

Design and Fabrication of a Portable High-Current Resistance Spot-Welding Machine using Upcycled Components.

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Abstract - This paper presents the design, fabrication, and performance analysis of a low-cost, portable resistance spot-welding (RSW) machine. Conventional industrial spot welders are highly efficient but are predominantly stationary and capital-intensive, creating a functional gap for small-scale workshops and remote repair tasks. To address this mobility and cost constraint, a discarded Microwave Oven Transformer (MOT) was safely extracted and modified into a step-down transformer. By replacing the high-voltage secondary coil with heavy-gauge copper cabling, the system successfully outputs a high-current, low-voltage electrical profile of approximately 2300 A at 2.5 V. The architecture integrates a spring-loaded mechanical lever to apply consistent forging pressure and an active cooling system to mitigate thermal overload. Empirical testing demonstrated the system's capability to successfully forge structural weld nuggets in 2 mm Mild Steel sheets within a 5-second weld cycle. By utilizing repurposed electronic waste, the total fabrication cost was reduced by 70% to 90% compared to commercial units, offering an accessible, plug-and-play manufacturing solution without sacrificing fundamental welding efficiency.

Keywords - resistance spot welding; microwave oven transformer; portable fabrication; joule heating; upcycled manufacturing

I. INTRODUCTION

Resistance spot welding (RSW) remains one of the most reliable and fundamental manufacturing methods for fusing thin metal sheets. The technique operates on the principle of electrical resistance, specifically Joule heating; when a massive electrical current is forced through clamped metal surfaces, it generates intense, localized heat that melts the faying surfaces into a solid weld nugget. However, while traditional industrial RSW machines are incredibly efficient, they are also notoriously bulky, completely stationary, and require massive capital investment.

This high cost of entry essentially locks independent fabrication workshops, hobbyists, and educational laboratories out of utilizing high-quality spot welding technologies. Furthermore, because industrial resistance welders are tied to fixed factory floors, they cannot be deployed for remote or on-site repair jobs. While operators sometimes attempt to use portable arc welders as a substitute for joining thin metals, arc welding often proves highly

inefficient and carries a severe risk of burning straight through thin-gauge materials. Therefore, there is a critical functional gap in the market for a joining technology that is both highly mobile and accessible.

To bridge this divide, researchers and independent fabricators have increasingly explored low-cost alternatives, most notably the upcycling of electronic waste like Microwave Oven Transformers (MOT). Standard MOTs naturally operate as step-up transformers, but previous academic studies have demonstrated that by stripping away the high-voltage secondary coil and replacing it with just a few turns of heavy-gauge copper cable, the unit can be successfully converted into a high-current step-down transformer. While the core physics of this process—governed mathematically by Joule's Law of Heating ($H=I^2Rt$)—are well established, building a reliable portable system introduces significant functional hurdles. A review of existing literature highlights that maintaining consistent electrode contact pressure to prevent metal expulsion, alongside managing the severe thermal degradation of the

transformer windings in air-cooled environments, are the primary causes of failure in portable setups.

Addressing these specific engineering gaps, this paper details the design, fabrication, and evaluation of a highly portable, cost-effective resistance spot welder built around a repurposed MOT. The primary objective of this study is to engineer a compact system that successfully generates high-amperage welding currents while integrating critical safety and performance features. By incorporating an active thermal cooling system to prevent overheating and a customized spring-loaded lever mechanism to guarantee uniform forging pressure, this work aims to provide a sustainable, reliable welding solution that bridges the divide between heavy industrial power and small-scale accessibility.

