

Development of a Double-Cutting Blade Sharpening Jig to Reduce Setup Time at PT XYZ

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Abstract

- Background** : The sharpening process of double-cutting blades plays a critical role in maintaining production efficiency in manufacturing industries. However, the existing sharpening jig requires complex setup procedures involving dial indicator adjustments, resulting in prolonged setup and machining times that limit productivity and make it difficult to achieve production targets.
- Purpose** : This study aims to develop and modify a double-cutting blade sharpening jig to simplify the setup process, reduce sharpening time, and improve productivity in the blade maintenance process at PT XYZ.
- Methodology** : The sharpening jig was designed using SolidWorks software to develop a three-dimensional (3D) model that facilitated an efficient and accurate design process. The jig was then fabricated through machining operations, including surface grinding and milling. The effectiveness of the modified jig was evaluated by comparing the sharpening performance before and after the improvement based on the total processing time required to sharpen ten double-cutting blades..
- Findings** : The modified sharpening jig simplified the operating procedure by eliminating the need for dial indicator adjustment and repeated setup operations. Performance evaluation showed that the original jig required **6 h 49 min 58 s** to sharpen **10 double-cutting blades**, whereas the improved jig completed the same task in **4 h 32 min 32 s**, corresponding to a processing time reduction of approximately **33.5%**. In addition, the average sharpening time was reduced to **27 min 15 s per blade**, demonstrating a significant improvement in operational efficiency and productivity.
- Implications** : The proposed jig provides a practical solution for reducing setup complexity and machining time while improving production efficiency. The simplified design can support lean manufacturing initiatives by minimizing non-value-added setup activities, increasing equipment utilization, and reducing operational costs associated with blade maintenance.
- Originality** : This study introduces an improved double-cutting blade sharpening jig that eliminates dial indicator adjustments through a simplified fixture design. The proposed modification not only reduces setup time but also enhances machining efficiency, offering a practical and cost-effective solution for improving blade sharpening operations in manufacturing environments..

Keywords : Jig, knife double cutting, improvement, modifikasi, produktivitas

INTRODUCTION

The manufacturing industry has experienced rapid technological development, encouraging companies to continuously improve productivity, product quality, and operational efficiency to remain competitive. One of the key strategies to achieve these objectives is the implementation of manufacturing support devices, such as jigs and fixtures, which are designed to simplify machining processes, improve dimensional accuracy, reduce setup time, and increase production consistency. The use of appropriate jigs not only shortens processing time but also minimizes operator error and enhances overall manufacturing efficiency.

Production cost is one of the primary considerations in manufacturing because it directly influences product competitiveness. Production costs include all direct and indirect expenses associated with transforming raw materials into finished products (Restu Anugerah Harefa et al., 2022). Therefore, manufacturing companies continuously seek improvements through process optimization, automation, and tooling innovation to increase productivity while reducing production costs. Effective production can only be achieved when manufacturing resources, including machines, tooling, and human resources, are properly managed (Julianti & Nur Lestari, 2021).

PT XYZ is a manufacturing company operating in the packaging industry that utilizes double-cutting blades as the primary cutting tools for plastic materials. During continuous production, these blades gradually lose their sharpness due to wear, resulting in poor cutting quality such as burr formation on plastic products. Burrs not only reduce product quality but also require additional finishing operations, thereby increasing production time and operational costs. Consequently, the double-cutting blades must be sharpened periodically to maintain cutting performance and production efficiency.

The existing sharpening process employs a conventional sharpening jig that requires several setup procedures, including dial indicator adjustment and repeated alignment before grinding. These setup activities consume a significant amount of time and limit the number of blades that can be sharpened within the available maintenance schedule. Based on production requirements, the sharpening process is allocated a maximum of 5 hours to complete 10 double-cutting blades. However, actual production records indicate that the average sharpening time reaches approximately 41 minutes per blade, allowing only 1–7 blades to be completed within the allocated time, whereas the production department typically requests 8–10 blades through work orders. This discrepancy causes maintenance delays and may negatively affect production continuity.

