Mutiara: Multidiciplinary Scientifict Journal
Volume 3, Number 11 November 2025
p-ISSN 2988-7860 ; e-ISSN 2988-7992

Design Changes to the Grinding Wheel Shaft on End Mill Cutter Grinders in the Machine Shop of the Medan State Polytechnic

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KEYWORD
end mill cutter, sharpening machine, mounting shaft, grinding stone

ABSTRACT
An end mill cutter is a type of blade that is commonly used in milling machine operations. Because it dulls easily, these blades need sharpening to achieve a good geometric shape on the cutting surface. At the mechanical engineering workshop of the Medan State Polytechnic, the sharpening process uses an end mill cutter grinder machine. However, the quality of the sharpened results remains suboptimal. The goal was to improve sharpening quality by modifying the grinding wheel shaft on the end mill cutter grinder in the machine shop of the Medan State Polytechnic. The method involved a technical experiment that changed the shaft dimensions and locking system to make grinding stone rotation more symmetrical and stable. Primary data were obtained by measuring shaft symmetry with a dial indicator and conducting cutting tests on workpieces. Data analysis compared results from the old shaft and the new modified shaft. Sharpening experiments on the Ø20 mm end mill cutter yielded very good cut quality, with symmetry tests showing results of 0.055 mm, 0.04 mm, and 0.01 mm—all below the 0.05 mm tolerance standard.

INTRODUCTION

Vocational universities as educational institutions that produce a generation that are ready to work in the industry have practical equipment to hone the skills and expertise of students. Medan State Polytechnic as a vocational college has supporting equipment for learning machine work practices such as lathes (*lathe*) and machine *Milling*. The learning process of machine work practice *Milling.* This requires cutting points (*Cutter*) which are used to form the working material into the desired finished material (Grigoriev et al., 2019; Rizzo et al., 2020). The cutting tools used have a lifespan based on the time of use, the work process and the type of material being cut (Wibisono et al., 2023). As the machining process progresses, the sharp parts of the cutting tool slowly deteriorate in quality due to constant contact with the material being worked (Mohamed et al., 2022). This repeated friction leads to reduced sharpness as well as changes in the geometry of the cutting angle (Agrawal et al., 2021; Arslan et al., 2016; Liang et al., 2022). This condition ultimately has an impact on the decline in the quality of the cutting results, especially on the surface quality of the workpiece (Tian et al., 2022; G. Zheng et al., 2018). Shear angle *End Mill Cutter* which is already dull makes the surface of the workpiece rough (Tan et al., 2017; M. Zheng et al., 2020). For a cut angle that is too small to make *End Mill Cutter* not sharp but stronger, whereas the overly large shear angle makes *End Mill Cutter* sharper but more prone to wear (Mursidi, 2015; Putra et al., 2022; Wibisono et al., 2023). Sharpening *End Mill Cutter* A well-sharpened will result in a smooth shear, on the other hand, if the sharpening is less sharp, it will result in a rough shear. (Putra et al., 2022). Therefore, *End Mill Cutter* needs to be rehoned so that it is more effective in the process of machine work practice and efficient from the use of operational costs for purchase *End Mill Cutter* new (Khan et al., 2023; Okotubu, n.d.; Wilmot, 2016).

The cutting blade sharpening machine in the mechanical engineering workshop of the Medan State Polytechnic is an end *mill cutter tool grinder* machine of the HARO Robert Habib GENEVE brand which has existed since this campus was established. In the process of using grinding stone as a sharpening component, the rotation is asymmetrical, so it is unstable or vibrates in the process of sharpening the cutting surface (*flute*) *end mill* and the sharpening results are less precise than the shape and angle of the *flute cut* (Chen & Huang, 2023; Karpuschewski et al., 2021; Kharlamov et al., 2020). After the author made observations, it was found that the cause was because the grindstone support shaft was smaller than the grinding stone support hole and the locking bolt did not press the grinding stone strongly (Williams & Harding, 2018; Xiang et al., 2025). Repairs have been made to the shaft of this sharpening grinding stone stand by blocking the base shaft with *seal tape*, but the rotation of this sharpening grinding stone is still vibrating.

