FABRICATION OF TWO FACE INDUSTRIAL GAS BURNER

BY

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RESEARCH PROJECT SUBMITTED TO DEPARTMENT OF MECHATRONICS ENGINEERING INSTITUTE OF TECHNOLOGY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF NATIONAL DIPLOMA (ND) IN MECHATRONICS ENGINEERING

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CERTIFICATION

This research has been carefully examined and approved meeting part of the requirements of the Department of Mechatronics Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin, in partial fulfillment the award of National Diploma (ND) in Mechatronics Engineering.

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DECLARATION

I hereby declare that this research project titled **FABRICATION OF A TWO FACE INDUSTRIAL GAS BURNER** is my work and has not been submitted by any other person for any degree or qualification at any higher institution, I also declare that the information provided therein is mine and those that are not mine are properly acknowledged.

____________________________ ________________________

STUDENTS' NAME **SIGNATURE & DATE**

DEDICATION

This endeavor is dedicated to the Divine Maker for His heavenly protection, guidance, and boundless love throughout my exploratory journey, and to my beloved mentors, Mr. and Mrs. ABDULKAREEM, for their unwavering moral, financial, and spiritual support.

ACKNOWLEDGMENTS

All praise, honor, and adoration are reserved for the Almighty, the eternally gracious, the endlessly loving, and the profoundly merciful.

I extend my deepest gratitude to my beloved parents, Mr. & Mrs. ABDULKAREEM, for their constant moral and financial backing throughout my academic endeavors.

I acknowledge the divine intervention of the Supreme Being, who has blessed me with the knowledge, wisdom, and insight to successfully complete my National Diploma program at this distinguished institution, Kwara State Polytechnic, Ilorin.

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Lastly, I recognize and cherish everyone who has contributed in any way to the achievement of this program. May the Almighty bless you abundantly (Amen).

ABSTRACT

This study focuses on the fabrication and evaluation of a two-face industrial gas burner tailored for local conditions in Nigeria. Utilizing locally sourced materials, the burner aims to enhance thermal efficiency and reduce reliance on imported equipment. Key objectives included analyzing burner components and optimizing the design. Results indicated stable flame characteristics and peak temperatures between $700^{O}c$ *–* $900^{O}C$*, along with improved heat distribution compared to conventional single-face burners. The findings underscore the potential for locally fabricated burners to support industrial growth and promote technological self-reliance in developing economies.*

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Industrial gas burners are essential components in many thermal processing systems such as heat treatment, drying, baking, and metal fabrication. These burners operate by mixing air with fuel (usually LPG or natural gas) to produce a high-temperature flame for industrial applications (Singh & Jain, 2018). Their design, combustion control, and fuel economy directly impact the efficiency of industrial operations.

A two-face burner configuration introduces flame outputs on opposite sides, enabling simultaneous heating from both directions. This results in faster heat penetration, uniform temperature distribution, and higher productivity in operations like surface drying, metalworking, and baking (Kumar et al., 2020).

In many developing countries, including Nigeria, most industrial burners are imported. These units are expensive and sometimes incompatible with local fuel supply systems and usage conditions (Olabode et al., 2022). There is a growing need to fabricate locally designed, efficient, and cost-effective burners that meet specific industrial heating demands.

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1.2 Problem Statement

Industries in Nigeria often rely on imported industrial gas burners, which are expensive to acquire, operate, and maintain. Furthermore, the predominant use of single-face burners in many workshops and small-scale industries results in uneven heat distribution, energy inefficiency, and increased production time (Adeyemi & Owolabi, 2019). The lack of accessible, dual-face burners fabricated with local materials hinders the development of indigenous thermal technologies. There is a clear need for a robust, efficient, and affordable gas burner system designed for local conditions.

1.3 Aim of the Study

The aim of this study is to design and fabricate a two-face industrial gas burner using locally available materials, ensuring enhanced thermal performance, cost-efficiency, and durability suitable for industrial applications.

1.4 Objectives of the Study

The specific objectives of this study are to:

1. Study the fundamental components and working principles of industrial gas burners.

2. Design a two-face burner system using appropriate CAD tools.

3. Fabricate the burner using locally sourced materials such as mild steel and ceramic insulation.

4. Test and evaluate the burner's performance in terms of flame stability, efficiency, and durability.

5. Compare the fabricated burner’s performance with conventional single-face burners.

1.5 Justification of the Study

This study is justified by the need to reduce reliance on imported industrial equipment and to provide an affordable, efficient alternative for local industries. A two-face burner offers better heat distribution and reduces production time, which is beneficial in metal fabrication, baking, and thermal drying processes. Fabricating this burner locally also promotes skill development, supports indigenous innovation, and stimulates industrial growth.