To address this problem, an improvement to the sharpening jig is required to simplify the setup procedure and reduce the sharpening cycle time. By eliminating unnecessary adjustment steps and improving the fixture design, the sharpening process is expected to become faster, simpler, and more consistent without compromising sharpening quality.

Previous studies have reported the application of jigs and fixtures to improve machining accuracy and manufacturing efficiency. However, limited attention has been given to the development of sharpening jigs specifically designed for double-cutting blades, particularly those aimed at reducing setup time by eliminating dial indicator adjustment while maintaining sharpening precision. Therefore, a more efficient jig design is needed to support higher productivity in blade maintenance operations.

The novelty of this study lies in the development of an improved double-cutting blade sharpening jig that simplifies the setup procedure by eliminating dial indicator adjustment and reducing repeated alignment operations. The proposed jig was designed using SolidWorks and manufactured through conventional machining processes, enabling a significant reduction in sharpening time while improving operational efficiency. The effectiveness of the proposed design is quantitatively evaluated by comparing the sharpening performance before and after the jig modification, providing practical evidence for setup time reduction in manufacturing environments.

Therefore, this study aims to design, manufacture, and evaluate an improved sharpening jig for double-cutting blades to reduce setup time and improve productivity in blade maintenance operations at PT XYZ. The findings are expected to provide a practical and cost-effective solution for enhancing maintenance efficiency while supporting continuous improvement initiatives in manufacturing industries.

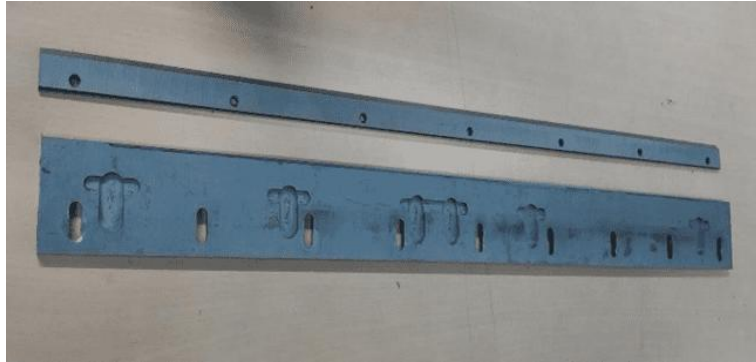


Figure 1. Knife double

METHODOLOGY

Process Theory

In manufacturing, a process is defined as a series of systematic activities carried out to transform raw materials or components into products with added value that meet predetermined specifications. Each process consists of several interconnected stages, including preparation, execution, inspection, and evaluation, to ensure that the final product satisfies quality, time, and cost requirements. Therefore, the effectiveness of a manufacturing process is influenced by the working method, equipment, and the operator's capability in performing each stage of the operation.

1. Process Concept

A process is a sequence of interrelated activities performed systematically to achieve a specific objective through the effective and efficient utilization of available resources. In this study, the process refers to the sharpening operation of double-cutting blades, which includes tool preparation, blade positioning on the jig, setup and alignment, grinding, inspection of the sharpening results, and blade removal from the jig. Each stage contributes to the overall processing time and directly affects the productivity of the sharpening operation.

2. Process Theory

From a theoretical perspective, a manufacturing process is considered a system composed of several interdependent elements, including human resources, machines, materials, methods, and tooling, all of which work together to produce products that satisfy the required specifications. In the double-cutting blade sharpening process, the jig plays a crucial role in maintaining the correct blade position throughout the grinding operation. An inefficient jig design increases setup time because operators must repeatedly perform alignment and measurement using a dial indicator. Conversely, a well-designed jig minimizes non-value-added activities, thereby reducing setup time, improving process consistency, and enhancing overall productivity.