This research aims to determine the rotational symmetry of the modified shaft in an end mill cutter sharpening machine and to evaluate the resulting sharpening quality, specifically in terms of the cutting surface angle, the surface shape of the cutter, and the final incision result. The study is specifically confined to modifications made to the grinding stone stand at the Medan State Polytechnic's mechanical engineering workshop, focusing on changes to the shaft design, the material (using ST 41 steel), and the locking mechanism, while utilizing a 20 mm diameter High-Speed Steel (HSS) square end mill for testing. Consequently, the objectives are to ascertain the shaft's rotational symmetry and to define the quality of the sharpening performed with the modified setup. The anticipated benefits of this study are a significant improvement in the quality of end mill cutter sharpening at the workshop and the provision of a practical reference for students and technicians in the proper techniques for honing and maintaining these sharpening machines.

RESEARCH METHOD

The author employed an experimental quantitative research model in which end mill cutters were designed, turned, twisted, aligned, and sharpened. The results of the sharpening were tested for geometry and shape on the incision eye surface.

The subject of this research was the End Mill Cutter Grinder machine used in the Mechanical Engineering Workshop of the Medan State Polytechnic. This research focused on the grinding stone support shaft, which was modified to improve the machine's stability and working efficiency.

At the design stage of this research, the author addressed the research questions set out in the first chapter and used them as guidelines for the entire series of research activities. The research design included problem identification, data collection, data analysis, tool design and manufacture, test implementation, and conclusions.

The author's research roadmap for the next five years is illustrated in the following chart:

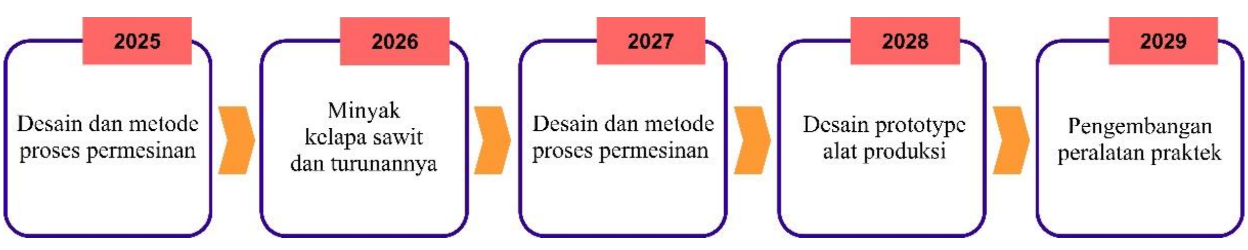


Figure 1. Research Roadmap Chart

RESULTS AND DISCUSSION

Research Results

Shaft Planning

After it was known that the problem arose from the grindstone stand shaft that was not asymmetrical in rotation, a new design of the mounting shaft was made with changes in the dimensions and locking system using M12 x 1.25 nuts.

