

Design of a Welding Table with Electromagnetic Magnet Application to Enhance Welding Stability and Precision

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Article Information	ABSTRACT
Article History Received : October 10, 2024 Revised : November 19, 2024 Published: January 02, 2025	Precision is very important in the welding process to ensure that the welding results are strong and accurate. A sturdy and well-designed welding table is essential to maintain workpiece stability and precision in welding operations. The method used in this research is Research and Development (RnD) with the ADDIE model. This research aims to design a welding table with the application of electromagnetic magnets through literature study, design and testing of welding table prototypes. The result of the research is a welding table product with the application of electromagnetic magnets. Testing shows the use of electromagnetic magnets on the welding table can improve the stability and accuracy of welding results. This study also obtained data on user/practitioner satisfaction after using a welding table with electromagnetic magnets based on 12 important aspects which include Purpose, Specific, Measurable, Achievable, Relevant, Time-bound, Innovative, Functional, Efficiency, Reliability, Ease of Use, and Safety.
Keywords: <i>Electromagnetic Innovation Development Design</i>	

INTRODUCTION

Welding is a crucial process in the manufacturing industry for joining two or more metal objects into a unified and strong structure. In welding, heat energy is utilized to bond materials, both metallic and non-metallic, at a specific temperature (Sihombing, 2024). The welding process is widely employed in industrial sectors such as automotive, construction, aerospace, and general manufacturing. To achieve high-quality welds, many factors must be considered. One significant factor is welding parameters such as welding speed, pulse frequency, and welding current, which can affect the quality of the weld (Yao et al., 2019). By optimizing these parameters, optimal tensile strength, impact toughness, and hardness can be achieved in the metal joints (Safeen et al., 2016). In addition to parameter settings, weld quality is also determined by the stability and accuracy required for precise welding results. Furthermore, (Sidoruk et al., 2021) emphasizes the importance of technological advancements in maintaining welding process stability, particularly focusing on the electrode melting process in arc welding. Improving stability in the welding process can significantly enhance the overall quality of the welds.

One of the essential components that support a stable and precise welding process is the welding table. The welding table serves as a platform to support and hold the workpiece during the welding process. (Komarudin & Towip, 2022) highlight the importance of an ergonomic welding table design to reduce fatigue and improve work productivity. However, in conventional welding, especially during welding technique practice, after observing students who have completed welding practice courses, several issues were found, including difficulties in stabilizing

the position and orientation of the workpiece. These limitations make the workpiece susceptible to shifting or uncontrolled position changes, leading to inaccuracies in welding and reducing the final quality. Moreover, this condition also increases the risk of postural stress. Previous research by (Bakri et al., 2018) points out that welding processes often occur in uncomfortable working positions, which over time can lead to musculoskeletal disorders. (Ruengdech, 2024) notes that welders are at risk of muscle injuries due to factors such as uncomfortable posture, long working hours, and continuous exertion. These findings underscore the need to address ergonomic factors and work procedures to reduce welders' postural stress and enhance workplace safety. One critical aspect to consider is the ergonomic design of the welding table.

Electromagnetic technology is a branch of science that studies the interaction between electric and magnetic fields. The basic principle of this technology is that an electric current flowing through a conductor will generate a magnetic field around it. One of the basic principles of this interaction is that an electric current flowing through a conductor can generate a magnetic field around it, and conversely, changes in the magnetic field can induce an electric current in the conductor, known as electromagnetic induction (Bayerl et al., 2012). The use of electromagnetic magnets in welding tables emerges as a solution that needs further development. Electromagnetic magnets utilize the principle of electromagnetic induction to generate a strong attractive force on metallic objects. The application of electromagnetic magnets in welding tables allows the workpiece to be locked in a precise and stable position during the welding process. This is supported by Abdurahman et al., (2021), who state that in the welding process, the position and stability of the material are crucial for producing high-quality weld joints. A well-designed welding table can help reduce vibration and unwanted movement during the welding process, which can affect weld quality. The application of electromagnetic technology also enhances welding ergonomics across various welding positions, enabling practitioners to operate with a sense of safety, comfort, and confidence without fearing injury risks that could compromise their health (Komarudin & Towip, 2022). By using an electronic control system, the magnetic force can be adjusted according to the type of material being welded and specific application requirements.

