Depth, Tool Rake Angle and Workpieces Material Type on the Main Cutting Forces During a Turning Process. Chalkidiki. Greece.

[15] Korkut, I., and Boy, M., 2008, Experimental Examination of Main Cutting Force and Surface Roughness Depending on Cutting Parameters, Journal of Mechanical Engineering 54, hal. 531 – 328.

[16] Kosaraju, S., Anne, V.G., Ghanta, V.R., 2011. Effect of Rake Angle and Feed Rate on Cutting Forces in an Orthogonal Turning Process, ICTMIE, Bangkok

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