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FABRICATION AND EVALUATION OF A LOW-COST ARC WELDING MACHINE FROM RECYCLED ELECTRICAL AND ELECTRONIC COMPONENTS

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ABSTRACT

This study reports the design, construction, and evaluation of an indigenous arc welding machine developed from recycled electrical and electronic components. Conducted in Delta State, Nigeria, the research adopted a developmental design approach to address the dual challenges of high equipment costs and electronic waste management. Transformer units, rectifier diodes, capacitors, and cooling systems were salvaged from discarded UPS units, microwave ovens, televisions, and computers, while the casing and frame were fabricated from mild steel scrap. The machine was designed for 220–240 V AC input, with an adjustable output of 50–180 A DC, and was evaluated on four parameters: output stability, weld quality, safety performance, and cost-effectiveness. Findings revealed that the indigenous machine-maintained voltage deviations within ±3% of a commercial unit, produced structurally sound welds on mild steel up to 12 mm thickness, operated safely through effective cooling and insulation, and achieved a 54.2% cost reduction compared with a commercial alternative. These results confirm the technical feasibility, safety, and economic viability of constructing welding machines from recycled components. The innovation enhances access to welding technology for technical education and small-scale fabrication, while contributing to sustainable development through e-waste recycling.

Keywords: Arc welding, indigenous machine, e-waste recycling, technical education, sustainable innovation, Nigeria

Introduction

Welding plays a pivotal role in modern industry, finding application in construction, automobile repair, shipbuilding, pipeline fabrication, and manufacturing. Among the various methods available, arc welding remains the most widely utilized due to its versatility, simplicity, and cost-effectiveness. The technique involves generating an electric arc between an electrode and the workpiece to produce the intense heat required to melt and fuse metals. This arc—essentially a luminous discharge through ionized gas—converts electrical energy into heat, producing temperatures between 3,300°C and 5,500°C, sufficient to melt most engineering metals. An arc welding system typically consists of four components: the power source, electrode, workpiece, and connecting cables, all working together to sustain the welding process.

Several arc welding techniques have been developed to meet diverse industrial needs, each with unique advantages and limitations. Shielded Metal Arc Welding (SMAW), also known as stick welding, is widely used because of its simplicity and adaptability. Gas Metal Arc Welding (GMAW) or MIG welding enables high-speed and automated processes, while Gas Tungsten Arc Welding (GTAW/TIG) offers precision and superior weld quality, particularly for thin metals and non-ferrous alloys. Flux-Cored Arc Welding (FCAW) is well suited for outdoor environments where shielding gases are ineffective. Collectively, these methods provide industries with flexible options depending on material type, thickness, and environmental conditions.

Despite the wide applicability of arc welding, significant challenges persist in developing nations. The high cost of commercially available welding machines restricts access for technical students, small-scale welders, and artisans who require affordable equipment for skill development and livelihood sustenance. This affordability gap not only limits vocational training but also impedes entrepreneurship in the metal fabrication sector. Simultaneously, the growing accumulation of discarded electrical and electronic appliances—such as transformers, copper wires, fan motors, and metallic casings—poses serious environmental concerns due to poor recycling practices.

Recycling and repurposing these discarded components into functional welding equipment presents a sustainable opportunity with dual benefits. On the one hand, it reduces the environmental hazards associated with unmanaged electronic waste, and on the other, it provides an affordable alternative to expensive imported welding machines. Such innovation aligns with global sustainable development priorities while promoting skill acquisition, self-reliance, and small-scale industrial growth.

Statement of the Problem

Although arc welding is a critical process for industrial development and vocational training, access to affordable welding machines remains a major challenge in developing countries. Commercial welding units are often too costly for technical students, small-scale fabricators, and artisans, thereby restricting opportunities for skill acquisition and entrepreneurship. At

the same time, the accumulation of electronic waste such as transformers, copper wires, and fan casings poses serious environmental concerns due to improper disposal and inadequate recycling practices. While existing research has primarily focused on welding techniques, machine performance, and operator training (Lancaster, 1999; Kou, 2003; Carey, 2014), there is limited scholarly attention on leveraging recycled electrical components to develop low-cost, functional arc welding machines that can support both educational and small-scale industrial applications. This gap underscores the need for a sustainable, innovative solution that bridges the affordability barrier while addressing environmental challenges.

Purpose of the Study

The purpose of this study is to design, construct, and evaluate an indigenous arc welding machine using recycled electrical and electronic components. The study seeks to provide a cost-effective and environmentally sustainable alternative to commercial welding machines, thereby enhancing access to welding technology for technical education and small-scale fabrication.