The use of electromagnetic magnets in welding tables is still rare in educational institutions. Welding tables equipped with electromagnetic magnets offer several significant advantages. First, this system can enhance the stability of the workpiece during welding, reducing the risk of uncontrolled shifting or position changes and ensuring more precise welding results. Research shows that better stability can minimize the chance of material displacement that could affect the final weld quality (Prabowo, 2023). Second, welding tables with electromagnetic magnets allow users to lock the workpiece quickly and easily without needing additional clamps or bolts. This feature enables welding tasks to be completed more efficiently, saving time. With the ability to quickly and efficiently adjust the material's position and orientation, welders or practitioners can save time that would typically be spent setting up and securing the material before starting the welding process. This contributes to increased productivity and efficiency in industrial environments (Suhartono & Mindhayani, 2020). Third, electromagnetic welding tables can also improve work safety. By reducing the need for mechanical clamping tools that could pose injury risks, this table provides a safer solution for welders. Moreover, reducing the risk of material displacement during the welding process also lowers the likelihood of workplace accidents (Prabowo, 2023).

In conclusion, the design of a welding table with the application of electromagnetic magnets promises to be an effective solution for improving stability and precision in the welding process. The use of electromagnetic technology in welding tables is expected to enhance welding efficiency, quality, and safety, as well as provide better flexibility in handling various types of welding tasks. In this proposal, we will outline the technical design of the welding table with electromagnetic magnets, the electronic control system to be implemented, and the testing plan to verify the performance and effectiveness of this design. Through a scientific approach and the application of electromagnetic technology in welding tables, this proposal aims to contribute significantly to the development of more advanced and efficient welding technology, especially in assisting students in performing welding technique practices.

RESEARCH METHODS

This research employs the Research and Development (R&D) methodology using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to design and produce a welding table with the application of electromagnetic magnets. The development stages in this research are as follows:

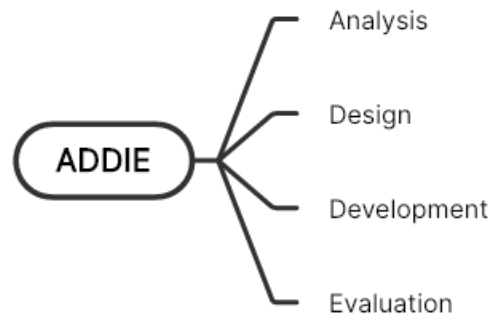


Table 1. Development Stages

Stages	Activities
<i>Analysis</i>	Literature Review on Modern Welding Technology
<i>Design</i>	Technical Design of a Welding Table with Electromagnetic Magnet Application (Design Drawings, Material Selection, and Electromagnetic Application Design)
<i>Development</i>	Fabrication of the Welding Table and Integration of the Electromagnetic Magnet System
<i>Implementation</i>	Testing the Use of the Electromagnetic Welding Table and Surveying Welder/Practitioner Satisfaction
<i>Evaluation</i>	Evaluation of Test Results, Analysis of Satisfaction with 12 Satisfaction Aspects

RESULTS AND DISCUSSION

Results

Analysis

In the analysis stage, references were obtained regarding the criteria for modern welding that can be applied in the design of the welding table. The criteria for modern welding tables obtained from several references are summarized in the table below:

Table 2. Criteria for Modern Welding Tables

No	Criteria	Description
1	High Stability and Precision	Modern welding tables are often equipped with electromagnetic or mechanical locking systems that allow materials to remain stable during the welding process. This stability is crucial for producing high-quality weld joints and reducing the likelihood of defects in the final output (Ahmed et al., 2022).
2	Flexibility	Modern welding tables are typically designed with the capability to easily adjust the position and orientation of materials. This allows welders to work with various types of materials and shapes without the need to replace the table or additional tools. This flexibility is highly beneficial in dynamic work environments where various types of projects are often undertaken (Akhonin et al., 2015).
3	Integration of Advanced Technology	Welding tables can also be connected to automation systems to enhance productivity and can detect the geometry and position of materials, which can improve welding accuracy and efficiency (Curiel et al., 2023).