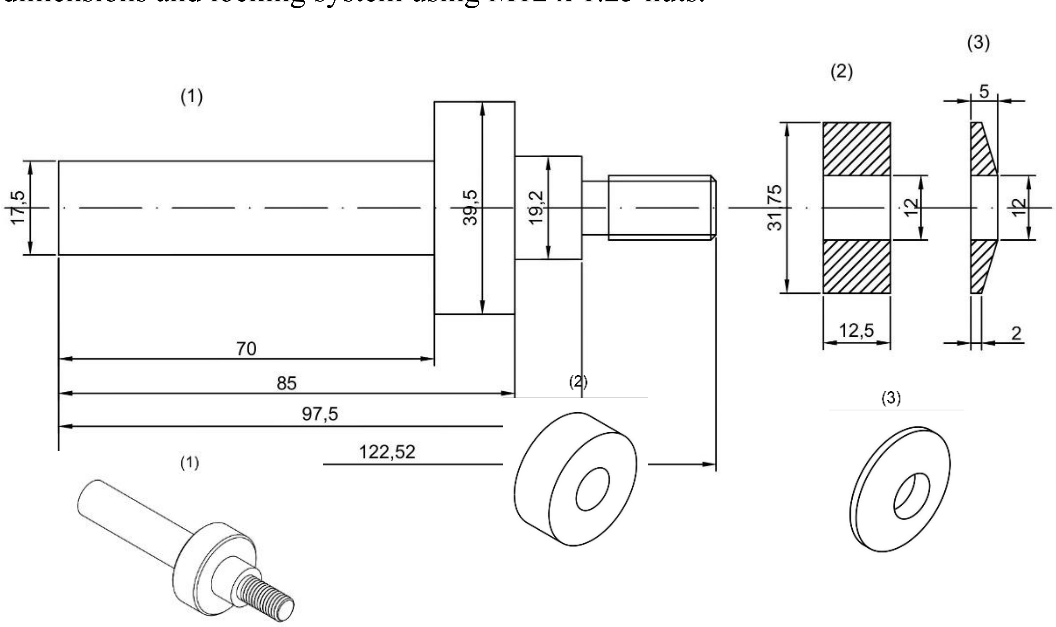


Figure 2. Shaft Design

Information:
1. Shaft mount
2. Bearing (*bushing*)
3. Locking ring

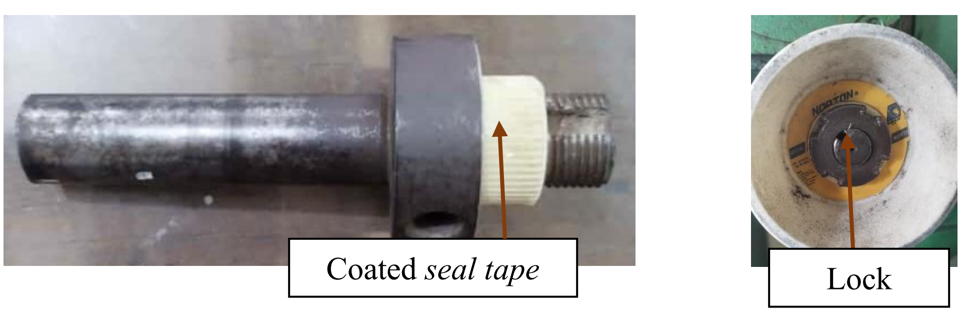
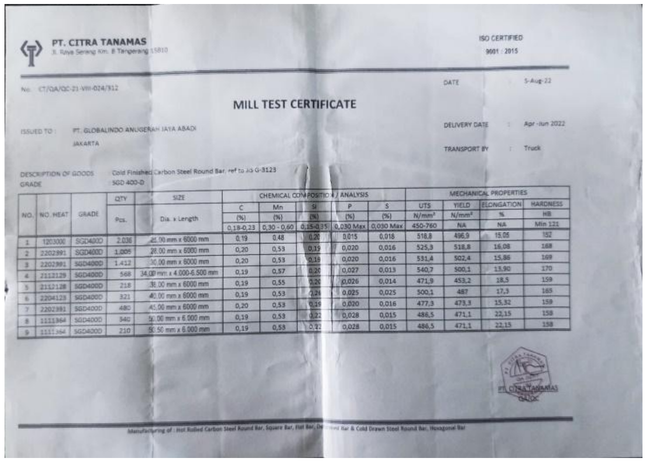


Figure 3. Old Mounting Shaft

Preparation of Tools and Materials

This shaft working tool is a lathe, caliper, M12 x 1.25 snei. The material used for the manufacture of this shaft is round US iron *Grade* SGD 400 D is the same as ST 41.



