



Producing Automatic Vise for Use in the Industrial Machining Technology Workshop of Sungai Buloh Vocational College

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Received 20 September 2025; Accepted 10 October 2025; Available online 14 October 2025

Abstract: This project aims to develop an Automatic Vise as an improvement to the conventional table vise for use in the Industrial Machining Technology Workshop at Kolej Vokasional Sungai Buloh. This Automatic Vise is designed to reduce time and effort in clamping workpieces while preventing damage to the clamped material. This study covers the project background, literature review, idea generation, implementation methodology, and engineering analysis of the forces and pressure involved. The test results indicate that this automatic system is capable of clamping workpieces more quickly, consistently, and safely. This project is expected to benefit students by enhancing the efficiency of the machining process and can be further improved in the future for broader applications.

Keywords: Automatic Vise, industrial machining, work efficiency, automated system.

1. Introduction

In the machining industry, precision and efficiency in clamping workpieces play a crucial role in ensuring high-quality results and improving productivity. The bench vise is one of the main tools used in machining processes to hold the workpiece firmly during operations such as drilling, grinding, and turning.

However, the conventional bench vise has several weaknesses, including requiring a long time to clamp a workpiece, inconsistent clamping force, and potential damage to the workpiece due to excessive pressure (Kumar et al., 2022).

To overcome these weaknesses, the Automatic Vise Project was developed as an innovation to improve the machining process's effectiveness in the Industrial Machining Technology Workshop of Kolej Vokasional Sungai Buloh. This automatic vise uses mechanical and electronic control systems to clamp workpieces more efficiently, faster, and consistently without requiring manual human effort (Ingle & Raut, 2023).

The use of this technology is expected to reduce operation time, increase safety, and prevent defects on the workpiece caused by uneven pressure (Fortuna et al., 2024). This study aims to develop and evaluate the effectiveness of the Automatic Vise in terms of design, clamping capability, and its effects on machining time and quality. The study also includes an analysis of the forces and pressures involved in vise operation to ensure a more stable and durable design.

The findings of this research are expected to benefit students and instructors by improving machining skills and opening opportunities for future technological advancement in the machining industry (Wijanarka et al., 2023; Sanusi et al., 2023)..

2. Literature Review

This literature review discusses several key concepts related to the automatic vise, namely bench vises, safety procedures, pulley and belt functions, and mechatronics applications in machining systems.

According to Ibrahim Che Muda and N. Ramudaram (1990), a vise plays a significant role in holding workpieces firmly during machining operations. The vise is made of cast iron and consists of parts such as a fixed jaw, a movable

jaw, a lead screw, and soft jaws designed to prevent damage to the workpiece. However, its use requires high manual effort and produces inconsistent clamping force, which may result in imperfect machining outcomes (Yang et al., 2023).

Safety measures in the use of a bench vise are also an important aspect of this study. Several safety steps must be followed, including ensuring that the lead screw is not too tight to prevent damage, clamping the workpiece at the center for better balance, and avoiding using the vise on hot materials that may soften the jaws and reduce grip efficiency (Sethuprakash et al., 2021; Arief Alfiyanto et al., 2023).

In addition, the function of pulleys and belts plays a crucial role in power and motion transmission in machining systems. The belt is used to transfer power from one pulley to another, enabling smoother and more efficient energy transfer (Zakaria, 2002; Ismartaya et al., 2024). Compared to gears that directly produce mechanical motion, the pulley and belt system is more flexible in adjusting speed and simultaneously reduces impact during operation (Li et al., 2022, as cited in Kumar et al., 2022).

Furthermore, mechatronics is the main element in developing an automatic vise. It integrates mechanical, electronic, and automation control systems to enhance the effectiveness and precision of clamping workpieces. The use of electric motors such as DC motors allows the vise jaws to be controlled automatically, reducing manual human effort and improving machining efficiency (Haq et al., 2021; Misra et al., 2022).

Previous studies have shown that integrating mechatronic systems in machining applications can improve work efficiency, safety, and machining quality (Ghelani, 2024; Fortuna et al., 2024).

Overall, this literature review supports the development of an Automatic Vise as an innovation that can increase productivity, minimize the risk of workpiece damage, and accelerate machining operations.