3. Process Practice

The practical application of process theory in this study is demonstrated through the design and fabrication of an improved sharpening jig for double-cutting blades. The jig was designed using SolidWorks software and manufactured through machining operations, including milling and surface grinding. After fabrication, the jig was experimentally evaluated by comparing the sharpening process

before and after the modification. The evaluation focused on processing time and operational efficiency to determine the effectiveness of the proposed jig in reducing setup time and improving productivity. Therefore, the implementation of process theory in this study emphasizes process improvement through tooling redesign to achieve a more efficient and reliable blade sharpening operation.

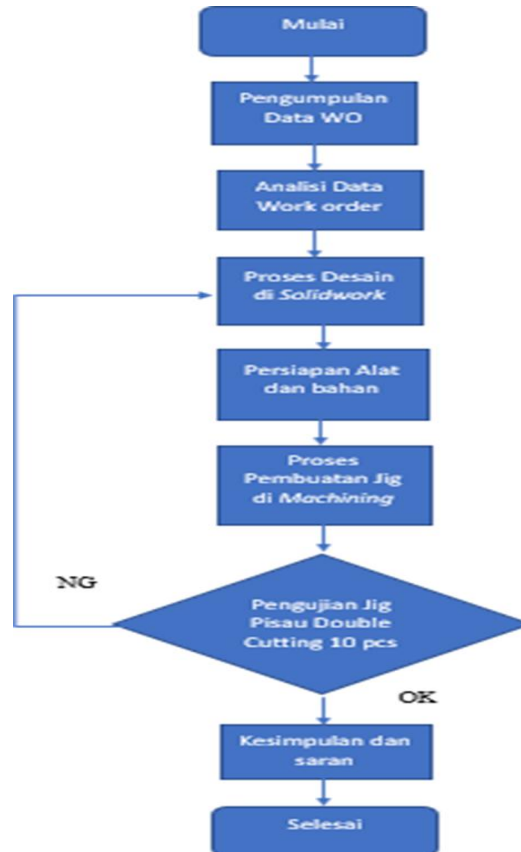


Figure 2. Research Framework

The explanation of the research flowchart is presented as follows:

1. Start

The research begins with the preparation of all activities required to conduct the study.

2. Work Order (WO) Data Collection

Production work order (WO) data submitted to the engineering department are collected to obtain information regarding the existing double-cutting blade sharpening process.

3. Work Order Data Analysis

The collected work order data are analyzed to identify problems associated with the current sharpening process, particularly those related to setup time and productivity.

4. Jig Design

An improved sharpening jig is designed using SolidWorks software to develop a three-dimensional (3D) model that meets the required operational specifications.

5. Preparation of Tools and Materials

All tools, materials, and machining equipment required for jig fabrication are prepared before the manufacturing process begins.

6. Jig Fabrication

The sharpening jig is manufactured through machining processes, including milling and surface grinding, according to the completed design.

7. Jig Performance Testing

The fabricated jig is tested by positioning the double-cutting blade on the jig and performing the sharpening process to evaluate its functionality and operational performance. The processing time and sharpening results are compared with those of the existing jig. If the expected performance or processing time is not achieved, the jig design is revised and improved before being retested.

8. Conclusion and Recommendations

The experimental results are analyzed to draw conclusions that address the research objectives. Recommendations are also provided for future improvements and further research related to the developed sharpening jig.

9. End

The research is completed after all objectives have been achieved and the results have been documented.

Table 1. Data of Peminaaman pisau double

Peminjaman Pisau <i>Double Cutting</i>	
Uji Coba	Waktu
1	00:41:17
2	00:48:14
3	00:39:08
4	00:40:15
5	00:43:07
6	00:38:21
7	00:42:34
8	00:39:25
9	00:40:29
10	00:37:08
Total	6:49:58
Avarage	00:41:00



Figure 3. Testing diagram

Based on the experimental results, the average sharpening time required for one double-cutting blade was 41 min 00 s. Consequently, within a 2-hour maintenance period, only three double-cutting blades could be sharpened. This indicates that the existing sharpening process is relatively inefficient and unable to meet the production demand within the allocated maintenance time, highlighting the need for an improved sharpening jig to reduce setup and processing time.