The three criteria for a modern welding table serve as key considerations in the development of a welding table that can enhance stability and precision, flexibility, and technology integration. These criteria also support improved safety in the welding process.

Design

This design employs 2D modeling software to generate a visual representation of the welding table concept.

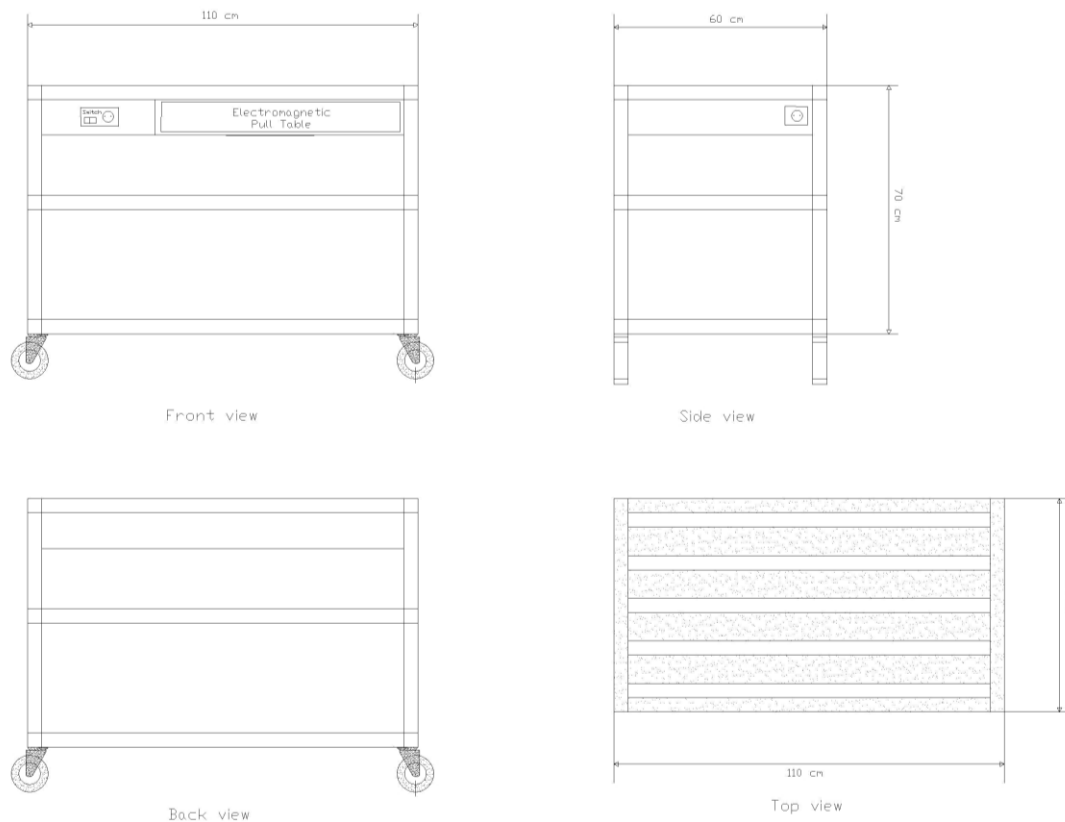


Figure 2. Electromagnetic Welding Table Design

The next step involves designing the electromagnetic system for the welding table. This integration includes the design of the electromagnetic components, sensors, and control devices that are connected to the locking mechanism.