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MILL TEST CERTIFICATE

ISSUED TO : PT. GLOBALINDO ANUGERAH JAYA ABADI
JAKARTA

DELIVERY DATE : Apr -Jun 2022

TRANSPORT BY : Truck

DESCRIPTION OF GOODS Cold Finished Carbon Steel Round Bar, ref to JIS G-3123
GRADE SGD 400-D

NO.	NO. HEAT	GRADE	QTY	SIZE	CHEMICAL COMPOSITION / ANALYSIS					MECHANICAL PROPERTIES			
			Pcs.	Dia. x Length	C	Mn	Si	P	S	UTS	YIELD	ELONGATION	HARDNESS
					(%)	(%)	(%)	(%)	(%)	N/mm²	N/mm²	%	HB
					0,18-0,23	0,30 - 0,60	0,15-0,35	0,030 Max	0,030 Max	450-760	NA	NA	Min 121
1	1203000	SGD400D	2.036	25.00 mm x 6000 mm	0,19	0,48	0,20	0,015	0,018	518,8	496,9	15,05	152
2	2202991	SGD400D	1.005	28.00 mm x 6000 mm	0,20	0,53	0,19	0,020	0,016	525,3	518,8	16,08	168
3	2202991	SGD400D	1.412	30,00 mm x 6000 mm	0,20	0,53	0,19	0,020	0,016	531,4	502,4	15,86	169
4	2112129	SGD400D	568	34,00 mm x 4.000-6.500 mm	0,19	0,57	0,20	0,027	0,013	540,7	500,1	13,90	170
5	2112128	SGD400D	218	38,00 mm x 6000 mm	0,19	0,55	0,20	0,026	0,014	471,9	453,2	18,5	159
6	2204123	SGD400D	321	40.00 mm x 6000 mm	0,19	0,53	0,26	0,025	0,025	500,1	487	17,3	165
7	2202391	SGD400D	480	45,00 mm x 6000 mm	0,20	0,53	0,19	0,020	0,016	477,3	473,3	15,32	159
8	1111364	SGD400D	340	50,00 mm x 6.000 mm	0,19	0,53	0,22	0,028	0,015	486,5	471,1	22,15	158
9	1111364	SGD400D	210	50.50 mm x 6.000 mm	0,19	0,53	0,22	0,028	0,015	486,5	471,1	22,15	158

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QA/QC

Manufacturing of : Hot Rolled Carbon Steel Round Bar, Square Bar, Flat Bar, De[illegible] Bar & Cold Drawn Steel Round Bar, Hexagonal Bar

Figure 4. Mill Test Cerificate

Mounting Shaft Manufacturing

The round US iron ST 41 is cut to size and then turned to shape and threaded at the end of the shaft using a snei. Bearings (*Bushing*) and locking rings are also made using lathes.

Figure 5. Axis Rotation

Figure 6. Modified Shaft Shape

Sharpening End Mill Cutter

The shaft that has been made is tested against *End Mill Cutter* Φ 20 mm with four sides of a cut eye that is already blunt or damaged.

The procedure for sharpening *the end mill cutter* is as follows:

1. Flatten the surface of the *end mill cutter* using cut grinding stones if the cutting blade surface has been damaged. If the surface of the cut eye is just blunt, then it does not need to be flattened and can enter step number 2.

Figure 7. Broken End Mill Cutter

Figure 8. Leveling the Surface of the End Mill Cutter

2. Sharpening the surface of the cutting eye end mill cutter.

The steps are as follows:

a. Install the *flaring cup grinding wheel* on the modified shaft and then attach it to the sharpening machine.
b. Set the table slope of the anvil *end mill grinding attachment* with an angle of 2o.

Figure 9. Angle 2o Grinding Attachment

c. Set the height of the grinding stone with *the end mill cutter* with a distance of 1 cm below the center point of the grinding stone.

Figure 10. Height of the Grinding Stone

d. Set the slope *of the end mill grinding attachment* with an angle of 15^o to create a *secondary angle free angle*.

Figure 11. Angle 15º *Grinding Attachment*

e. Perform feeding movements by moving the X-axis table to the right and left. For the depth of feeding the table movement towards the Y axis as many as 5 lines from the *hand wheel scale* of 0.02.

Figure 12. Depth of Feeding

f. Perform this feeding movement to the four sides of the cut by dividing the end *mill grinding attachment dividing head plate into four parts*.
g. Set the tilt *of the end mill grinding attachment* large angle 5º to make the primary angle *free angle*.

Figure 13. Angle 5º *Grinding Attachment*

h. Set the slope *of the end mill grinding attachment* at an angle of 10^{o} to create the groove angle of *the end mill cutter*. Perform forward motion feeding on the Y-axis to the desired depth.