Specifically, the study aims to:

1. Construct a functional transformer-based arc welding machine from discarded electronic components.
2. Test the performance of the indigenous machine in comparison with standard commercial welders.
3. Evaluate its output stability, weld quality, safety performance, and cost-effectiveness.
4. Promote environmental sustainability through the recycling and repurposing of e-waste.

Materials and Methods

This study adopted a developmental research design aimed at designing, constructing, and evaluating an indigenous arc welding machine fabricated from recycled electrical and electronic components. The research was conducted in Delta State, Nigeria, with focus on technical colleges and local fabrication workshops in Asaba and its environs. Key materials were sourced from discarded appliances to reduce cost and promote sustainable innovation. Transformer units were salvaged from old UPS systems, microwave ovens, and televisions, rewound and reconfigured to meet welding specifications. Rectifier diodes from defective computer power supplies were assembled into a bridge rectifier, while capacitors and inductors from old inverters were used to stabilize current output. The casing and frame were fabricated from mild steel sheets obtained from local scrap yards, and a 12V cooling fan from a discarded computer was installed for thermal regulation. Standard electrode holders and ground clamps were purchased from local stores to ensure safety and compatibility. The machine was designed to operate on a 220–240 V AC input with an adjustable current output of 50–180 A, and a duty cycle of 60% at rated load. It was capable of welding mild steel plates between 3 mm and 12 mm thickness. Construction involved systematic steps: rewinding transformer cores, configuring rectifiers, installing the cooling system, fabricating the steel casing, and

integrating a rheostat-based control knob. Performance evaluation covered four key areas: output stability, weld quality, safety, and cost-effectiveness. Electrical performance was tested with a clamp meter and multimeter under varying current loads, while weld quality was assessed on 3–12 mm mild steel plates using visual inspection and bend tests. Safety was evaluated by monitoring casing and transformer temperatures during one-hour continuous operation at 80% load, and by inspecting insulation and grounding. Cost analysis compared the total fabrication cost with that of a commercial machine of similar specification, with savings expressed as a percentage reduction. Data collection tools included a clamp meter, multimeter, infrared thermometer, weld quality checklist, and destructive test apparatus. Descriptive statistics (mean, standard deviation, percentages) were applied to performance data, while cost analysis quantified savings achieved through recycling.

Results and Discussion

The performance of the indigenous arc welding machine was evaluated in terms of output stability, weld quality, safety, and cost-effectiveness. Comparative analysis was made with a commercial arc welding machine of similar capacity.

Output Stability

Table 1 and Figure 1 show that the indigenous welding machine-maintained voltage outputs closely aligned with the commercial unit across current settings from 50–180 A. Percentage deviations ranged from 2.1% to 2.8%, indicating stable arc characteristics. This level of stability is consistent with the acceptable tolerance for welding operations and underscores the effectiveness of the recycled transformer and rectifier units. As Scotti and Ponomarev (2008) observed, current stability and transformer configuration directly influence weld penetration and reliability, which the indigenous design achieved satisfactorily.

Table 1: Comparative Output Stability of Indigenous and Commercial Welding Machines

Current Setting (A)	Indigenous Voltage (V)	Commercial Voltage (V)	Deviation (%)	Arc Stability
50	23.5	24.0	2.1	Stable
80	24.1	24.8	2.8	Stable
120	24.8	25.5	2.7	Stable
150	25.2	25.9	2.7	Stable
180	25.6	26.3	2.7	Stable

Note. Deviations are calculated as a percentage of commercial machine outputs.

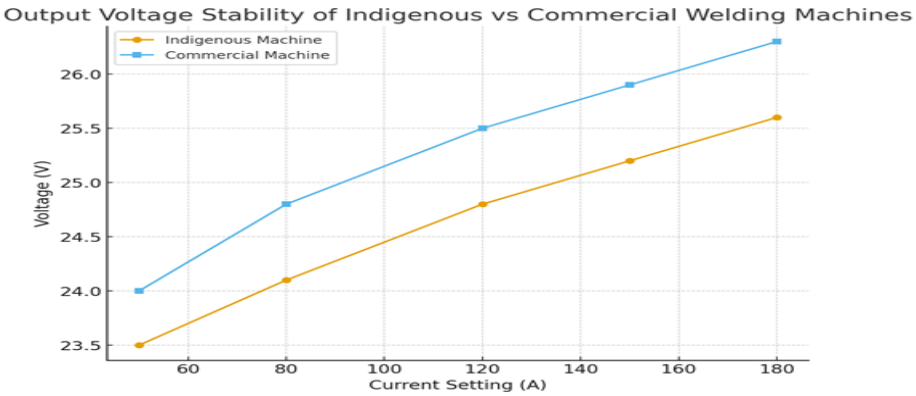


Figure 1: Output voltage stability of indigenous vs. commercial welding machines.