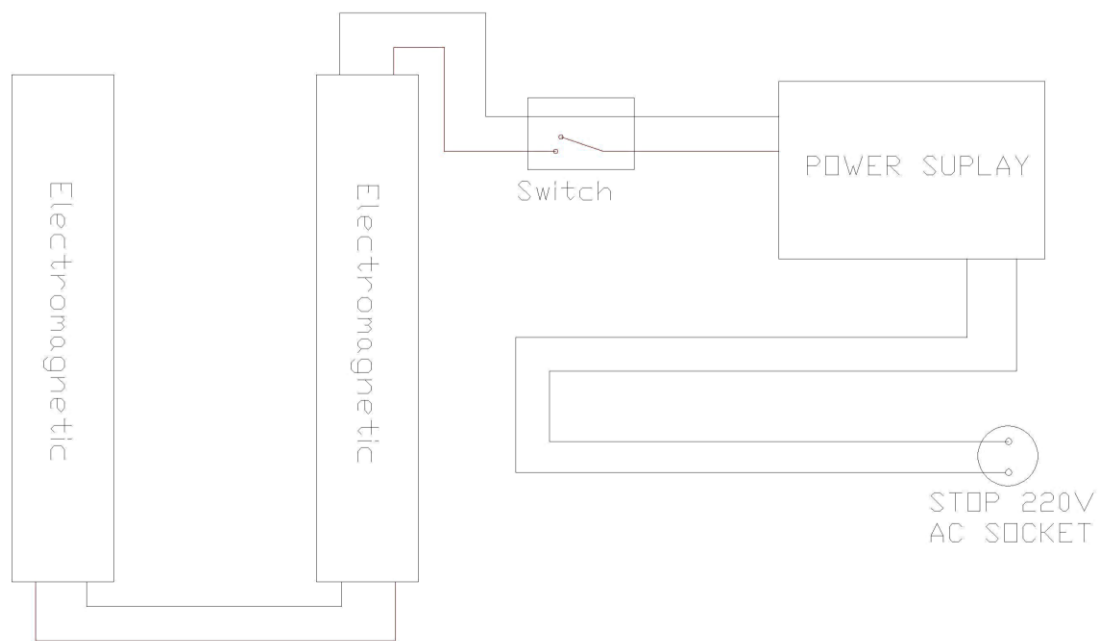


Figure 3. Integration of Electromagnetic System in the Welding Table

Welding Table Structure Design

1. **Materials and Dimensions:** High-strength steel is used for the table frame, and corrosion-resistant aluminum is employed for the work surface.
2. **Special Features:** The table surface is equipped with a grid to assist in material alignment, and slots are included for welding accessories..

Electromagnetic Drawer Design

1. **Locking Mechanism:** The drawer is equipped with an electromagnetic locking mechanism that can be activated and deactivated via a switch.
2. **Drawer Structure:** The ergonomic design of the drawer includes smooth sliding rails and sufficient capacity for storing welding tools and small materials..

Developmet

At the design stage, both the welding table and the electromagnetic system are translated into the creation of a prototype. This welding table prototype is developed based on the technical designs previously formulated, with a focus on meeting functional requirements and operational safety in accordance with the three key criteria for a modern welding table. The prototype development process includes several important stages, which are summarized in the table below.

Table 3. Stages of Welding Table Prototype Development

No	Stage	Activity
1	Material Selection	Material selection is made with consideration for strength, heat resistance, and durability under extreme working conditions. The materials used include thick iron to ensure the robustness of the table.
2	Component Assembly	This stage includes assembling a sturdy and stable table frame, installing a flat work surface resistant to sparks, and integrating an electromagnetic drawer designed to facilitate the placement and locking of workpieces during the welding process. All components are carefully assembled in accordance with applicable technical standards to ensure structural fit and safety.

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| 3 | Preliminary Testing | Before the full integration of the electromagnetic system, a series of preliminary tests is conducted. These tests aim to ensure that all components of the welding table, including the frame, work surface, and electromagnetic drawer, function properly. The testing covers frame strength, work surface resistance to high temperatures, and the effectiveness of the electromagnetic mechanism in securing workpieces. |
| 4 | Electromagnet Installation | The electromagnet is directly connected to a switch and power outlet for the welding machine plug. With this configuration, the electromagnetic locking system can be activated or deactivated via the switch. |



Figure 4. Electromagnetic Welding Table Prototype

Implementation

The next stage involves testing the welding table in real conditions, where the drawer is evaluated to determine whether it can be locked and unlocked accurately and safely using the electromagnetic system. The parameters tested include the electromagnetic response time to commands, locking strength, and the reliability of the system under various operational conditions.