II. METHODOLOGY AND SYSTEM ARCHITECTURE

A. Electrical Modification and Power Conversion

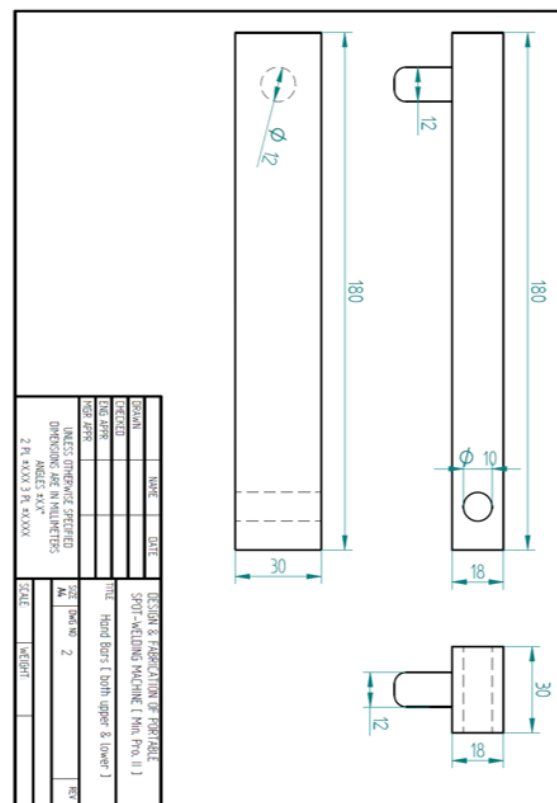
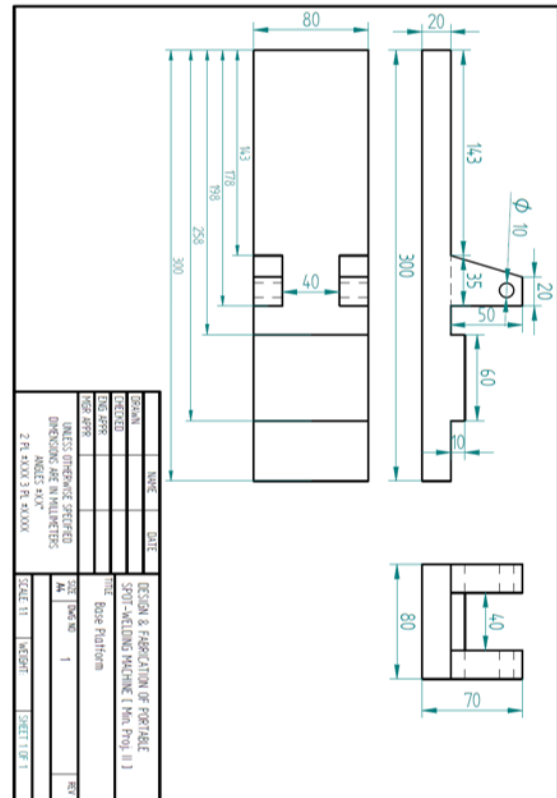
The core of the welding apparatus relies on the strategic modification of a standard Microwave Oven Transformer (MOT). In its factory state, an MOT operates as a step-up transformer designed to generate thousands of volts. To achieve the specific electro-mechanical profile required for resistance spot welding, the transformer had to be converted into a step-down unit. This was accomplished by carefully extracting the original high-voltage secondary coil using hand tools, ensuring the primary coil remained completely intact and undamaged. The secondary winding was then replaced with 1.5 to 2 loops of heavy-gauge, insulated copper cabling. When standard 230 V alternating current (AC) is supplied to the primary coil, this modified secondary coil fundamentally alters the output—dropping the voltage down to a highly safe range (approximately 2.5 V) while proportionally amplifying the current to extreme, welding-capable levels.

B. Circuit Design and Thermal Management

The system's architecture bifurcates the incoming AC power into two parallel sub-circuits to maximize both operator safety and machine longevity. The first sub-circuit is hardwired directly to a rotary cooling fan. This active cooling system continuously dissipates heat from the transformer coils as soon as the machine is powered on, which is a critical feature for mitigating thermal overload during repeated short-circuiting weld cycles.

To ensure precise control, the primary welding circuit incorporates a dual-switch safety mechanism. Power is initially routed through a primary ON/OFF switch, which arms the system and illuminates a visual LED indicator on the chassis. From this indicator, the current passes to a momentary contact trigger switch, repurposed from an angle grinder. Mounted directly on the operating lever, this component functions as a dead-man's switch. It grants the

operator instantaneous manual control over the duration of the current burst, allowing for precise timing adjustments to prevent accidental burn-through on thin metal sheets. The complete structural and mechanical design of the portable spot-welding prototype is detailed in the CAD models shown.