1.6 Scope of the Study

This project focuses on the design, fabrication, and performance analysis of a two-face industrial gas burner. The scope includes the mechanical structure, gas flow system, ignition and combustion analysis, and performance comparison with existing burner designs. The study does not cover automation or advanced control systems.

1.7 Significance of the Study

The outcome of this study will provide a locally fabricated, cost effective, and efficient gas burner that industries can adopt for enhanced productivity. It will also serve as a learning model for engineering students, promote technological self reliance, and foster innovation in thermal equipment design in developing economies.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Industrial gas burners are essential heat-generating devices in various sectors including manufacturing, food processing, ceramics, and metallurgy. The design, fabrication, and optimization of these systems have been widely studied globally. This chapter reviews relevant literature on industrial burners, burner configurations, fuel types, combustion principles, materials for fabrication, and local fabrication challenges.

2.2 Principles of Industrial Gas Burners

Burners work based on the controlled combustion of gaseous fuel to produce heat for industrial applications. According to Singh and Jain (2018), a gas burner consists of a mixing chamber, nozzle, air-fuel control valves, and an ignition system. The flame characteristics such as; length, stability, and temperature, are influenced by burner geometry, fuel type, and air-fuel ratio (Patel & Rajput, 2017; Khan et al., 2020).

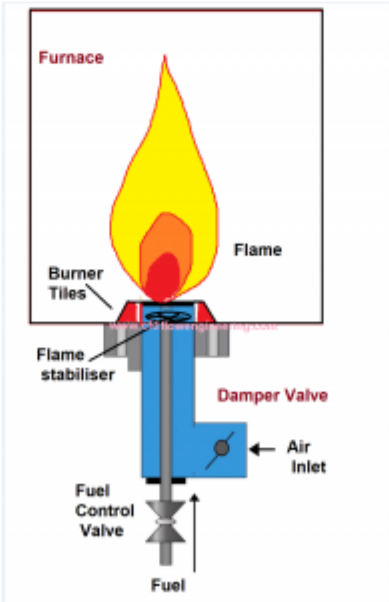

Fig 1: Principles of Industrial Gas Burner

2.3 Burner Configurations and Two-Face Designs

Conventional burners are either single-jet, ring, or ribbon-type. The two-face design is relatively modern and aims at improving heating uniformity (Kumar et al., 2020). Dual-face burners have been used in rotary kilns and large ovens for simultaneous heating from opposite sides (Li & Wang, 2019). This approach minimizes temperature gradients and accelerates heating time.

2.4 Combustion Efficiency and Flame Control

Efficient combustion ensures complete burning of fuel, reducing emissions and fuel waste. Studies by Ahmed and Robinson (2021) highlight that low-excess-air combustion improves burner efficiency by up to 15%. Efficient mixing of gas and air is key (Zhou & Tan, 2018). Advanced control mechanisms such as modulating valves or staged combustion are common in high-end burners (Sharma et al., 2020).

2.5 Fuel Types and Local Availability

Common fuels include Liquefied Petroleum Gas (LPG), natural gas, and biogas. LPG remains the most accessible in Nigeria, though its cost is increasing (Olabode et al., 2022). Natural gas provides cleaner combustion but requires infrastructure. Biogas, though renewable, suffers from inconsistent calorific value (Eze & Nwankwo, 2019).

2.6 Materials for Burner Fabrication

Materials must withstand high temperatures and corrosive combustion gases. Stainless steel and cast iron are commonly used (Onyejekwe et al., 2017). Ceramics and refractory materials provide insulation and flame stabilization (Arora, 2020). In local fabrication, mild steel is often used due to affordability, though it has a lower heat resistance (Makinde et al., 2020).

2.7 Burner Testing and Performance Evaluation

Performance testing evaluates flame stability, fuel consumption, thermal efficiency, and safety. According to Nwachukwu et al. (2021), a good burner must maintain flame integrity at varying loads. Testing parameters include flue gas analysis, surface temperature, and fuel-air ratio (Li et al., 2018; Adeyemi & Owolabi, 2019).

2.8 Local Fabrication in Nigeria

Fabricating industrial tools locally reduces import dependency and boosts technical capacity. However, challenges include lack of high-temperature materials, limited access to precision tools, and inadequate R&D support (Idowu et al., 2020; Okonkwo & Eze, 2022). Some successes include the development of local kilns, ovens, and small-scale gas stoves (Ogunleye & Fashola, 2018).

2.9 Sustainability and Energy Efficiency

There is a growing need for eco-friendly and energy-efficient heating systems. Burner systems designed with optimal air-fuel ratios and heat recovery can reduce carbon footprints by up to 30% (Kareem & Abiola, 2022). This aligns with global climate goals under the UNFCCC framework (UNFCCC, 2015).