Figure 5. Dokumentasi Uji Coba Meja Las Elektromagnetik

During this phase, 30 respondents were asked to assess the performance of the welding table using a research instrument in the form of a Likert scale, designed to measure two main

indicators: the stability of the table during the welding process and the precision level of the welding results. The obtained results are shown in the following figure 5.

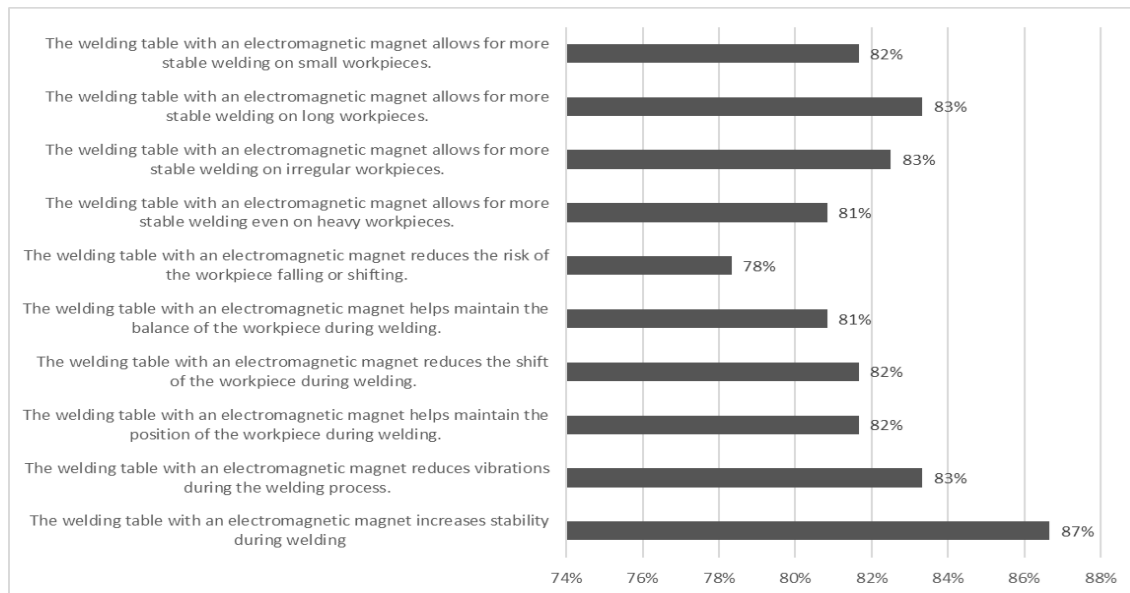


Figure 6. User Response Graph on Table Stability

The welding table with the electromagnetic magnet significantly improves stability during welding, achieving a maximum score of 104 and a satisfaction percentage of 87%. This indicates that the electromagnetic magnet effectively keeps the workpiece stable throughout the welding process.