1500 °C. Based on the target weld nugget volume, yielding an estimated mass (m) of 0.00066 kg, the heat requirement is:

$$Q = m \times C \times \Delta T \quad \dots(2)$$

According to (2), the theoretical energy strictly required to melt the nugget is 445.5 Joules.

B. System Efficiency and Secondary Output.

Empirical testing of this upcycled prototype determined that an optimal weld duration (t) of 5 seconds was required to achieve a secure joint in 2 mm MS sheets. The total energy delivered (H) by the machine over this timeframe is:

$$H = P_{in} \times t \quad \dots(3)$$

Operating at 5750 W for 5 seconds delivers 28,750 Joules of energy. Consequently, the thermal efficiency (η) of the system can be evaluated as the ratio of theoretical heat required to the total energy delivered:

$$\eta = \left(\frac{Q}{H}\right) \times 100 \quad \dots(4)$$

This results in a system efficiency of approximately 1.55%. While seemingly low, an efficiency range of 1% to 2% is highly standard for portable, air-cooled spot-welding fabrications, which must dissipate massive amounts of excess heat into the surrounding electrodes and chassis due to the lack of industrial water-chilling.

Finally, the output profile of the modified transformer can be determined. Measuring the secondary voltage (V_s) at the copper electrodes yields approximately 2.5 V. Applying the power relation, the secondary welding current (I_s) is:

$$I_s = \frac{P_{in}}{V_s} \quad \dots(5)$$

This confirms that the step-down modification successfully outputs roughly 2300 A of current, providing the extreme amperage required for Joule heating.

C. Performance Benchmarking

To contextualize the viability of this prototype, its operational parameters were benchmarked against commercial portable units and heavy-duty stationary industrial machines. While industrial welders operate at 25 kW to over 50 kW to deliver ultra-fast welds under 0.5 seconds, they require exorbitant capital investment and dedicated three-phase power supplies. The fabricated MOT welder operates on a standard 230 V single-phase supply, drawing roughly 5.75 kW. By sacrificing processing speed—requiring a 5-second weld time compared to a commercial portable unit's 1-to-2 seconds—the upcycled model successfully delivers comparable forging power at a fraction of the cost, utilizing active air cooling and a manual lever to mimic the pneumatic pressure of expensive industrial

systems. "The complete operational parameters and performance benchmarks of the prototype, compared against standard commercial and industrial units, are summarized in

Table 1.

Operating Parameter	Fabricated MOT Welder (Our Model)	Commercial Portable Welder	Industrial Stationary Welder
Transformer Type	Modified Repurposed MOT	Dedicated Step-Down	Large-scale Water-cooled
Input Power	5.75 kW	8.0 kW – 12.0 kW	25.0 kW – 50.0 kW+
Output Current (I)	~2300 A	~4000 A	10000 A +
Weld Time (2mm MS)	5.0 seconds	1.0 – 2.0 seconds	\$ < 0.5\$ seconds
Applied Pressure	Manual Lever (Moderate)	Pneumatic / Manual Tong	Heavy Pneumatic / Hydraulic
Thermal Management	Active Air Cooling (Fan)	Passive Air / Heat Sinks	Closed-loop Water Chiller
Power Supply Needed	Standard Single-Phase (230V)	High-Amperage Single Phase	Dedicated Three-Phase
Capital Cost	Extremely Low (Upcycled)	Moderate	Exorbitantly High

Table 1

IV. RESULTS AND DISCUSSION

A. Electrical and Mechanical Performance

The primary objective of scaling down high-current resistance welding into a highly mobile format was successfully achieved. The modification of the MOT effectively converted the high-voltage input into a high-current, low-voltage output profile. Yielding approximately 2300 A at 2.5 V, the system provided the precise electrical footprint required for standard RSW operations without tripping standard workshop circuit breakers.

Practical trials confirmed the machine's operational readiness. By leveraging the spring-driven lever to exert steady downward force, operators were able to produce robust weld nuggets on 2 mm mild steel (MS) test plates. Although massive industrial machines can complete this fusion almost instantly, the fabricated device successfully balanced thermal penetration with manual clamping force over an ideal 5-second activation window. Subsequent visual inspection of the joined MS-to-MS and MS-to-Stainless Steel (SS) workpieces confirmed strong, uniform metal fusion with negligible surface spatter or expulsion.