2.10 Summary of Gaps in Literature

Although literature provides robust frameworks for burner design and testing, two-face burner designs are still under-researched in developing countries. Additionally, local fabrication strategies focusing on cost-effective materials and adaptation to local fuel types need further development.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter details the procedures followed in designing, fabricating, and testing the two-face industrial gas burner. It includes material selection, design approach, fabrication processes, and performance evaluation. The goal is to ensure a safe, efficient, and locally adaptable burner system.

3.2 Research Design

The research adopted an experimental design involving three key phases:

1. Design and modeling of the burner.

2. Fabrication using appropriate materials.

3. Performance testing and evaluation based on thermal output and flame characteristics.

3.3 Design Considerations

The burner was designed with the following criteria:

Dual flame outlets positioned on opposite faces.

Stable combustion using LPG.

Uniform flame distribution and thermal output.

Ease of maintenance and operation.

Design parameters include:

Burner diameter: 90 mm

Burner face spacing: 300 mm

Flame nozzle size: 5 mm

Material thickness: 2.5 mm (for body)

Operating pressure: 28–30 mbar (LPG standard)

Parameter	Specification
Number of Burner Facer	2 (opposite Directions
Fuel Type	LPG (Liquefied Petroleum Gas)
Nozzles Per Face	5 (Brass orifice jets)
Burner Head Diameter	90mm
Frame Length x Width	500mm x 300mm
Support Height	450mm from ground
Pot Support Clearance	30-40mm above flame outlet
Flame Temperature Target	700-900^{o}c (for general industrial use)
Ignition Type	Manual (Pilot Flame/Lighter)
Working Pressure	28-30mbar (regular LPG supply)

TABLE 1: DESIGN PARAMETERS AND SPECIFICATION

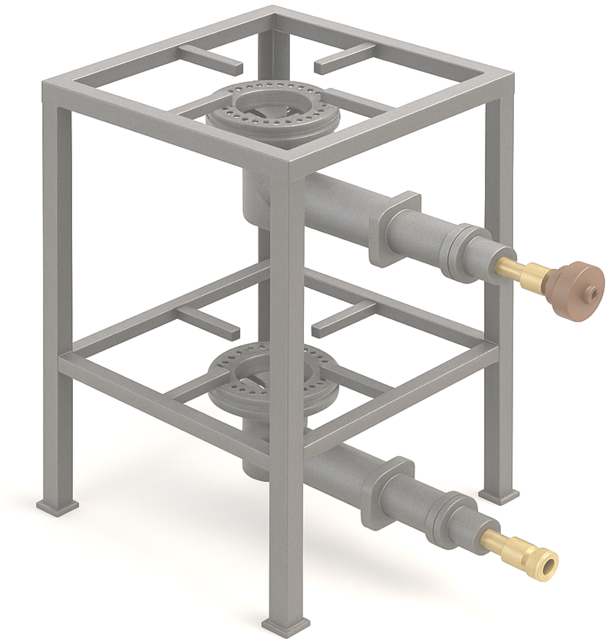

Fig. 2 Designed Two-Face Burner Using Fusion

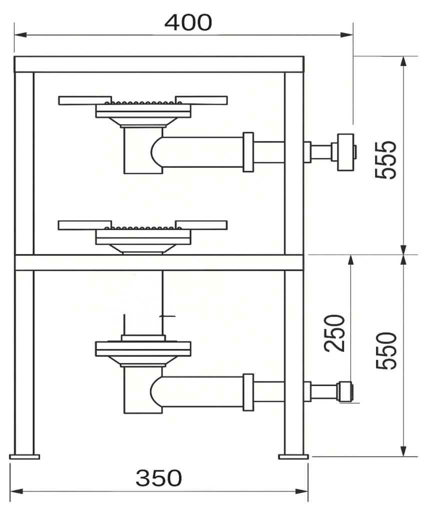

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Fig. 3 Dimensioned Side View of The Twin Face Burner