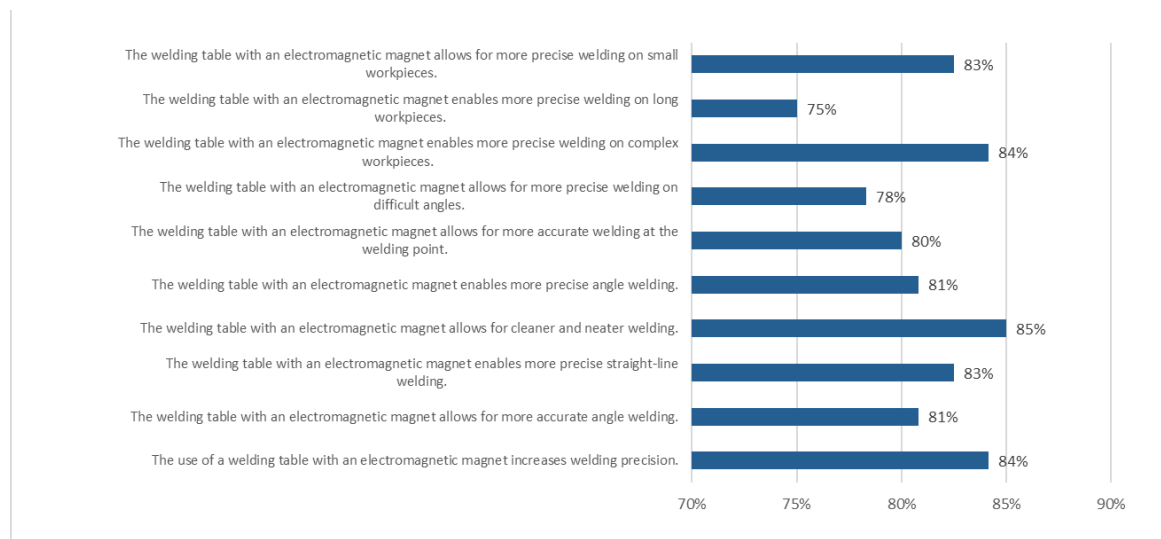


Figure 7. User Response Graph on Welding Result Precision

The use of the welding table with the electromagnetic magnet significantly enhances welding precision, achieving a maximum score of 101 and a satisfaction percentage of 84%. This indicates that the electromagnetic magnet plays a crucial role in producing more accurate and high-quality welds.

Evaluation

A total of 32 respondents provided evaluations of the product based on 12 important aspects, including Specificity, Measurability, Achievability, Relevance, Timeliness, Innovativeness, Functionality, Efficiency, Reliability, Ease of Use, and Safety. The assessment

was conducted using a numerical scale from 1 to 4, where 1 indicates the lowest level and 4 indicates the highest level. Overall, the evaluations from the respondents provide a comprehensive overview of how well the product meets the established criteria. A summary of the respondents can be seen in the following figure.

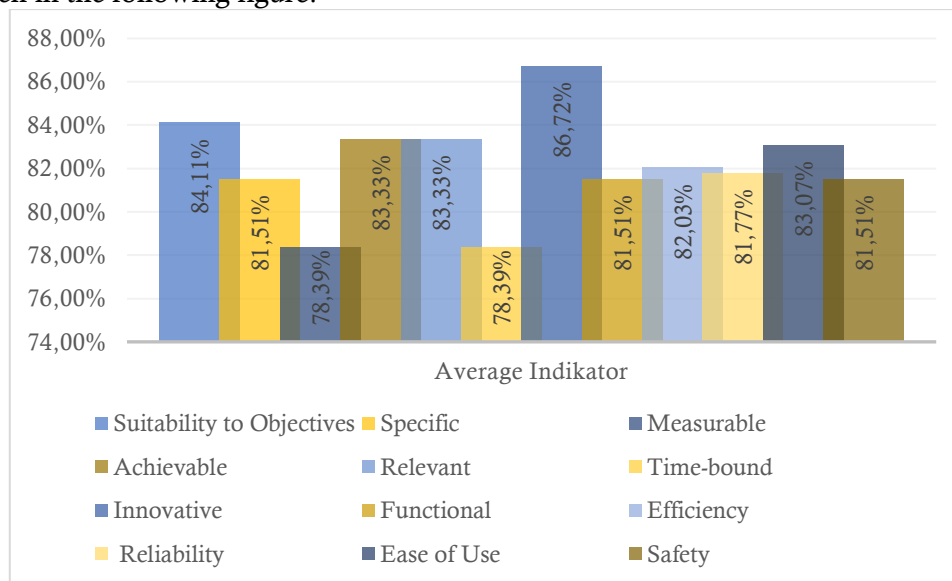


Figure 8. User Feasibility and Satisfaction Presentation

The user response for the electromagnetic welding table, after testing, shows an average satisfaction score of 82.14% across the 12 indicators. This figure indicates that the electromagnetic welding table falls into the category of being suitable for use.

Discussion

The electromagnetic welding table demonstrates several significant advantages that can enhance the quality of the welding process.

