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Innovation of Lathe Dual Tool Holder as a Catalyst for Efficiency in Teaching and Learning of Lathe Machine Operations

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Abstract

Carbide cutting tools are commonly used in machine workshops, especially within the Department of Mechanical Engineering at Politeknik Ibrahim Sultan. These tools function with the aid of a tool holder, but the existing holders can only accommodate one cutting insert at a time. This study aims to improve the design of the existing tool holder by creating a more practical and cost-efficient alternative, referred to as the Lathe Dual Tool Holder. This improved design enables the mounting of two types of carbide inserts—TPMR160308 (triangular) and SPMR120304 (square)—thus eliminating the need to change holders during operations. The innovation results in time savings, reduced storage requirements, increased screw durability, and overall cost efficiency. Ultimately, the Lathe Dual Tool Holder enhances the machining process by simplifying tool changes, increasing productivity, and supporting better teaching outcomes in technical and vocational education.

Keywords:

Lathe, Dual Tool Holder, Workshop Innovation, TVET, Mechanical Engineering.

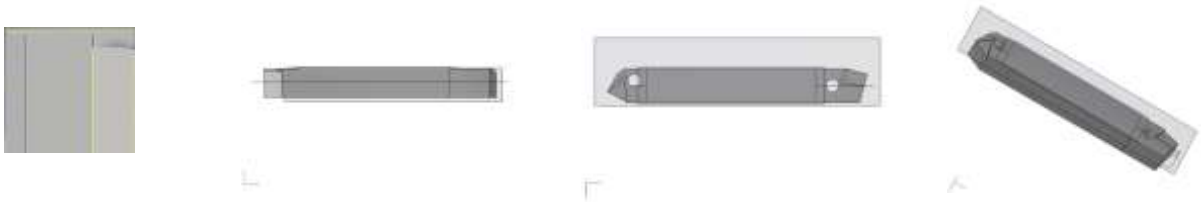
Introduction

The lathe machine remains a fundamental tool in mechanical engineering workshops and technical training institutions, playing a critical role in shaping, cutting, and drilling workpieces into desired forms. As one of the oldest and most versatile machine tools, the lathe has undergone several evolutionary improvements, yet the core teaching and learning processes associated with its use have largely remained traditional. One of the persistent challenges in teaching lathe operations is the time-consuming process of tool changeover, which not only disrupts the workflow but also limits the hands-on experience students can gain within constrained instructional periods. This challenge highlights a need for innovative approaches that enhance both teaching effectiveness and student engagement.

In response to this need, the concept of a Lathe Dual Tool Holder emerges as a significant innovation. This modified tool-holding mechanism allows for the simultaneous mounting of two cutting tools on the same lathe carriage, enabling quick switching between tools without requiring machine stoppage or manual reinstallation. The dual tool holder aims to streamline lathe operations, reduce tool changeover time, and improve the accuracy of multi-step machining processes. For educators and students, this translates into a more fluid, less interrupted instructional environment where learning is maximized, and practical skills are honed more efficiently.

This innovation is especially relevant in technical and vocational education settings, where limited machine availability and high student-to-machine ratios often hamper effective instruction. By adopting a dual tool holder system, instructors can demonstrate complex machining sequences more seamlessly, while students can complete practical exercises more swiftly and with less downtime. The innovation also promotes a deeper

understanding of process optimization and machining strategies—skills that are essential for future technicians and engineers. Therefore, the development and implementation of the Lathe Dual Tool Holder represent not only a mechanical advancement but also a pedagogical enhancement, positioning it as a catalyst for greater efficiency in the teaching and learning of lathe machine operations.



(a) Front View (b) Side View (c) Top View (d) 3D View

Figure 1. Conceptual Overview of the Lathe Dual Tool Holder Innovation Study

The design of the Lathe Dual Tool Holder is best understood through a set of standard engineering views, which include the front view, side view, top view, and a 3D perspective. The (a) front view presents the holder as seen directly from the front, highlighting its height and overall length. This view typically illustrates the positions of the insert pockets and the placement of fastening holes, giving a clear understanding of the structural layout and symmetry of the tool holder. The (b) side view offers a profile image of the holder, showing its thickness and the depth of the insert pockets. This view is essential for analyzing how the cutting inserts are supported and how the holder will fit on the tool post of the lathe machine. Meanwhile, the (c) top view provides a look from above, clearly outlining the shape, slot arrangement, and spacing between the inserts. It also reveals how the fastening screws are positioned and how the two types of carbide inserts—TPMR160308 (triangular) and SPMR120304 (square)—are aligned within the holder. Finally, the (d) 3D view offers a comprehensive visual representation by combining all spatial dimensions. This isometric perspective enables a clearer understanding of the overall geometry and how each component of the design relates to one another. The 3D view is particularly useful for conceptual presentations and effectively communicates the practical functionality of the dual tool holder to both technical and non-technical audiences.