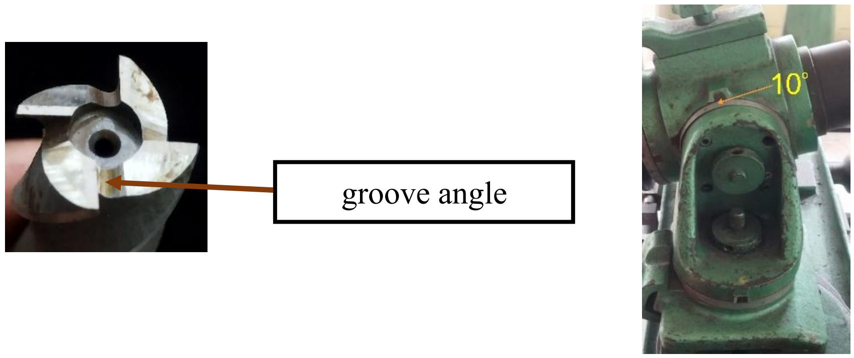


Figure 14. Groove Angle

i. After finishing the validation, check the results of the validation by placing the *cutter* perpendicular to the leveling table. If the result is good, then there is no protrusion in the middle *of the cutter*.

Figure 15. Verification of Validation Results

Consumption End Mill Cutter

The next step is the feeding test of *the end mill cutter* against the workpiece. It is carried out in an Aciera brand fresh engine type F4 with an engine rotation speed of 360 rpm, a feeding depth of 0.1 mm. Feeding was carried out on the ST 37 workpiece in the form of a block measuring 25x25x100 mm.

Figure 16. Nutrition Test

Discussion

The modified grindstone base shaft was tested for symmetry and also feeding results using *End Mill Cutter* which is honed with grinding stones mounted on the modified shaft.

Symmetric Test

Shaft symmetry testing is carried out by measuring the bending of the shaft using *dial indicator* with a precision of 0.01 mm.

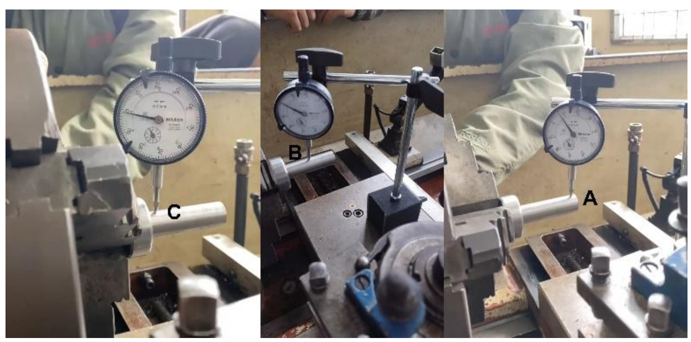


Figure 17. Measuring Shaft Bending

The steps are as follows:

1. Clean the lathe and shaft to be measured
2. Install the shaft on the lathe grip
3. Set the shaft rotation sintering
4. Install the indicator dial in the *top drag* post tool
5. Touch the needle of the dial on the surface of the shaft
6. Press until the short needle shows the number 1
7. Set the long needle until it shows the number 0 and then tighten the lock.
8. Mark a dot or strip for the first position (position A)
9. Gently turn the lathe grip by hand
10. Record the measurement of the farthest deviation of the right-hand hand and the farthest deviation of the left-hand hand on the *indicator dial*.

11. Repeat the same measurement method for the second position (position B) and the third position (position C).

The numbers obtained are processed with the formula:

$$\frac{Jka+Jki}{2}$$

Information:
Jka = Right-hand hand
Jki = Left-hand needle

Table 1. Symmetric Test Results

No	Shaft Name	Point A	Point B	Point C
1	Modified Shaft	0.055 mm	0.04 mm	0.01 mm
2	Old Shaft	0.075 mm	0.10 mm	0.045 mm

From the data table above, it can be concluded that the modified shaft has a much better symmetry value than the old shaft where it still carries the permitted standards. The symmetry tolerance of the shaft is generally 0.05 mm (Mursidi, 2015).

