INTI JOURNAL | Vol.2025, Issue 5, No.15
eISSN:2600-7320

Development of Portable Electroplating Equipment to Enhance the Efficiency of Small and Medium-Sized Jewelry Industries Indonesia

I Ketut Suarna*, Rico Mario

Design Product, Faculty of Technic and Design, Institut Teknologi Sains Bandung, Kota Deltamas, Kabupaten Bekasi, Jawa Barat, Indonesia

***Email:** ketut.suarna@itsb.ac.id

Abstract

Small and medium-sized jewelry enterprises (SMEs) in Indonesia face challenges because traditional electroplating methods are expensive and lack flexibility, which reduces their productivity and slows down operations. This study addresses this problem by creating a novel, affordable, and user-friendly electroplating tool specifically designed for these small businesses.To develop the tool, the researchers reviewed existing literature and conducted field visits and interviews with personnel at three jewelry companies located in Bekasi, Bandung, and Riau to understand the primary technical issues they face.The resulting tool measures approximately 400 mm long, 110 mm wide, and 150 mm tall, and is constructed from polypropylene, which is resistant to chemical damage. It features a built-in system to ventilate harmful gases and adjustable voltage control. Testing the tool using copper plating on bracelets demonstrated that it operates 25% faster than conventional methods and produces a smoother, shinier finish. The compact size allows it to be used efficiently in tight workspaces, and the dedicated ventilation system provides protection for workers against hazardous fumes. Furthermore, this tool is cheaper than comparable tools currently on the market, enhancing affordability for small businesses. This innovation is expected to enhance SME autonomy, lower production costs, and facilitate greater design diversity within the Indonesian jewelry industry. Future research should validate its efficacy across a broader range of applications, including micro-jewelry. This collaboratively developed portable tool offers a sustainable and technologically innovative solution to bolster the advancement of Indonesia's creative industry.

Keywords

Electroplating, SME, Jewelry, Portable Tool Design, Technology Innovation, Cost-Effectiveness.

Submission: 22 September 2025; **Acceptance:** 11 December 2025; **Available online:** December 2025

Introduction

The small and medium-sized jewelry enterprises in Indonesia is a pivotal industry that substantially enhances the national economy, especially regarding employment generation and the elevation of local product value. Nonetheless, despite its significant potential, the jewelry SME sector encounters numerous hurdles, one of which is restricted access to suitable metal plating or electroplating equipment. Electroplating is essential for augmenting the aesthetic appeal, longevity, and commercial worth of jewelry items(Brepohl, 2001). Regrettably, the majority of existing electroplating technologies are tailored for large-scale enterprises, necessitating substantial investment, ample workspace, and specialized technical proficiency, rather than catering to small scale requirements

The current circumstances reveal that electroplating equipment is typically substantial, costly, and rigid in functionality, rendering it inappropriate for small and medium-sized enterprises (SMEs) with constrained capital and limited production space. The absence of ergonomic designs and sufficient safety systems (e.g., ventilation) further heightens operational risks for SME operators. These challenges lead to diminished production efficiency, variable plating quality, and elevated costs due to the necessity of outsourcing electroplating services.

Prior research has consistently highlighted the importance of electroplating for the jewelry sector, emphasizing its role in enhancing visual appeal(Indriastuti, Surti, 2005), prolonging material longevity, and offering corrosion protection(Sumardi, S., & Sriatun, 2014). Studies by (Yuliana and Hartono, 2022) and (Hidayat, 2023) confirm that the effective application of electroplating improves product quality and enhances the competitiveness of SMEs in the global market.

However, a consistent barrier persists in Indonesia: the inaccessibility of effective and appropriate electroplating technology for small businesses (Soeprapto et al., 2007; Wibowo et al., 2021). Research by (Ismail and Setiawan, 2021) and (Pratama, 2022) explicitly underscores the necessity for equipment designs that are straightforward, cost-effective, and specifically adapted to the requirements of SMEs, considering factors like size, capacity, and ease of operation.