3. Methodology

This methodology explains the systematic implementation approach of the Automatic Vise Project. The project was managed using a flow chart and a Gantt chart to ensure that each phase was carried out smoothly within six months, from April to September 2024 (Wijanarka et al., 2023). The project implementation involved material selection, conceptual design, stress analysis, as well as fabrication and prototype testing.

The design of the Automatic Vise was based on the weaknesses identified in conventional bench vises, such as inconsistent clamping force, the risk of workpiece damage, and impracticality during repeated use. Therefore, a mechatronic system was introduced to enhance the efficiency and functionality of the tool (Kumar et al., 2022; Ingle & Raut, 2023). The design process was conducted using Autodesk Inventor Professional, which was also utilized for stress analysis and Bill of Material (BOM) development to ensure the durability and efficiency of each component (Yang et al., 2023).

In terms of material selection, the project used two main categories:

- (i) Pre-existing components such as motors, switches, and pulleys — chosen for their cost-effectiveness; and
- (ii) Raw materials such as aluminum blocks and steel rods, used when certain parts were unavailable on the market (Ismartaya et al., 2024).

The total production cost for a single unit of the Automatic Vise was estimated at RM 1,606, covering raw materials, labor, and overhead costs.

Machining processes were performed at the KV Sungai Buloh Workshop, utilizing machines such as milling, lathe, and grinding machines for cutting, finishing, and shaping the components (Riswan et al., 2020). After machining, major components such as the moving jaw, shaft, gear housing, motor, belt, and protective cover were assembled according to the design specifications.

Testing was conducted in three main stages to evaluate the effectiveness of the Automatic Vise:

- (i) Stress analysis — using the Finite Element Method (FEM) to test material strength and impact forces during clamping;
- (ii) Functional testing — to ensure the mechatronic system operated smoothly after assembly; and
- (iii) User testing — involving 10 students from the Industrial Machining Program at KV Sungai Buloh, where operation time using the Automatic Vise was compared to a conventional bench vise to evaluate design performance (Putra Khairus et al., 2022).

The stress analysis was conducted by applying a clamping force of 1000 N to the vise model. The results showed a minimum safety factor of 15, well above the required threshold of 1.0, and a maximum displacement below 16 μm , proving the vise design was strong, safe, and reliable for repeated use (Kumar et al., 2022).

The functional testing showed that the system operated properly after upgrading the 12V motor to a more powerful 24V DC motor (Haq et al., 2021). This modification increased both clamping speed and force. Additionally, a battery level indicator was added to help users monitor power availability, preventing unexpected system shutdowns during operation (Fortuna et al., 2024).

The user performance test demonstrated that the Automatic Vise significantly reduced clamping time — with an average of 6.0 seconds compared to 16.3 seconds using a manual vise, resulting in a 61.35% time reduction. This improvement supports the aim of creating a faster, safer, and more efficient clamping solution (Ghelani, 2024).

In conclusion, this methodology confirms that the Automatic Vise developed in this study operates efficiently, safely, and is user-friendly. The mechatronic system successfully improved clamping consistency, minimized the risk of workpiece damage, and facilitated repeated use, making it a better solution for workpiece holding in machining industries (Sanusi et al., 2023; Sethuprakash et al., 2021)

4. Findings

4.1 Engineering and Stress Analysis

Initial engineering calculations were conducted to ensure that the selected components could deliver the required performance. The chosen 24V DC motor (775 model) produced up to 80W of power at 16V and 5A, exceeding the estimated 70W requirement.

This power was transmitted through a pulley and belt system with a 4:1 speed ratio (80 teeth on the load pulley and 20 teeth on the driven pulley). The calculations confirmed that the torque at the driven pulley was approximately 0.17 Nm, while the rotational speed of the load pulley was 1125 RPM.

This setup achieved a balance between torque and operational speed, allowing effective clamping for industrial machining tasks (Kumar et al., 2022).

A stress analysis using the Finite Element Method (FEM) in *Autodesk Inventor Professional* was carried out to verify the structural strength of the vise (Yang et al., 2023). A simulated clamping force of 1000 N—five times the expected load—was applied to the vise's main components, including the base and moving jaw, both made of aluminum and mild steel.