K-Nearest Neighbor (KNN) Implementation. The K-Nearest Neighbor (KNN) algorithm was employed to classify the feasibility of firefighting equipment based on historical inventory data. Equipment feasibility was evaluated using four assessment criteria: service life, functional performance, overall physical condition, and safety, as presented in Table 1. Each criterion was represented by categorical attributes that were converted into numerical values during the preprocessing stage to facilitate distance calculation.

For the service life criterion, equipment was categorized into three groups according to the duration of use, namely 1–30 months (Very Good), 31–60 months (Good), and 61–90 months (Poor). The remaining criteria—functional performance, physical condition, and safety—were assigned numerical weights based on their qualitative assessment levels, as summarized in Tables 2–5. These numerical representations enabled the calculation of similarity between training and testing instances. The KNN model requires the determination of the parameter K, which specifies the number of nearest neighbors considered during the classification process. In this study, the value of K = 5 was selected empirically to achieve a balance between classification stability and sensitivity to noise. A relatively small value of K may produce unstable predictions due to outliers, whereas a larger value may reduce classification accuracy by incorporating observations from different classes. Therefore, K = 5 was considered appropriate for the characteristics of the dataset used in this study.

The similarity between testing data and training data was calculated using the Euclidean Distance metric, as expressed in Equation (2). After calculating the distances, the five nearest neighbors were identified, and the equipment feasibility was determined using a majority voting mechanism. The final classification categorized each equipment item as either feasible for continued use or requiring replacement, providing decision support for inventory management within the XYZ City Fire and Disaster Management Department.

Table 2. Data work order produksi

Data Work Order Produksi	
Tanggal	permintaan Penajaman
03/03/2024	8 pcs
05/03/2024	7 pcs
07/03/2024	8 pcs
08/03/2024	7 pcs
Jumlah	30 pcs pisau

RESULT AND DISCUSSION

The sharpening jig was designed using SolidWorks to develop a three-dimensional (3D) model prior to fabrication. The primary objective of the design process was to produce an accurate and functional jig for sharpening double-cutting blades. The design procedure involved modeling each component of the jig to ensure proper assembly and operational performance.

The developed jig serves as a fixture to securely hold the double-cutting blade during the sharpening process. Unlike the previous design, the proposed jig features a non-adjustable (non-setting) configuration, eliminating the need for repeated alignment and dial indicator adjustments before sharpening. This simplified design reduces setup time, facilitates easier operation, and improves the efficiency of the blade sharpening process. Figure X illustrates the design of the proposed double-cutting blade sharpening jig.

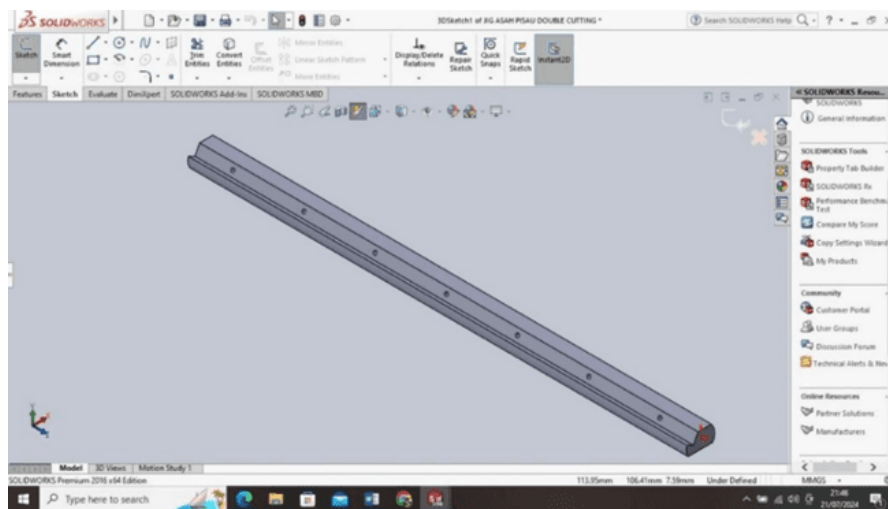


Figure 4. jig double knife

A. Material and Tool Preparation

The primary material used to fabricate the sharpening jig was **solid steel bar** with a diameter of **40 mm**. This material was selected because it is readily available, easy to machine, and suitable for manufacturing the proposed jig efficiently. The dimensions of the raw material were **700 mm × 40 mm × 25 mm**.

