Training on Tool Grinding for Teachers, SMK Muhammadiyah, 1 Klaten Utara, Central Java

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\textbf{Abstract.} The formation of metal products in machining processes is carried out with the help of cutting tools. The principle of metal cutting is essentially rubbing and pressing, so in long-term use, the cutting tools will experience wear and require reconditioning. Tool reconditioning through sharpening is done by gently rubbing it against a grinding wheel, where the abrasive material on the wheel will cut or erode the tool. Sharpening can be done by machine or manually. The sharpness and geometry of cutting tools greatly determine the quality of metal manufacturing products. From the observations of partners, the skill of manually sharpening cutting tools is not yet possessed by the teachers or students of Muhammadiyah 1 Klaten Utara Vocational School. This community service activity is carried out by providing knowledge about cutting tools and manual sharpening skills. The target output is an improvement in the sharpening technique competency, especially for the teachers of Muhammadiyah 1 Klaten Utara Vocational School, and it is expected to be taught to their students.

\textbf{Keywords:} grinding tool, manual machine, vocational school

\section{1 Introduction}

SMK Muhammadiyah 1 Klaten Utara is under the auspices of the Ministry of Education and Culture and is located at Jl. Ki Ageng Pengging 40, Gergunung, Kec. Klaten Utara, Kab. Klaten, Central Java, with postal code 57434. SMK Muhammadiyah 1 Klaten Utara offers five vocational programs: Machining Engineering, Computer Network Engineering, Electrical Installation Engineering, Construction and Property Business, and Software Engineering. Specifically, teachers from the Machining Engineering field are the target participants of the service activities. This vocational program has achieved several important achievements, namely 1st place in the Welding Skills Competition and 1st place in the CNC Machining Skills Competition at the district level. In the machining process, SMK Muhammadiyah 1 Klaten Utara currently uses conventional lathe machines, milling machines, and drilling machines for student practice. In addition, students are also equipped with machining skills using CNC technology. All types of machines require sharp cutting tools to effectively remove material from the workpiece. Cutting tools are used to remove material from the workpiece through shear deformation \cite{1}. The material used for cutting tools in the machining process is a key factor that can affect the machining process itself.

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During the machining process, cutting tools experience temperature rise and stress due to friction with the workpiece. Prolonged use will result in wear. Reconditioning to restore the sharpness and geometric angles of the cutting tool can be done through the sharpening process using grinding machines, both manually and with the help of tools.

From observations and information gathered by the PKM Team, it was found that knowledge and skills in sharpening cutting tools have not been optimally provided to the students at SMK Muhammadiyah 1 Klaten Utara. The PKM Team focused on observing the cutting tools used in the lathe machining process and drill bits for hole-making. The types of lathe tools and drill bits used are made of HSS (High-Speed Steel) material (Darmawan et al., 2016). Worn-out HSS tools and drill bits need to be sharpened according to their needs before machining. The sharpening process of tools and drill bits by teachers and students is usually done manually by holding the tool and rubbing it against a sharpening stone. During sharpening, students and teachers only assess sharpness visually and do not pay attention to the important geometric angles of the cutting tool. Incorrect tool geometry will increase vibration during cutting, accelerate tool wear, and result in rough surface finish (Duc et al., 2020) (Sonia et al., 2013). HSS cutting tool angles are formed by sharpening them with a tool grinder machine, and the angle measurements need to be ensured using measuring tools (Setyawan, 2011) (Sugeng, 2017). This sharpening process will shape the tool geometry used in the machining process. Maintaining the geometry of HSS cutting tools in accordance with the characteristics of the workpiece in use essentially maximizes their lifespan (Singh & Venkateswara Rao, 2007).

A drilling machine is used for creating round holes using twist drill bits. To achieve good cutting performance, correct geometric angles are required, such as helix angle, clearance angle, and point angle or lip angle (Armarego, 1994). The peak angle geometry of the drill bits depends on the uniformity of the cutting edges and the angle formed at the tip of the drill bit, which corresponds to the drill bit angles. The peak angle of the drill bit also determines the cutting edge's sharpness and compatibility with the material being drilled (Demir, 2018; Heisel & Pfeifroth, 2012). The drill bit sharpening performed at SMK Muhammadiyah 1 Klaten Utara does not consider and measure its geometric angles, resulting in higher drill bit wear and frequent breakage.

Considering the aforementioned issues, the PKM Team sees the importance of training on drill bit and lathe tool sharpening for teachers at SMK Muhammadiyah 1 Klaten, especially, and students in general. Therefore, the theme of manual tool sharpening training is proposed as a community service activity. The training organized by the PKM Team will enhance their competence, particularly in the field of Tool Grinding.

2 Implementation Method

The training will be conducted for a duration of 40 hours, consisting of 50% theory and 50% practical sessions. The participants are expected to master the skills of manually sharpening lathe tools and drill bits using the Tools Grinder correctly. Table 1 below outlines the stages of the activity's implementation.