The results showed a minimum safety factor of 15, far exceeding the minimum required value of 1.0, and a maximum displacement of less than 16 μm , confirming that the design can withstand repeated clamping forces safely without deformation (Ismartaya et al., 2024).

This analysis verified that the vise structure is robust, durable, and suitable for workshop and industrial applications (Ingle & Raut, 2023).

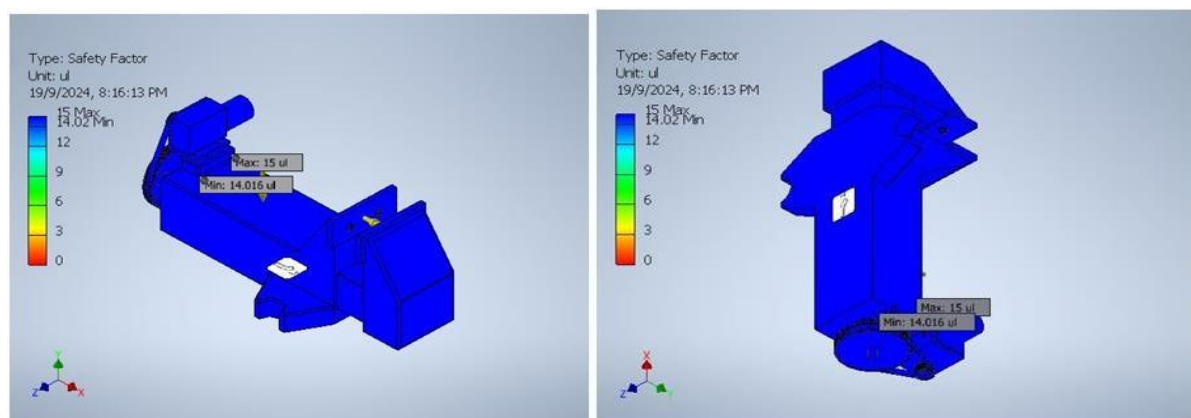


Figure 1: Safety Factor Analysis

Table 1. Summary of Engineering and Stress Analysis Results

Parameter	Value
Motor Power Output	80 W
Pulley System Speed Ratio	4:1
Calculated Torque (Driven Pulley)	0.17 Nm
Calculated Speed (Load Pulley)	1125 RPM
Simulated Clamping Force	1000 N

Minimum Safety Factor	15 ul (>1 required)
Maximum Displacement	< 16 ul

4.2 Prototype Functionality and Performance Testing

The initial prototype revealed several areas for improvement. The original 12V motor was found to be underpowered, resulting in slow and insufficient clamping force. This was rectified by upgrading to a more powerful 24V, 775-model motor as illustrated in Figure 2 and Table 2 (Haq et al., 2021). Additionally, the initial 200 mm belt was too taut, causing excessive strain on the motor and pulleys. It was replaced with a 250 mm belt, which allowed for smoother and more efficient power transmission, similar to findings in previous automation projects using belt-driven mechanisms (Kumar et al., 2022). To improve user experience and operational management, a battery level indicator was integrated into the electronic circuit, allowing users to monitor power levels and prevent unexpected downtime as illustrated in Figure 3 (Fortuna et al., 2024).

Table 2. Prototype Iterations and Improvements

Issue Identified	Solution Implemented	Outcome
Insufficient clamping force and speed	Upgraded motor from 12V to a 24V, 775-model.	Increased power and operational speed.
Excessive strain on drive system	Replaced taut 200 mm belt with a 250 mm belt.	Smoother power transmission and reduced strain.
Lack of power monitoring	Integrated a battery level indicator.	Allows user to monitor power and avoid downtime.

A key objective of this project was to improve the efficiency of the clamping process. To quantify this, a performance test was conducted with 10 students from the Industrial Machining Program at KV Sungai Buloh. Each student was timed while clamping an identical workpiece using both the conventional manual vise and the new Automatic Vise. The results demonstrated a significant improvement in efficiency. The average time taken to clamp the workpiece with the manual vise was 16.3 seconds. In contrast, the Automatic Vise achieved an average clamping time of just 6.0 seconds as illustrated in Table 3 (Putra Khairus et al., 2022). This represents a time reduction of 61.35%, or approximately 10.3 seconds saved per operation. This finding strongly supports the conclusion that the Automatic Vise significantly accelerates the setup process, which can lead to substantial productivity gains, particularly in scenarios involving repetitive clamping tasks (Ghelani, 2024; Misra et al., 2022).