The fabrication of the double-cutting blade sharpening jig required the following tools and equipment:

- Vernier caliper

- Measuring tape
- Protractor
- 4 mm twist drill
- M5 tap
- Hand tap wrench
- 10 mm end mill
- Vertical milling machine
- Surface grinding machine

B. Machining Process

The machining process was performed to manufacture the jig according to the specified design dimensions. The fabrication was primarily carried out using a vertical milling machine and a surface grinding machine. The machining procedures are described as follows.

C. Jig Fabrication Procedure

1. Preparation of Working Drawing

The fabrication process began by preparing the engineering drawing, raw material, and measuring instruments required for machining, as illustrated in **Figure 5**

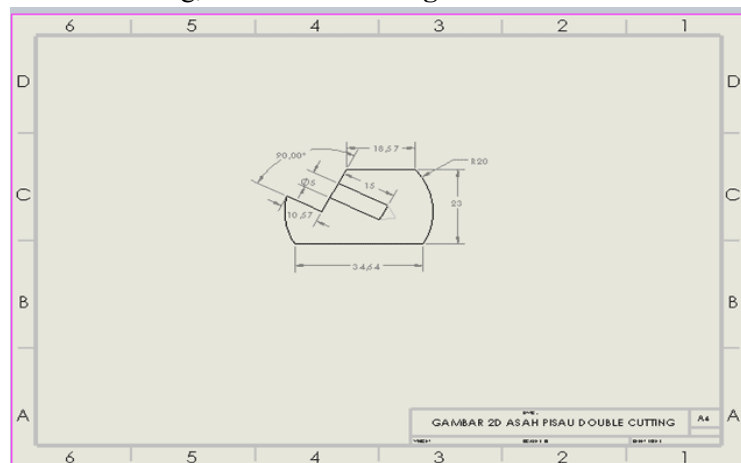


Figure 5. Engineering drawing of the sharpening jig.

2. Preparation of Raw Material

Figure 6 shows the solid steel bar with dimensions of **40 mm in diameter and 700 mm in length**, which was selected because of its availability and good machinability for jig fabrication.

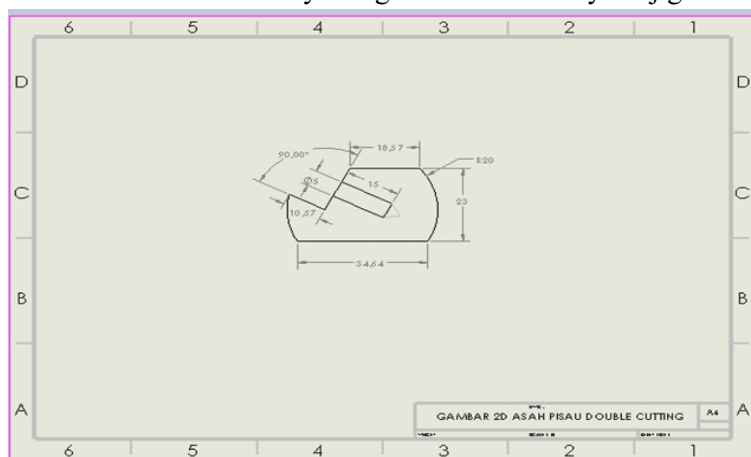


Figure 6 Solid steel bar used as the raw material.

3. Surface Grinding Setup

Before the grinding operation, the workpiece was securely clamped and tack-welded at one end to prevent movement during machining, as shown in **Figure 7**.