The synthesis of this literature reveals a substantial disparity between the high cost and industrial scale of currently available electroplating technology and the fundamental requirements of Indonesian jewelry SMEs, which are characterized by limited capital, restricted space, and a need for user-friendliness and integrated safety features. There is a clear need for an innovative, portable, and ergonomically designed electroplating tool that can effectively overcome these physical and financial constraints while maintaining high plating quality

Based on the background and identified gap, the primary objective of this research is to design, develop, and evaluate a portable electroplating tool prototype that is effective, efficient, cost-effective, safe, and ergonomically suitable for small and medium-sized jewelry producers in Indonesia. This aims to provide an innovative, accessible solution to directly improve the productivity, plating quality, uniformity, and autonomy of local jewelry businesses amid escalating market competition.

Methodology

This study uses qualitative and quantitative approaches to gain a comprehensive understanding of the needs and implementation of portable electroplating equipment for jewellery SMEs. The methods used include the following main stages:

Table 1. Research Methodology Stage

No	Stages	Activities	Output
1	Literatur Study	Collection of references on electroplating, ergonomic design, case studies	Theoretical basis and gap identification
2	Observation	Observation of the plating process at three jewellery SMEs	Data on actual needs and problems in the field
3	Deep Interview	Semi-structured interviews with SME owners and operators	User requirements data and tool specifications
4	Problem Statement	Preparation of technical specifications for portable electroplating equipment	Equipment requirements specifications
5	Concept Development and prototyping	User-driven design and prototyping	Desain Prototype of a portable electroplating device
6	Testing Prototipe	Testing the performance of the tool with a copper plating solution	Technical and ergonomic performance evaluation
7	Data Analysis	Analysis of test results and user feedback	Conclusion on the effectiveness of the tool

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1. Literature review was performed to collect information on the fundamental principles of electroplating, the features of commercially available electroplating equipment, ergonomic considerations in the design of small industrial apparatus, and case studies regarding the application of electroplating technology in the creative sector. Data sources comprised scientific publications, textbooks, research reports, and pertinent patent filings.
2. Field observations were performed at three jewellery SMEs in Bekasi (Eka Permata Shop), Bandung (PT. Rekayasa Plating), and Riau (Heri Permata Shop). The observations were to comprehend the true conditions of the electroplating process, ascertain facility constraints, user requirements, and safety considerations that must be addressed. The subsequent distinctions in apparatus, preparation, and procedures at each SME sample
3. Semi-structured interviews were performed with business proprietors, technicians, and plating process operators at each small and medium-sized enterprise (SME). The questions aimed to investigate user experiences, technical difficulties encountered, equipment repair requirements, and preferences for optimal equipment design. The interview data were analyzed topically to ascertain functional and technical equipment requirements.
4. Formulation of Equipment Requirements The results of literature studies, observations, and interviews were compiled to formulate equipment requirement specifications.
5. Concept and Prototype Development Based on the specifications that have been formulated, the design concept for a portable electroplating device was developed. An initial prototype was

created for the main body and support tray, with a modular configuration for easy assembly and disassembly.

6. Prototype Testing The prototype was tested using a standard copper plating solution, with samples consisting of copper bracelets/jewellery. The parameters evaluated included: (a)Voltage stability during the process, (b)Plating time until optimal results, (c)Plating quality (uniformity, gloss, layer thickness), (d)Operational ease and ergonomics of use (e)Effectiveness of gas ventilation in maintaining work safety
7. Data Analysis Data from the trials was collected and analysed descriptively to evaluate the performance of the device based on technical parameters and user feedback. The results of the analysis were used to assess the advantages, limitations, and potential for further development of this portable electroplating device

Results and Discussion

The preparation, instruments, and methodologies for each sample differed. The workstations for each example failed to comply with ergonomic standards, demanded excessive space, and lacked proper organization. of the three samples,

Field Observation Summary

Workstations in all SMEs lacked ergonomic standards, required excessive space, and showed inconsistent process sequencing. PT. Rekayasa Plating demonstrated the most effective workflow.

Comparative Equipment Summary

Before presenting the comparative data, it is necessary to describe the general differences observed across the three SMEs. Each SME uses varying equipment configurations depending on available resources, workspace conditions, and operational practices. These variations influence workflow efficiency, safety, and plating quality. The following table summarises the key equipment differences identified during observations.