Improved Work Stability

The electromagnetic magnet has proven effective in increasing the stability of the workpiece during welding, as evidenced by high average scores across various tested parameters, such as reduced vibrations, minimized shifting, and the ability to maintain the workpiece's position. This enhanced stability ensures that welding results are more consistent, reducing the risk of errors caused by the movement of the workpiece during the process. This finding is supported by research conducted by Baskoro et al. (2013), which indicates that the application of an electromagnetic field can produce a more stable and narrower arc, thereby enhancing weld penetration. With better arc stability, welders can achieve more consistent and high-quality joints, minimizing the risk of defects such as porosity and cracks.

Better Welding Precision

The use of electromagnetic magnets in the welding table allows for more precise welding, especially in corner welding, straight lines, and spot welding. This accuracy is crucial for producing welds that are strong and meet the necessary technical specifications, particularly in industrial applications that require high tolerances. Research by Maksimov et al. (2021) shows that the influence of an electromagnetic field can control the flow of molten metal in the weld object, which helps improve joint quality.

Flexibility in Handling Workpieces

The welding table with the electromagnetic magnet exhibits the ability to handle various shapes and sizes of workpieces, including heavy, complex, long, or small items. This illustrates the flexibility of this technology in various welding scenarios, making it a versatile solution in dynamic work environments.

In addition to its many advantages, the electromagnetic welding table also has several drawbacks that need to be considered. These disadvantages can affect the effectiveness and efficiency of using the table in the welding process.

High Initial Cost

One of the main drawbacks of the electromagnetic welding table is the high initial cost. The electromagnetic technology and components required to build this table are often more expensive than conventional welding tables. This can be a barrier for small businesses or individuals looking to invest in more advanced welding equipment (Muhaimin et al., 2022).

Material Limitations

Electromagnetic welding tables are generally designed to work with ferromagnetic materials. This means that the table may not be effective for welding non-ferromagnetic materials such as aluminum or copper. This limitation can restrict flexibility in using the welding table for various types of projects and materials (Winarno & Yuwono, 2017).

Operational Complexity

Operating the electromagnetic welding table can be more complex than traditional welding tables. Users may need to understand how the electromagnetic system works and make the necessary adjustments to ensure optimal performance. This may require additional training for welders, which can be a challenge, especially for those new to the welding field (Tierl et al., 2022).

Potential Magnetic Interference

The use of an electromagnetic field can cause interference with other electronic devices located near the welding table. This can be problematic in work environments where sensitive electronic equipment is used. Such interference can affect the performance of tools and other devices, necessitating measures to isolate the electromagnetic welding table from other equipment (Sundawa et al., 2020).

Complex Maintenance

The electromagnetic welding table may require more complex maintenance compared to conventional welding tables. The electromagnetic system and other electronic components may require special attention to ensure everything functions properly. If damage occurs to the electromagnetic system, repairs can be more difficult and expensive (Nurhidayati, 2023).

Dependency on Power Supply

The electromagnetic welding table relies on an electrical power source to operate. In locations without stable access to electricity, using this welding table may not be practical. The dependence on electricity also means that if there is a power outage, the welding process can be interrupted (Sistayani et al., 2020).

Health Risks

Although the electromagnetic welding table can enhance workplace safety by reducing the risk of injuries due to material movement, the use of electromagnetic fields can also pose certain health risks. Prolonged exposure to strong electromagnetic fields may potentially have negative health effects on workers, although further research is needed to understand the long-term impacts (Ruqayah, 2024).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The electromagnetic welding table product demonstrates significant benefits for welders and practitioners by enhancing precision and stability during the welding process, thereby improving the final quality of the welded product. Furthermore, feedback from respondents indicates a high level of user satisfaction with the welding table, evaluated across 12 aspects of satisfaction. The positive responses from users suggest that the integration of electromagnetic

technology with conventional welding tables can facilitate users in achieving greater precision and stability in welding.

Recommendations

Based on the findings, the following recommendations are proposed for practical implementation, theoretical development, and future research. Firstly, further research is essential to investigate methods for reducing the production costs of electromagnetic welding tables, such as utilizing more cost-effective materials or simplifying the design without compromising functionality. This approach aims to enhance accessibility to the technology, particularly for small businesses and individuals with budget constraints. Additionally, research could focus on cost-reduction strategies for the manufacturing of electromagnetic welding tables, making these technologies more economically viable, especially for small enterprises.

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