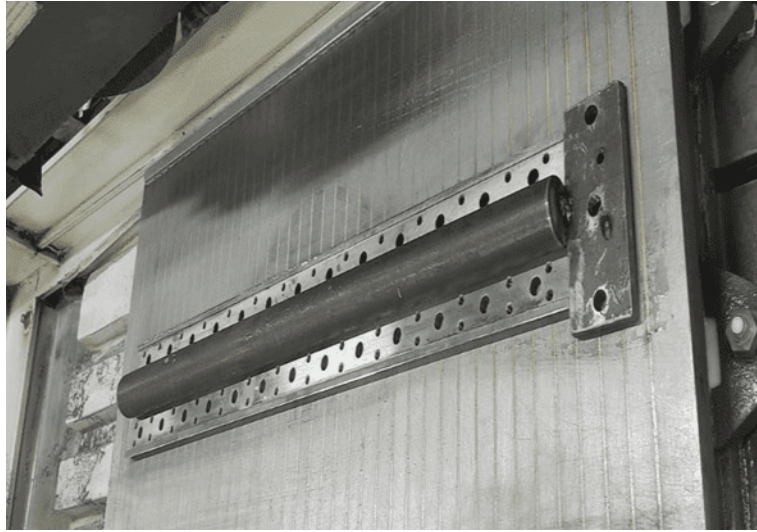


Figure 7. Workpiece setup for the surface grinding process.

4. Surface Grinding Operation

The workpiece surface was machined using a surface grinding machine to obtain a flat and smooth reference surface. The workpiece was placed on the magnetic chuck before the grinding operation and subsequently prepared for the milling process.

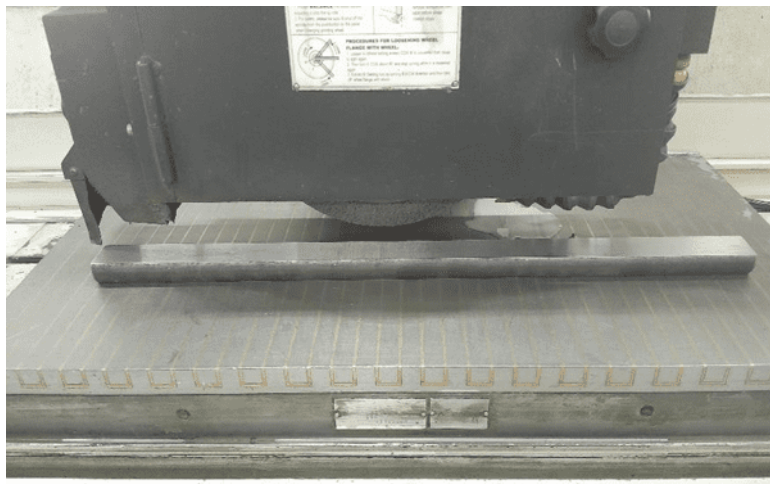


Figure 8. Surface grinding operation.

5. Milling Machine Preparation

Before machining, the milling machine table was thoroughly cleaned to remove debris and contaminants. This cleaning process ensured machining accuracy and prevented dimensional errors during fabrication.



Figure 9 Milling machine table.

6. Workpiece Clamping

The workpiece was securely fixed using machining clamps to prevent movement during milling operations. Proper clamping is essential to maintain dimensional accuracy and machining stability.