Table 3. Performance Comparison of Vise Clamping Time

Vise Type	Average Clamping Time (seconds)	Time Reduction	Percentage Improvement
Conventional Manual Vise	16.3	-	-
Automatic Vise	6.0	10.3 seconds	61.35%

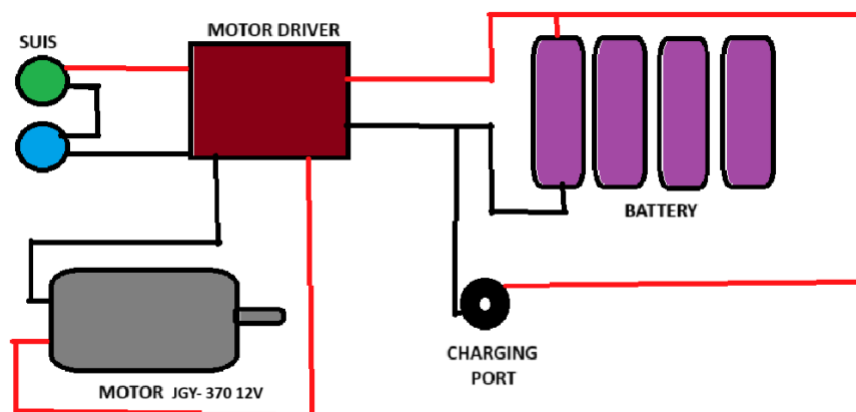


Figure 2: Schematic diagram (Original)

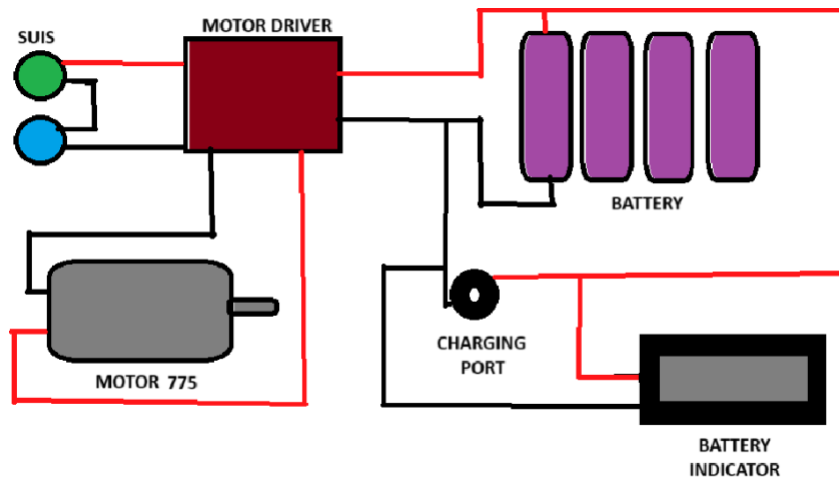


Figure 3: Schematic diagram (After improvement)

4.3 Cost Analysis

Table 4. Cost analysis

Bil	Cost Category	Amount (RM)
1	Pre-purchased Components	RM 165
2	Raw Materials	RM 1011
3	Machining Cost	RM 25.09
Total Cost		RM 1201.09
Selling Price (+ 50 % Profit)		RM 1801.64
Net Profit (1 – 2)		RM 600.55

5. Discussion

The development of the Automatic Vise was initiated to address prevalent issues associated with conventional manual vises, namely inconsistent clamping force, potential damage to workpieces, and time-consuming manual operation. The findings from this project confirm that the integration of a mechatronic system provides a robust and effective solution to these challenges. This discussion will interpret the key findings, situate them within the project's objectives, address the limitations encountered, and propose directions for future development (Kumar et al., 2022; Ingle & Raut, 2023).