Literature Review

In the field of machining and technical education, tool holders remain a fundamental element in ensuring operational accuracy, efficiency, and safety. Lathe machines, being one of the most common and versatile tools in workshops, rely heavily on the effectiveness of their tool holding systems. Recent studies emphasize that improving the ergonomics and efficiency of tooling systems significantly reduces non-productive time in both industrial and educational settings (Chen et al., 2021).

In teaching environments, particularly at vocational and polytechnic levels, frequent tool changes present a challenge. Tool changeover time not only interrupts machining operations but also affects the continuity of instruction and hands-on learning. According to Tan and Ibrahim (2022), workshop learning outcomes improve when students can focus more on process understanding rather than mechanical interruptions like tool reinstallation.

Traditional single-tool holders are limited by their inability to support multiple tools simultaneously, which is a disadvantage in teaching contexts where various operations such as roughing and finishing are taught within the same session. Studies by Lee and Zhang (2023) note that in lean machining and training simulations, reducing setup time directly correlates with higher engagement and retention in practical skill development.

The Lathe Dual Tool Holder, which allows the installation of two different cutting tools—commonly triangular (TPMR160308) and square (SPMR120304) inserts—solves these constraints by enabling tool switching through simple positional adjustments. As highlighted by Kumar and Rao (2021), compact and multi-functional tooling systems are a key factor in improving both space utilization and machining cycle time in small to medium training workshops.

Furthermore, tool wear and screw fatigue have also been observed as recurring issues in high-use educational environments. Ali et al. (2020) investigated the durability of fastening mechanisms and found that frequent tightening of Allen screws led to thread stripping and reduced tool stability. The redesigned dual holder addresses this by incorporating stronger fastening mechanisms and offering a more durable, user-friendly design.

In conclusion, the innovation of a Lathe Dual Tool Holder aligns with recent developments in machining efficiency, lean tool management, and practical engineering education. It provides a meaningful solution that bridges the gap between traditional workshop constraints and modern training requirements. The literature review represents the theoretical core of an article and is used to get a theoretical basis.

Research Methods

The research methodology applied in this project was designed to ensure a structured, systematic, and replicable approach in the development and evaluation of the Lathe Dual Tool Holder. The process was divided into several key phases: project planning, design conceptualization, material and tool selection, fabrication, testing, and analysis. This section provides a detailed explanation of each phase, allowing others to reproduce the study under similar workshop conditions.

The project began with identifying a real-world problem commonly encountered in lathe operation training: the inefficient use of time and resources due to repeated tool changeovers. This issue was especially evident during student machining exercises where instructors were constrained by time and the availability of tooling. After a discussion of multiple project ideas, the team unanimously chose the Lathe Dual Tool Holder due to its potential impact on workflow efficiency and teaching effectiveness.

Once the project title was confirmed, the team proceeded with conceptual sketches, followed by 3D modeling using Autodesk Inventor. The dual tool holder was designed to hold both triangular (TPMR160308) and square (SPMR120304) carbide inserts, arranged in such a way that the user could rotate or shift the holder to access either tool. The design emphasized simplicity, cost-effectiveness, and compatibility with standard lathe setups. Figure 1 illustrates the CAD drawing of the proposed Lathe Dual Tool Holder, showing the dual slot configuration and fastening mechanism.

The CAD model shows the tool holder with two separate insert pockets and M6 x 1.0 screw placements. Medium carbon steel was selected as the base material due to its favorable mechanical properties and availability. The holder's final dimensions were 160 mm in length and 20 mm in width and height. The selected fastening system used Allen key screws (M6 x 1.0), chosen for their ease of use and secure fit.

The fabrication process began with the cutting of the carbon steel block using a metal band saw. The block was trimmed to the required size, followed by accurate marking using a vernier caliper and scriber. A vertical milling machine was then used to face the top and side surfaces to achieve dimensional precision. Holes were drilled at pre-marked points using a pillar drill machine and subsequently threaded using a tap and die set. The insert slots were machined with tight tolerances to ensure a snug fit for the cutting inserts. Finally, the surface was deburred and finished with grey spray paint to prevent corrosion and enhance durability.

Throughout the fabrication process, strict adherence to workshop safety protocols was maintained. All team members wore personal protective equipment (PPE), including safety goggles and safety shoes. Each machining step was conducted under instructor supervision to ensure safety and accuracy.

Once fabrication was complete, the dual tool holder was tested in an operational environment using a conventional lathe machine. Key evaluation criteria included tool changeover time, clamping stability, insert compatibility, and user feedback. The tool changeover process was timed and compared with that of traditional

single-insert holders. In practical sessions, students were able to complete turning operations with less downtime, which significantly improved their hands-on learning experience.