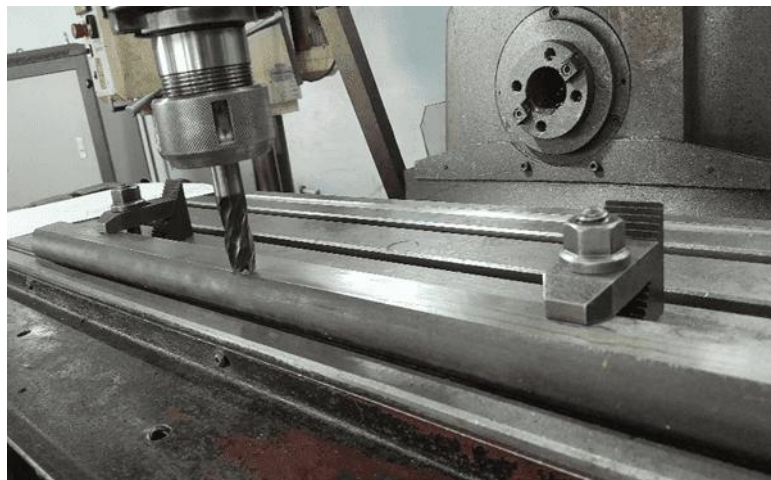


Figure 10. Workpiece clamping.

7. Milling Operation

The milling machine head was tilted to 27° to match the required angle of the double-cutting blade. An arbor fitted with a **10 mm end mill** was installed to machine the blade seating area according to the specified dimensions.



Figure 11. Milling operation using an end mill.

8. Drilling Process

After completing the milling operation, the cutting tool was replaced with a **4 mm drill bit** to produce bolt holes with a drilling depth of **15 mm**. The drilled holes were prepared according to the dimensions required for the clamping bolts.

9. Tapping Process

Following drilling, an **M5 hand tap** was used to create internal threads in the drilled holes. These threaded holes allow the installation of M5 bolts, which securely clamp the double-cutting blade during the sharpening process.

D. Jig Performance Evaluation

Table 4.1 presents the processing time required to sharpen double-cutting blades using the original sharpening jig before any improvement or modification was implemented. Each blade was sharpened individually, and the recorded processing times were used as the baseline for evaluating the effectiveness of the proposed jig design.

Table 3 Testing double cutting

Penajaman Pisau <i>Double Cutting</i>	
Uji Coba	Waktu
1	00:41:17
2	00:48:14
3	00:39:08
4	00:40:15
5	00:43:07
6	00:38:21
7	00:42:34
8	00:39:25
9	00:40:29
10	00:37:08
Jumlah	6:49:58

Rata-rata	00:41:00
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Table 4.2 presents the processing time obtained from the sharpening trials after the sharpening jig had been improved and modified. The experimental results were used to evaluate the effectiveness of the redesigned jig in reducing setup time and improving the efficiency of the double-cutting blade sharpening process.

Table 4. Testing knife double modification

Penajaman Pisau <i>Double Cutting</i>	
Uji Coba	Waktu
1	00:26:31
2	00:27:41
3	00:32:52
4	00:25:08
5	00:25:43
6	00:31:27
7	00:23:45
8	00:24:48
9	00:26:33
10	00:28:04
Jumlah	4:32:32
Rata-rata	00:27:15

As shown in Table 4.2, after the improvement and modification of the sharpening jig, the average sharpening time was reduced to 27 min 15 s per double-cutting blade. This result demonstrates that the redesigned jig significantly improved the efficiency of the sharpening process by reducing both setup time and overall machining time.

Figure 12 illustrates the double-cutting blade sharpening process after the implementation of the improved and modified jig. The redesigned jig provides a simpler setup procedure, eliminates the need for repeated blade alignment using a dial indicator, and enables a faster and more efficient sharpening operation.



Figure 12. Jig After Modification

B. Discussion

The performance comparison between the original and the improved sharpening jig is presented in **Table 5**. The experimental results demonstrate that the modification of the sharpening jig significantly reduced the total processing time required for sharpening double-cutting blades.

Before the improvement, sharpening **10 double-cutting blades** required **6 h 49 min 58 s**, exceeding the company's target processing time of **5 h**. The average sharpening time was **41 min per blade**, indicating that the existing jig required a lengthy setup process due to repeated blade alignment and adjustment using a dial indicator. Consequently, the maintenance department was unable to complete the required number of blades within the allocated maintenance schedule, potentially affecting production continuity.