Table 2. Comparative Equipment

Equipment	Toko Eka Permata Bekasi	PT. Rekayasa Plating Bandung	Toko Heri Permata Riau
Power Supply	Adaptor	Rectifier (DC power supply)	Adaptor
Anode–Cathode	Yes	Yes	Yes
Heating Tools	Heat gun	Heater & stirrer	Heat gun
Ventilation	None	Exhaust blower	None

Process Comparison

The electroplating stages conducted at each SME show distinct differences in sequence and thoroughness. These variations contribute to inconsistencies in coating results and production times. To illustrate these differences more clearly, Table 3 provides a comparison of the main process stages across the three SMEs

Table 3. Comparative Process

Stage	Toko Eka Permata Bekasi	PT. Rekayasa Plating Bandung	Toko Heri Permata Riau
Cleaning	Brushing – Molen -Polish	Cleaning – Rinse - Pickling	Brushing - Polish
Plating	E plating #1 – E plating #2	E plating	E Plating #1 – E plating #2
Finishing	Rinse - Dry	Rinse - Dry	Rinse - Dry

Prototype Overview

The prototype includes:

- Main body: 400 × 110 × 150 mm
- Adjustable voltage (2–5 V)
- Polypropylene structure
- Modular containers for pickling, cleaning, and plating
- Built-in ventilation fan

Final Design of the Electroplating Equipment The final design of the electroplating equipment consists of one main body measuring 400 mm x 110 mm x 150 mm and two support bodies for holding e-cleaning, pickling, plating, and rinsing solutions.

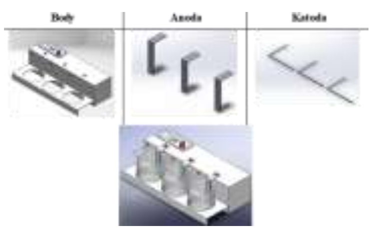

Figure 3. Prepare eletroplating portable

Figure 4. Set up components

Figure 5. Prototype

Performance Test Results

Figure 5. Product opertional scheme

To evaluate the functionality and effectiveness of the developed portable electroplating tool, performance tests were conducted using copper plating on jewelry samples. The evaluation focused on electrical stability, duration of plating, coating quality, ergonomics, and safety. The summary of these test results is presented in the following table.

Table 4. Test Result with electroplating portabel tools

Parameter	Result
Voltage Stability	Stable at 2 – 5 V
Couting Duration	12 minutes (vs. 18-20 minutes conventional)
Coating Quality	Uniform, glossy, abrasion – resistant.
Ergonomics	High (minimal movement- requared)
Ventilation	Effective in reducing fumes

Discussion

The device cut plating time by 30 to 40 percent, which matches findings from studies showing how modern technology helps small aand medium businesses work more efficient. The even coating made the product more competitive, which backs up earlier research on how important good electroplating quality is. The stable voltage proved that a lowcost electrical system is possible. The design that's easier on the body helped workers feel less tired and made the work process faster, which fits with guidelines for making tools that are good for small businesses. The built in ventilation system made the workplace safer by reducing exposure to harmful chemicals.
Novelty: Unlike conventional systems, this equipment is easy to move, takes up less space, and was made especially for more small businesses with low budgets, safety, comfort, and the ability to be changed or expanded are key parts of its design.
Business Implications: (1). Helps cut costs from outsourcing, (2) Allows for quickchanges to meet customer needs, (3) Opens up more possibilities for new designs, (4) Boosts the independence and output of small businesses

Conclusions

This study successfully developed a compact, efficient, and affordable electroplating device tailored for Indonesian jewelry SMEs. The tool demonstrated shorter plating times, stable electrical performance, improved coating quality, ergonomic workflow, and enhanced safety through built-in ventilation. These improvements support SMEs in reducing production costs, increasing efficiency, and elevating product quality.

Future research should address the following: (1). Integration of automation for voltage and timing control, (2). Use of more durable and eco-friendly materials, (3). Advanced filtration systems to enhance operator safety, (4). Sensor-based monitoring for real-time quality control, (5). Broader-scale industrial trials in micro-jewelry and electronics sectors

Acknowledgements

The authors are grateful to LPPM ITSB for the invaluable support provided, enabling the completion of this paper.

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