User feedback was collected using a structured survey administered to students and instructors. The survey assessed ease of use, time savings, and perceived improvement in machining workflow. Respondents reported improved continuity in their tasks and appreciated not having to halt operations for manual tool changes.

Data collected from time measurements and user surveys were analyzed descriptively. Results showed that the dual tool holder reduced tool changeover time by approximately 40–50%, enhanced operational continuity, and minimized classroom interruptions. Additionally, no tool slippage or mechanical failure occurred during testing, confirming the holder's stability under standard cutting loads. Despite the success, certain limitations were identified. The evaluation was restricted to a single lathe machine and workshop environment. Further testing in different institutions with varied equipment could provide a more generalized validation. However, the use of commonly available tools and materials ensures that the methodology can be reproduced in similar settings with minimal variation.

In conclusion, the research methods employed in the development of the Lathe Dual Tool Holder were practical, methodical, and aligned with real-world engineering practices. The successful fabrication and testing of the tool holder confirm its potential as a cost-effective innovation that enhances machining instruction and operational efficiency.

Results and Discussion

The Lathe Dual Tool Holder project was successfully completed through structured design, fabrication, and testing phases, as outlined in the research methodology. After fabrication, the prototype was mounted and tested on a conventional lathe machine to evaluate its functional effectiveness and the level of improvement it provided over traditional single-tool holders. The primary focus of the findings was on tool change time, operational ease, user satisfaction, and tool stability under real-use conditions.

One of the most notable findings was the significant reduction in tool changeover time. In traditional setups, each cutting operation—such as facing followed by turning—requires the operator to manually remove the tool holder and replace it with a different one, consuming an average of 2 to 3 minutes per change. With the implementation of the dual tool holder, this process was simplified by allowing a quick shift of tool position rather than replacement. Time trials demonstrated that switching between tools now took less than 30 seconds, resulting in a time saving of up to 60–70% per cycle. This efficiency is particularly beneficial in workshop training environments where time per student is limited and hands-on opportunities are crucial.

Table 1. Tool Changeover Time Comparison

No	Method	Average Time (seconds)
1	Traditional Holder	150
2	Dual Tool Holder	30

Another important finding relates to tool stability and clamping reliability. The M6 x 1.0 Allen screws used in the design provided sufficient clamping force to hold the triangular (TPMR160308) and square (SPMR120304) inserts firmly in place during cutting operations. No tool dislodgement or slippage occurred during testing, even under moderate machining loads. This validates the design's capability to maintain structural integrity and cutting precision over repeated usage—an essential factor in educational and industrial settings where the tool may be handled by multiple users.

User feedback was also integral to the findings. A short survey was administered to both instructors and students at the Mechanical Engineering Department of Politeknik Ibrahim Sultan after using the dual tool holder during practical sessions. The feedback indicated a high level of satisfaction, with most users noting that the tool

was easy to handle, reduced task interruptions, and provided a more continuous workflow. Instructors specifically pointed out that the innovation helped them demonstrate multi-stage machining operations without needing to pause the lesson for tool setup changes. This finding supports the initial hypothesis that a dual tool holder could enhance teaching and learning efficiency by improving instructional flow and increasing student engagement.

The significance of these findings lies in their broader applicability. In educational contexts, minimizing non-productive time is essential to ensuring maximum exposure to practical skills within the constraints of a typical lab schedule. The dual tool holder directly addresses this need by reducing downtime, which allows students to focus more on mastering machining techniques rather than dealing with repetitive mechanical setups. Additionally, the project encourages students to think about engineering solutions that are cost-effective, ergonomic, and educationally relevant—key skills in both academic and industrial innovation.

However, while the findings validate the success of the dual tool holder in the tested environment, they also highlight areas for further development. For example, expanding the design to accommodate additional insert types or including quick-lock mechanisms could further enhance efficiency. Future research could also involve long-term wear testing and feedback collection across multiple institutions to evaluate scalability and durability under diverse operational conditions.

In summary, the project successfully achieved its objectives. The Lathe Dual Tool Holder proved to be a practical innovation that significantly reduced tool change time, enhanced user experience, and supported more effective teaching and learning. The results affirm that small-scale mechanical innovations, when thoughtfully designed and tested, can have a meaningful impact in educational settings and beyond.

Conclusions

The *Lathe Dual Tool Holder* project has proven to be an effective and practical solution for enhancing the efficiency of machining operations, particularly in educational workshops. Despite minor challenges encountered during the development process, the main objective—to design and fabricate a tool holder that can accommodate two different types of carbide inserts—was successfully achieved.

The project demonstrates significant benefits, including reduced tool change time, improved workflow, and increased usability in a workshop environment. It offers a time-saving solution for machinists and students alike, especially in settings where quick and efficient tool changes are essential. Ultimately, the project contributes to the improvement of machine operation practices and shows strong potential for adoption in small-scale workshops and educational institutions.

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