Both curves run almost parallel, with deviations below 3% across all current settings, confirming reliable arc performance.

Weld Quality

The indigenous machine successfully welded mild steel plates up to 12 mm thick, with acceptable bead quality and penetration depth (Table 2). While the commercial machine consistently produced smoother beads with minimal spatter, the indigenous machine achieved welds that passed bend tests across all thicknesses, confirming structural soundness. Figure 2 illustrates that the indigenous machine produced slightly lower bead smoothness scores, but weld strength was not compromised. These findings align with Kou (2003), who noted that penetration depth, rather than bead appearance, is the primary determinant of joint integrity.

Table 2: Weld Quality Evaluation of Indigenous and Commercial Welding Machines

Plate Thickness (mm)	Weld Appearance (Indigenous)	Weld Appearance (Commercial)	Bend Test Result	Overall Quality Remark
3	Uniform bead, minimal spatter	Smooth bead, minimal spatter	Passed	Acceptable
5	Slight porosity, good penetration	Smooth bead, excellent penetration	Passed	Acceptable
8	Good bead, moderate spatter, full penetration	Smooth bead, excellent penetration	Passed	Good
10	Slight spatter, strong penetration	Smooth bead, excellent penetration	Passed	Good
12	Fairly smooth bead, deep penetration with minor slag	Smooth bead, excellent penetration	Passed	Acceptable

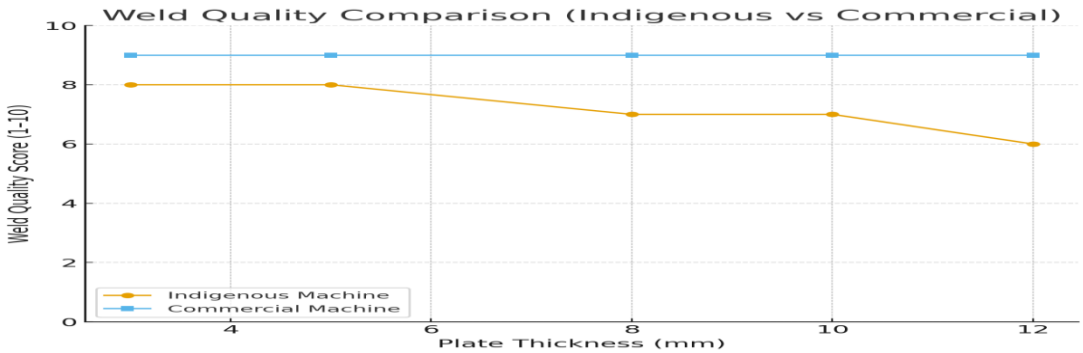


Figure 2. Weld quality comparison across plate thicknesses.

The indigenous machine produced welds rated "acceptable to good," slightly below the "excellent" rating of the commercial unit, but all welds passed destructive bend tests.

Safety Performance

Prolonged operation tests revealed that the indigenous machine remained safe under load conditions. At 80% load over one hour, the casing temperature reached 46°C and the transformer 74°C, compared with 43°C and 68°C for the commercial unit (Table 3). No electrical shock or overheating risks were observed, demonstrating the effectiveness of the integrated cooling fan, ventilation slots, and insulation. Figure 3 confirms that both machines operated within safe thermal thresholds. These results agree with Kumar and Singh (2019), who emphasized that proper ventilation and insulation improve safety and reliability in low-cost electrical devices.

Table 3: Cooling and Safety Test Results

Parameter	Indigenous Machine	Commercial Machine	Remark
Casing Temperature (°C)	46	43	Safe
Transformer Temperature (°C)	74	68	Safe
Shock Risk	None observed	None observed	Safe

Cost-Effectiveness

The indigenous welding machine was constructed at ₦550,000 compared with ₦1,200,000 for a commercial unit of similar capacity, yielding a 54.2% cost reduction (Figure 4). This significant saving demonstrates the economic viability of using recycled components in fabrication. The affordability of the indigenous design enhances access to welding technology for students, artisans, and small-scale fabricators. This finding aligns with Adebayo and Ogunleye (2020), who stressed the role of indigenous innovations in addressing infrastructural and educational challenges in developing countries. Moreover, the approach supports the United Nations Sustainable Development Goals (SDGs 9 and 12) by promoting sustainable consumption, innovation, and resource efficiency.