Nutrition Results Test

The end mill cutter that has been honed when compared between the sharpening of the modified shaft with the sharpening of the old shaft can be seen from the picture below.

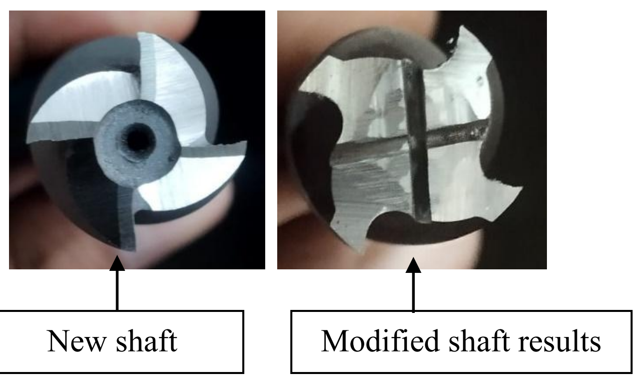
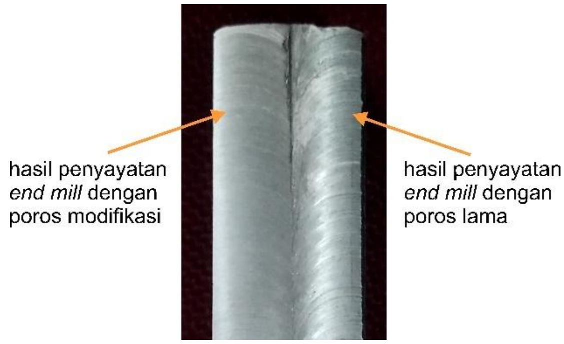


Figure 18. Comparison of Modified Honing Results

The feeding results on the ST 37 workpiece using modified shafts and old shafts, the depth of feeding can be seen in the following table:

Table 2. Comparison of Shearing Results

No	Diameter *End Mill*	Lap Spindle	Shearing Results

1	Ø 20 mm	360 rpm	

Based on the table above, it can be concluded that the results of cutting with *an end mill cutter* feeding depth of 0.1 mm, the results of the modified shaft are much smoother in the roughness level than the results of the old shaft.

Next Stage Plan

To follow up on the research on the modification of the grinding stone stand shaft of *the end mill cutter*, the author plans the next stage, namely:

1. Recommend to the Head of the Workshop to use the mount shaft resulting from this modification on the *end mill cutter sharpening machine* at the Mechanical Engineering Workshop.
2. Making Standard Operating Procedures (SOP) for the sharpening of end mill cutters on the HARO Robert Habib GENEVE brand sharpening machine.

CONCLUSION

Based on the experimental findings, it can be concluded that the design modification of the grinding wheel shaft on the end mill cutter grinder was successful. The newly designed shaft, which incorporated changes in dimensions, material (ST 41 steel), and a more robust M12 x 1.25 locking mechanism, demonstrated significantly improved rotational symmetry. Measurements from the symmetry test showed values of 0.055 mm, 0.04 mm, and 0.01 mm at three different points, all of which were within the acceptable tolerance standard of 0.05 mm. Furthermore, the practical sharpening test on a Ø 20 mm end mill cutter and subsequent cutting on an ST 37 workpiece confirmed a substantial enhancement in output quality. The sharpened cutter produced a much smoother surface finish on the workpiece compared to results obtained with the old shaft, validating that the modification effectively increased the stability of the grinding wheel and the precision of the sharpening process. For future research, it is recommended to extend the investigation to evaluate the long-term durability and wear resistance of the modified shaft under continuous operational loads. Subsequent studies could also explore the impact of similar design modifications on different models of sharpening machines or for sharpening cutters of various sizes and materials. Furthermore, developing a comprehensive Standard Operating Procedure (SOP) for the sharpening process, as planned by the author, should be formally documented and its effect on the consistency of sharpening results across different operators should be quantitatively assessed. This would help in standardizing best practices and further optimizing the maintenance and operation of workshop equipment.

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