The training materials are as follows:
1. Tool Grinder: Working principles; Machine components and their functions; Safety considerations during sharpening
2. Cutting Tool Angles: Lathe tool angles; Drill bit angles
3. Practical Sharpening Operations: Preparation: machine inspection and setup; Sharpening techniques; Measurement of sharpened tools
4. Individual Practice Assignments: Sharpening lathe tools; Sharpening drill bits
3 Results and Discussion

Before the training implementation, the PKM Team conducted an initial visit to SMK Muhammadiyah 1 Klaten Utara on January 24, 2023. The team gathered information about the relevance of the proposed theme to the needs of the target partners through discussions with several teachers. It was revealed that the sharpening of drill bits did not adhere to standard geometry, and the measurement of sharpening results was not performed. As a result, the quality of drilling outcomes was low, and the drill bit's lifespan was shorter than it should have been. Figures 1 and 2 illustrate the observation and discussion activities conducted with the teachers of SMK to identify the existing issues.

![Figure 1. Observation activity with SMK teachers](image-url)
Based on the identified issues through previous observation and discussion, the PKM Team provided a solution to the partners in the form of tool grinding training for the teachers of the machining field at SMK Muhammadiyah 1 Klaten Utara. The tool grinding training was conducted for six days, from February 19, 2023, to February 25, 2023, at the Workshop of the Machining Department, SMK Muhammadiyah 1 Klaten Utara. 10 teachers from the mechanical engineering program and 2 tool room officers attended the training. The training was conducted for a duration of 30 hours, with a composition of 30% theory and 70% practical sessions.

The participants were provided with theoretical knowledge about cutting tools, drill bits, and sharpening techniques. They were trained in the skill of manual tool sharpening using the Tool Grinder properly.

Figure 3 depicts Tugiran S. Ag., M.Pdi, the Principal of SMK Muhammadiyah 1 Klaten Utara, officially inaugurating the training program. In his opening speech, the Principal expressed gratitude and appreciation to the PKM Team from PPM UMY for trusting SMK Muhammadiyah 1 Klaten Utara as a partner and providing additional knowledge and skills to the teachers. Improving the teachers' competencies will have a positive impact on enhancing the quality of learning for the students.
In the next session, training participants will work on a pretest consisting of two parts: multiple-choice questions and an essay question about twist drill terminology. The purpose of this pretest is to assess the participants’ initial knowledge related to the upcoming material (Adri, 2020). By understanding their initial capabilities, the PMK team can determine the appropriate models and methods to be applied during the training.

Following the pretest, theoretical knowledge about cutting tools and drill bits, particularly focusing on important cutting angles and sharpening techniques, will be provided in the first two days. A summary of the theory of tool grinding is explained below.

1. Grinding Wheels: In principle, a grinding wheel consists of three components: abrasive, binder, and air pores. The abrasive material must meet requirements regarding hardness, sharpness, heat resistance, and chemical stability. There are four main groups of synthetic abrasive materials that meet these requirements:
   - Aluminum oxide, code A (SG)
   - Silicon carbide, code C
   - Cubic boron nitride, code B
   - Diamond, code SD Each type of abrasive has different application areas depending on the characteristics of the material being ground. Aluminum oxide is the most commonly used abrasive for grinding steel and is available in several variants. Silicon carbide is primarily used for grinding cast iron and austenitic stainless steel, although it can also be used for hardened tool steel. Cubic boron nitride (CBN), produced in a similar manner to synthetic diamond, is mainly used for sharpening high-speed steel and hardened carbide tool steel. The downside of CBN is its expensive cost, nearly twice that of synthetic diamond (Talab & Marza, 2017).

2. Cutting Tool Materials: The alloy composition of tool steel significantly affects its ease of sharpening (Hosseini & Kishawy, 2014). The higher the wear resistance of a steel, the more difficult it is to grind. The base hardness and the size, hardness, and quantity of carbides in the steel determine wear resistance and grindability. Improper grinding of hardened tool steel can result in high temperatures at the surface, exceeding the material's
tempering temperature. This leads to a decrease in surface hardness. If the temperature continues to rise, the material will reach its re-hardening temperature, causing re-hardening. This condition results in a mixture of non-tempered and tempered martensite in the surface layer, along with remaining austenite. Very high stresses occur in the material, often resulting in crack formation.

Steel with a relatively high carbon content (0.7%–1.4% C) without significant amounts of other elements (low percentages of 2% Mn, W, Cr) can achieve a sufficiently high surface hardness. Through heat treatment processes, this high hardness (500–1000 HV) can be achieved due to martensitic transformation. However, since martensite softens at temperatures around 250°C, this carbon steel can only be used at low cutting speeds. This type of tool can only be used for cutting purposes.