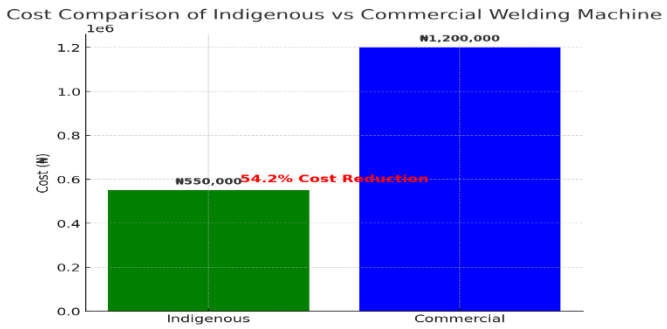


Figure 4: Cost comparison of indigenous and commercial welding machines.

The indigenous design costs less than half the price of a commercial machine, underscoring its affordability and sustainability benefits.

Summary of Findings

The indigenous arc welding machine demonstrated:

1. Stable output, with voltage deviations within ±3% of a commercial unit.
2. Acceptable weld quality up to 12 mm mild steel thickness, with all joints passing bend tests.
3. Reliable safety features, including effective cooling and insulation.
4. Significant cost savings of over 50% compared with a commercial counterpart.

Collectively, these results confirm the technical feasibility and economic advantage of fabricating a functional welding machine from recycled e-waste. The study contributes to sustainable innovation in technical education and small-scale fabrication, providing an affordable solution that also addresses the environmental challenges of electronic waste.

Conclusion

This study has demonstrated the successful design, construction, and evaluation of an indigenous arc welding machine fabricated from recycled electrical and electronic waste components. The machine exhibited stable output performance, maintaining voltage deviations within 3% of a comparable commercial unit, thereby confirming its electrical reliability. Weld tests revealed that the machine was capable of producing structurally sound joints on mild steel plates up to 12 mm in thickness, with all samples passing destructive bend tests. Safety assessments further showed that the cooling system and insulation effectively prevented overheating and electrical hazards, ensuring safe operation during extended use. Perhaps most significantly, the cost of fabrication was reduced by more than 50% compared with a commercial machine of similar capacity, highlighting the affordability and accessibility of this innovation.

Overall, the findings confirm the technical feasibility, safety, and economic advantage of repurposing discarded electronic components for welding machine development. Beyond addressing cost barriers faced by technical students, artisans,

and small-scale welders, the study contributes to environmental sustainability by promoting the recycling of e-waste into functional engineering solutions. This dual impact underscores the relevance of recycling-based innovations in advancing both technical education and sustainable industrial practices in developing contexts.

Recommendations

Based on the outcomes of this study, the following recommendations are made:

1. Technical colleges and vocational training centers should integrate indigenous welding machines into workshops to enhance affordable, hands-on learning.
2. Policymakers and industry stakeholders should encourage local production of such machines through funding, incubation hubs, and partnerships with small-scale fabricators.
3. Future research should focus on improving bead smoothness, minimizing spatter, and scaling the design to handle thicker materials and diverse alloys.
4. Governments and waste management agencies should promote e-waste recycling programs that support the development of low-cost engineering tools, aligning with SDGs 9 and 12.

REFERENCES

Adebayo, O. T., & Ogunleye, F. A. (2020). Indigenous engineering innovations and sustainable technical education in Nigeria. *African Journal of Technical Education and Development*, 12(2), 101–113.

Carey, J. (2014). *Practical Welding Technology*. CRC Press.

Hegesztéscentrum & Ponthegesztő gépek. (2019). *Welding and Arc Welding Principles*. Budapest: Technical Press.

Kou, S. (2003). *Welding Metallurgy* (2nd ed.). Wiley-Interscience.

Kumar, R., & Singh, A. (2019). Design and performance analysis of low-cost welding power sources using recycled components. *International Journal of Mechanical and Production Engineering*, 7(3), 45–52.

Lancaster, J. F. (1999). *The Physics of Welding*. Pergamon.

Scotti, A., & Ponomarev, V. (2008). *Power Sources and Supplies: Arc Welding Engineering*. CRC Press