B. Safety and Operational Stability

Managing heat accumulation is one of the most prominent hurdles when designing compact welding equipment. To combat this, the active cooling fan performed exceptionally well during live tests. By constantly circulating air and expelling trapped heat from the enclosure, the setup effectively shielded the transformer coils from catastrophic thermal damage even during back-to-back welding sequences.

Additionally, the control scheme was designed to prioritize operator safety and reduce mistakes. A bright LED panel light offered immediate feedback regarding the system's live status, lowering the chance of unintentional firing. Furthermore, using a repurposed angle grinder switch as a responsive dead-man's trigger gave users direct, split-second authority over the power delivery, helping them cut off the current exactly when needed to avoid burning through the thin metal. In the end, this condensed design successfully converted a traditionally stationary, factory-bound process into an accessible, user-friendly tool perfect for tight workspaces.

V. CONCLUSION

This study successfully demonstrated that high-amperage resistance spot welding, a process traditionally reserved for heavy manufacturing, can be effectively adapted into a highly accessible, low-cost, and mobile framework. By strategically upcycling a discarded microwave oven transformer, the fabricated equipment reliably generated a welding output of roughly 2300 A at 2.5 V, proving fully capable of fusing 2 mm mild steel plates within an optimal 5-second timeframe.

Ultimately, this project highlights a sustainable approach to small-scale fabrication. By utilizing repurposed electronic waste and standard hardware, the financial barrier to entry was reduced by 70% to 90% when compared to commercial alternatives. Furthermore, the integration of forced-air cooling and a spring-actuated trigger ensured that the system remained safe, thermally stable, and user-friendly over repeated cycles, entirely eliminating the need for permanent facility installations or specialized power grids.

While the current prototype meets all primary functional objectives, several design iterations could elevate its performance for professional environments. Implementing automated digital timing controls—such as a microcontroller or a 555-timer circuit paired with a solid-state relay—would eliminate human timing errors and deliver exact millisecond precision. Mechanically, replacing the manual lever with a compact pneumatic cylinder would guarantee perfectly uniform forging pressure. Finally, incorporating a TRIAC-based dimmer circuit for variable power output and exploring closed-loop water-cooling for the electrodes would allow the system to seamlessly handle thinner metal foils and higher-volume production workloads.

REFERENCES

[1] Chede, S. J., Chapke, G. M., Kalappurayil, J. G., Jain, P. M., & Sonawane, V. D. (2018). Design and manufacturing of 35 KVA table top spot welding machine. *International Journal of Advance Engineering and Research Development*, 5(4), 156–165.

[2] Ingle, A. H. (2023). A literature review on fabrication of portable spot welding machine. *International Journal for Research in Applied Science and Engineering Technology*, 11(6), 3844–3850. <https://doi.org/10.22214/ijraset.2023.53844>

[3] Pawar, S. (2021). Design of fixture for spot welding machine.

International Journal of Scientific Research and Engineering Development, 4(5), 573–580.

[4] Sathish, D., Kavin Kumar, R., & Jeevan Elton, A. (2019). Design and fabrication of portable resistance spot welding machine. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3362697>

[5] Fabrication of portable spot-welding machine. (2016). *Academia.edu*. https://www.academia.edu/30584222/Fabrication_of_Portable_Spot_Welding_Machine

[6] Design and fabrication of portable automatic spot-welding machine. (2021). *Journal of Emerging Technologies and Innovative Research*, 8(7).

[7] Assembly of portable spot-welding machine. (2023). *International Journal for Research in Applied Science and Engineering Technology*. <https://www.ijraset.com/research-paper/assembly-of-portable-spot-welding-machine>

[8] Development of a portable spot-welding machine. (2003). *IEEE Xplore Digital Library*. <https://doi.org/10.1109/ICIT.2003.1230907>

[9] Development of a portable spot welder. (2019). *IEEE Xplore Digital Library*. <https://doi.org/10.1109/ICAECT47350.2019.8955157>

[10] Clark, I. L. (2006). *Writing the successful thesis and dissertation: Entering the conversation*. Prentice Hall.