High-Speed Steel (HSS) can be categorized based on composition:

- Conventional HSS: Molybdenum HSS, Tungsten HSS
- Special HSS: Cobalt Added HSS, High Vanadium HSS, High Hardness Co HSS, Cast HSS, Powdered HSS, Coated HSS

Carbide is a tool material made by sintering carbide powder (nitride or oxide) with a binder material, typically Cobalt (Co). The base materials (powders) of Tungsten (Wolfram, W), Titanium (Ti), and Tantalum (Ta) are made into carbide by carburizing, followed by grinding (in a ball mill) and sieving.

3. Drill Bits: The twist drill is a cutting tool used to create holes in metal, wood, plastic, and other materials. It is typically made of high-speed steel and has a conical-shaped tip with cutting edges formed in a spiral shape. Two helical flutes along the body of it form the cutting edges and a pathway for the chips to exit. The cutting edges of the drill bit function to scrape and lift the cut material while the tool is rotated. Twist drills are commonly used on drilling machines, but they can also be used manually. The size of a twist drill varies depending on the desired hole diameter. Figures 4 and 5 illustrate the different parts of a drill bit.
4. Drill Bit Sharpening

Drill bit sharpening is primarily done to form the drill point, typically at 118 degrees, and to create lip clearance ranging from 8 to 12 degrees. Excessive lip clearance reduces cutting strength, while too little clearance increases drilling pressure (Zhang et al., 2015). The chisel edge is the least efficient surface of the twist drill, as it does not engage in cutting but rather presses or pushes the workpiece. To enhance cutting efficiency in this area, the width of the chisel edge is often reduced. Improper drill bit sharpening, such as uneven cutting edges and asymmetric angles, results in poor hole quality.

The types of grinding stones used for drill bit sharpening are as follows:

1. Silicon carbide grinding stone with 80 grit for coarse grinding of carbide materials
2. Silicon carbide grinding stone with 100 grit for finishing grinding of carbide materials

The following are the effects of sharpening on drill bits and drilling results:

3. Excessive clearance reduces the support behind the cutting edge. The cutting edge will become dull quickly, and its lifespan will be shorter. The normal clearance angle behind the cutting edge is between 8 and 12 degrees.

4. Insufficient clearance causes the surface behind the cutting edge to rub against the workpiece. This makes the drilling process more difficult, generates heat, and increases the axial load on the drill bit. It results in poor hole quality and the risk of drill bit breakage.

5. Unequal angles of the cutting edges cause one side of the cutting edge to work more than the other. This leads to torsional stress, asymmetric holes, accelerated wear, and shorter tool life.

6. Unequal lengths of the cutting edges cause the chisel point to shift its axis, resulting in oversized holes with approximately twice the eccentricity.

Figure 5. Lip clearance (Union Butterfield, 2018)

Figure 6. Unequal cutting edge angles (Union Butterfield, 2018)
Figure. 7. Unequal cutting edge lengths (Union Butterfield, 2018)

Indications that a drill bit needs to be sharpened:
• The color and shape of the chips change from normal
• Drilling pressure increases
• Chips turn blue due to excessive heat
• The end of the hole is not round
• Rough surface finish of the drilled hole
• The drill chatters when it contacts metal
• The drill bit becomes loose and gets stuck in the hole
• Presence of sharp edges (burrs) around the hole

Causes of early wear:
• The drill bit's rotational speed is too high and not suitable for the material being cut
• Excessive feed rate, causing overload on the cutting edge
• Insufficient feed rate causes the cutting edge to scrape instead of cutting
• Hard spots on the surface of the workpiece
• Improper clamping of the workpiece or drill bit, resulting in vibrations during cutting
• Improperly formed drill point not suitable for the material being drilled
• Poor finish on the cutting edge

The UMY PKM Team provides a demonstration of proper sharpening techniques. Training on sharpening drill bits and lathe cutting tools is conducted practically by demonstrating the correct sharpening methods and allowing participants to try sharpening themselves. Additionally, participants need to be provided with an understanding of different types of drill bits and lathe cutting tools, as well as how to select and maintain these cutting tools to keep them sharp and durable. Figure 8 illustrates the practical sharpening activity.

Figure. 8. The practical sharpening activity
The participants are also trained to assess the sharpening results. Evaluating the quality of the drill bit's sharpening can be done manually using angle measuring tools and visual observation. Figure 9 displays the process of evaluating the sharpening results.

Figure 9: Evaluating the quality

4 Conclusions and Recommendation

The participants have been trained in manual tool sharpening and evaluating the results. Sharpening cutting tools manually is a skill that needs to be trained and applied in daily practice. This training activity can serve as a solution to meet the needs for improving technical competence in tool sharpening, particularly for the teachers at SMK Muhammadiyah 1 Klaten Utara. Participants are encouraged to understand the theory of tool sharpening and then apply their skills to manual tool sharpening using bench grinders.

Through this training activity on tool sharpening for the teachers at SMK Muhammadiyah 1 Klaten Utara, it is expected to improve the quality of education and the students' competencies in the field of metal manufacturing, as well as enhance the competitiveness of the manufacturing industry in Indonesia.

References