After implementing the improved jig, the sharpening process became considerably more efficient. The total processing time for sharpening **10 double-cutting blades** decreased to **4 h 32 min 32 s**, with an average sharpening time of approximately **27 min 15 s per blade**. Compared with the original jig, the redesigned jig reduced the average sharpening time by approximately **13 min 45 s per blade**, representing a reduction of approximately **33.5%** in processing time. Furthermore, the total processing time was reduced by **2 h 17 min 26 s**, enabling the sharpening operation to be completed well within the company's target of **5 h**.

The significant reduction in processing time can be attributed to the redesigned non-adjustable jig configuration, which eliminates the need for repeated dial indicator adjustments and blade alignment prior to grinding. The simplified fixture design minimizes non-value-added setup activities, allowing operators to position and clamp the blade more quickly while maintaining the required sharpening accuracy. As a result, both setup time and machining time were substantially reduced.

From an industrial perspective, the improved jig offers several operational benefits. By shortening the sharpening cycle, maintenance personnel can process a greater number of blades within the same working period, thereby increasing equipment availability and supporting uninterrupted production. In addition, the reduction in setup activities contributes to improved labor productivity, lower maintenance costs, and more efficient utilization of machining equipment. These improvements are consistent with lean

manufacturing principles, which emphasize the elimination of waste and the enhancement of process efficiency through continuous improvement.

Overall, the experimental results confirm that the proposed jig modification successfully achieved the research objective of reducing setup time and improving sharpening productivity. The redesigned jig not only enabled the company to meet its production target of sharpening **10 double-cutting blades within the allocated 5-hour maintenance period**, but also provided a practical and cost-effective solution for enhancing maintenance efficiency in manufacturing operations.

Table 5 summarizes the comparison of sharpening performance before and after the implementation of the improved jig.

Table 45 Comparison of Double-Cutting Blade Sharpening Time Before and After Jig Improvement

Description	Before Improvement	After Improvement	Improvement
Number of blades	10	10	–
Target processing time	5 h	5 h	–
Actual processing time	6 h 49 min 58 s	4 h 32 min 32 s	Reduced by 2 h 17 min 26 s
Average sharpening time per blade	41 min 00 s	27 min 15 s	Reduced by 13 min 45 s (33.5%)
Production target achievement	Not achieved	Achieved	Improved

CONCLUSION

This study successfully designed, fabricated, and evaluated an improved sharpening jig for double-cutting blades to reduce setup time and improve sharpening productivity. The jig was designed using SolidWorks and manufactured through conventional machining processes, including milling and surface grinding, while considering appropriate material specifications and dimensional accuracy. The redesigned jig eliminated the need for repeated dial indicator adjustment during blade setup, resulting in a simpler, more practical, and more efficient sharpening procedure. Experimental results demonstrated that the proposed jig significantly improved operational performance by reducing the total sharpening time for **10 double-cutting blades** from **6 h 49 min 58 s** to **4 h 32 min 32 s**, representing a time saving of **2 h 17 min 26 s** or approximately **33.5%**. In addition, the average sharpening time decreased from **41 min** to **27 min 15 s per blade**, enabling the company to achieve its production target within the allocated **5-hour** maintenance period. These findings indicate that the proposed jig effectively minimizes non-value-added setup activities, enhances maintenance productivity, and improves operational efficiency. Therefore, the developed sharpening jig offers a practical and cost-effective solution for supporting continuous improvement initiatives and increasing manufacturing productivity in industrial applications involving double-cutting blade maintenance..

AUTHOR'S CONTRIBUTION

Agus Widodo conceived the research idea, designed the sharpening jig, supervised the machining and experimental procedures, analyzed the experimental data, and prepared the original manuscript. **Agung Tri Tjiptadi** contributed to the jig design using SolidWorks, participated in the fabrication process, and assisted in data collection and performance evaluation. **Merdieco Rivandi** contributed to the machining process, experimental validation, data interpretation, and manuscript revision. **Joko Prasetyo**

contributed to the analysis of the experimental results, discussion of the findings, and critical review of the manuscript. All authors read, reviewed, and approved the final version of the manuscript.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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