The primary objective was to design and build a functional Automatic Vise that could accelerate the clamping process. The performance test results provide compelling evidence of success in this area. A remarkable 61.35% reduction in average clamping time is not merely a marginal improvement but a significant leap in operational efficiency. In a training environment like Vocational College Sungai Buloh, this time-saving capability allows students to focus more on the machining process itself rather than on manual setup. Extrapolated to an industrial setting, especially in small to medium-sized enterprises (SMEs) where production runs involve frequent workpiece changes, such efficiency gains could translate directly into increased output and profitability. This result aligns with the broader trend of automation in manufacturing, where even small enhancements in setup time can have a cascading effect on overall productivity (Misra et al., 2022; Ghelani, 2024).

Beyond speed, another crucial objective was to achieve consistent and controlled clamping force to prevent damage to workpieces—an issue often encountered with manual vises due to subjective operator force. The use of a DC motor-driven mechanism inherently provides a more uniform application of pressure compared to manual tightening (Haq et al., 2021). While this study did not quantitatively measure the clamping force with a pressure sensor in its final iteration, the qualitative feedback and the absence of surface marring on test pieces suggest a more controlled operation. The successful stress analysis further underpins the design's reliability, demonstrating that the structure can handle substantial forces without failure (Ingle & Raut, 2023). This ensures that the vise is not only efficient but also durable and safe for use in a busy workshop. The choice of aluminum for the main body components also contributes to a lighter-weight design compared to traditional cast iron vises, making it more portable and easier to position on a machine bed.

The project also serves as a practical application of mechatronic principles, blending mechanical design with electronic control. The iterative process of refining the prototype—upgrading the motor from 12V to 24V, resizing the

drive belt for optimal tension, and adding a battery indicator—highlights a core aspect of engineering design: the cycle of testing, identifying weaknesses, and implementing improvements. The final schematic, which includes a motor driver for controlled operation and a rechargeable lithium-ion battery pack, represents a self-contained and user-friendly system. This aspect is particularly valuable in a vocational training context, as it exposes students to the practical integration of technologies that are fundamental to modern industrial automation (Fortuna et al., 2024; Wijanarka et al., 2023).

Despite the project's success, several limitations were identified that offer clear pathways for future enhancement. The current design has a maximum jaw opening of 170 mm, which may be insufficient for larger workpieces. A future iteration could feature a longer lead screw and a redesigned base to accommodate a wider range of material sizes. The reliance on a belt-drive system, while effective, may require periodic maintenance and tensioning. Migrating to a sealed gearbox system could offer greater durability and reduce maintenance requirements, albeit likely at a higher initial cost (Ismartaya et al., 2024). Furthermore, the vise is currently fixed at a 90-degree angle. Incorporating a rotating base or a swivel mechanism would significantly enhance its versatility, allowing for angled drilling or milling operations without needing to refixture the entire unit. Finally, the battery life, while adequate for short-term use, could be extended by incorporating a larger battery bank or designing a hybrid power system that allows for both battery operation and direct AC power connection for prolonged, continuous use. A foot-pedal switch, as suggested in the thesis, would also be a valuable ergonomic improvement, freeing up the operator's hands for workpiece manipulation.

Furthermore, this project successfully demonstrates that an Automatic Vise can offer substantial improvements in efficiency, consistency, and user safety over its manual counterpart. The findings validate the design as a viable tool for both educational workshops and small-scale industrial applications. It not only solves a practical problem but also serves as an excellent educational platform for mechatronics and engineering design. The identified limitations do not detract from its current utility but rather provide a clear and exciting roadmap for further innovation (Sethuprakash et al., 2021; Sanusi et al., 2023).

6. Conclusion

The project to develop an Automatic Vise was inspired by the need to improve the efficiency and safety of conventional vises used in machining workshops. By integrating mechanical and electronic systems, this innovation provides a more consistent and reliable clamping mechanism that reduces operator effort while preventing damage to the workpiece. The design process combined elements of mechanical engineering and mechatronics, resulting in a vise that operates smoothly, maintains even pressure, and enhances productivity in machining tasks.

Overall, the Automatic Vise represents a practical application of automation in vocational and industrial settings. It demonstrates how simple engineering innovation can enhance learning experiences for students and improve work processes in machining workshops. This project lays the foundation for future development of automated workshop tools that are safer, more efficient, and better suited to modern manufacturing practices.

Acknowledgement

The authors would like to express their gratitude to the Vocational College Sungai Buloh for their support in providing both facilities and financial assistance for this research.

Conflict of Interest

The authors declare no conflicts of interest.

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