[11] Purdue University Writing Lab. (2018). Writing a literature review. *Purdue Online Writing Lab*. https://owl.purdue.edu/owl/research_and_citation/conducting_research/writing_a_literature_review.html

[12] Scribbr. (2023). How to write a literature review: Guide, examples, & templates. <https://www.scribbr.com/dissertation/literature-review/>

[13] American Welding Society. (n.d.). *Recommended practices for test methods for evaluating the resistance spot welding behavior of automotive sheet steels*. American Welding Society.

[14] Nimje, A. A., et al. (2015). Design and fabrication of portable resistance spot welding machine. *International Journal of Engineering Research & Technology*, 4(5).

[15] Gowtham Rajan, A., et al. (n.d.). Modification of microwave oven transformer for spot welding applications.

[16] Rao, P. N. (n.d.). *Manufacturing technology: Foundry, forming and welding*. Tata McGraw-Hill Education.

[17] Goode, A. A., et al. (2013). Design and fabrication of portable resistance spot welding machine. *International Journal of Engineering Research & Technology*, 4(5).

[18] Schmidt, R., & Holmberg, S. (2018). *Manufacturing processes for engineering materials*. Pearson.

[19] Papazian, J. (2015). Analysis of portability in industrial tools. *Journal of Engineering Design*.

[20] Jenkins, L. (2004). *Welding: Principles and applications*. Cengage Learning.

[21] Groover, M. P. (2020). *Fundamentals of modern manufacturing: Materials, processes, and systems* (7th ed.). John Wiley & Sons.

[22] Zhang, H., & Senkara, J. (2011). *Resistance welding: Fundamentals*. CRC Press.

[23] Rajan, A. G. (2016). Modification of MOT for spot welding. *IJEERT*.

[24] Goode, A. A. (2015). Design and fabrication of portable RSW machine. *IJERT*.

[25] Gupta, S. (2018). Effect of weld time on 2 mm MS sheets. *JCOPE*.

[26] Schmid, S. R., & Kalpakjian, S. (2018). *Manufacturing processes for engineering materials* (6th ed.). Pearson Education.

[27] Espinosa, J., et al. (2018). Analysis of portability in industrial tools for remote maintenance and repair. *Journal of Engineering Design and Technology*, 16(4), 582–597.

[28] Jeffus, L. (2020). *Welding: Principles and applications* (9th ed.). Cengage Learning.

[29] O'Brien, R. L. (2004). *Welding handbook: Welding processes* (Vol. 2, 9th ed.). American Welding Society.

[30] Messler, R. W. (2008). *Principles of welding: Processes, physics, chemistry, and metallurgy*. John Wiley & Sons.

[31] Weman, K. (2011). *Welding processes handbook* (2nd ed.). Woodhead Publishing.

[32] Zhang, H., & Senkara, J. (2011). *Resistance welding: Fundamentals and applications* (2nd ed.). CRC Press.

[33] Zhou, Y., & Hu, S. J. (2003). Modelling of resistance spot welding: A

review. *Journal of Manufacturing Science and Engineering*, 125(2), 314–323.

- [34] Viňáš, J., et al. (2012). Analysis of materials for resistance spot welding electrodes. *Strojarsstvo*, 54(5), 393–397.
- [35] Gupta, S., & Kumar, P. (2018). Effect of weld time and current on the shear-tensile strength of 2 mm mild steel sheets. *International Journal of Mechanical and Production Engineering*, 6(11).
- [36] Mohit, K. (2021). Analysis of manual pressure mechanisms and electrode degradation in low-cost resistance spot welding systems. *International Journal of Scientific Research in Science and Technology*, 8(2), 45–52.
- [37] Zhang, L., et al. (2019). A review of circular economy and waste-to-resource: The case of discarded microwave oven transformers. *Journal of Cleaner Production*, 210, 1150–1165.
- [38] M., et al. (2018). Thermal modeling and performance evaluation of air-cooled transformers in portable welding equipment. *Applied Thermal Engineering*, 142, 280–289.