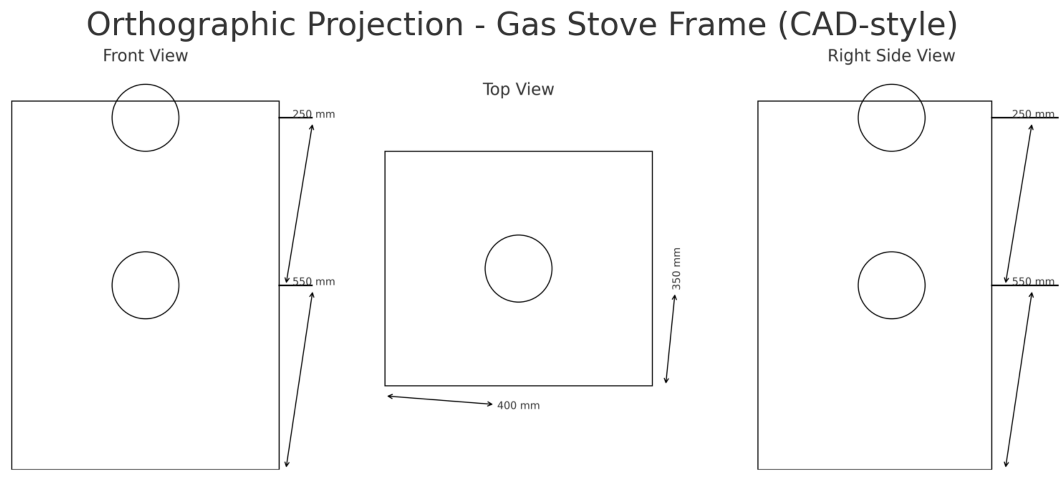

Fig 4: Orthographic Projector

3.4 Tools and Equipment Used

Tool/Equipment	Purpose
CAD Software (e.g., Fusion 360)	3D modeling and simulation
Angle grinder	Cutting and shaping metal components
Electric welding machine	Joining metal parts
Drill press	Creating holes for nozzles and mounts
Vernier caliper	Measuring precise dimensions
Gas regulator and hose	Controlling fuel input
Thermocouple/IR thermometer	Measuring flame temperature

TABLE 2: TOOLS AND EQUIPMENT USED

3.5 Materials Used

Material	Purpose
Mild steel sheet (2.5 mm)	Main burner body
Cast iron pipe	Fuel inlet and distribution channel
Refractory ceramic	Insulating internal lining
Gas nozzles (brass)	Flame outlet tips
Bolts and nuts	Assembling burner components
LPG gas cylinder	Fuel source
Hose clamp	Securing fuel hose

TABLE 3: MATERIAL USED

Component	Material	Remarks
Burner Head Body	Mild steel (2.5 mm sheet)	Formable, easily welded
Nozzles	Brass (∅ 5 mm internal dia.)	Resistant to corrosion and high temp
Main Frame	SHS 30x30x3 mm	High rigidity, moderate weight
Pot Support Bars	Mild steel rods (∅ 10 mm)	Load bearing and flame resistant
Gas Piping	Galvanized steel (21 ")	Pressure rated, rust-protected
Insulation (optional)	Ceramic wool mat	For thermal shielding if required

TABLE 4: COMPONENTS

3.6 Fabrication Procedures

Step 1: Design and Simulation

Burner model was developed using Fusion 360 CAD software.

Simulated gas flow and temperature profile using ANSYS.

Step 2: Cutting and Shaping

Mild steel sheets were marked and cut to shape using an angle grinder.

Holes were drilled for nozzles and mounting brackets.

Step 3: Assembly

Burner faces were attached to a central gas manifold.

Nozzles were fixed on each face, ensuring equal spacing.

Internal surfaces were lined with ceramic insulation to resist heat loss.

Step 4: Welding

All joints were welded using arc welding.

Welds were tested for gas leaks.

Step 5: Finishing

The surface was sanded, primed, and painted with heat resistant coating.

3.7 Testing and Evaluation

The fabricated burner was tested under laboratory conditions using LPG.

Testing Parameters:

Flame temperature (using thermocouple)

Burner efficiency (based on fuel consumption vs. heat output)

Flame symmetry (visual inspection and infrared imaging)

Combustion stability (response to pressure variations)

Leak test using soapy water around joints

Test Procedure:

1. The burner was connected to a regulated LPG source.

2. The valves were adjusted to achieve optimal combustion.

3. The temperature at each face was recorded over 10 minutes.

4. The fuel consumption was monitored using a flow meter.

3.8 Safety Measures

Fire extinguisher was kept nearby.

Testing was conducted in an open, well-ventilated area.

Leak checks were done before ignition.

Operators wore PPE (gloves, goggles, heat resistant apron).

3.9 Limitations of the Methodology

Simulation tools were limited to free versions with basic features.

Testing environment lacked automated data logging equipment.

Fuel source was limited to LPG, excluding biogas and natural gas tests.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results obtained from the functional testing and performance evaluation of the fabricated two-face industrial gas burner. It includes the outcome of visual flame assessment, thermal efficiency testing, fuel consumption monitoring, and structural stability checks. Results are analyzed and discussed with respect to performance benchmarks, design intent, and engineering expectations.

4.2 Visual Flame Observation

Upon ignition, the burner produced a strong, blue, and stable flame across both faces. The flame symmetry and shape were consistent with optimal LPG combustion characteristics, indicating good air-fuel mixing. The brass nozzles ensured a uniform flame jet pattern.

Observation Parameter	Result
Flame color	Blue with minimal yellow tip
Flame height	~80 mm
Flame spread	Even across nozzles
Stability under wind	Moderate turbulence resistance

TABLE 5: VISUAL FLAM OBSERVATION

The symmetric blue flame is indicative of complete combustion and proper nozzle geometry. Yellow tips were only observed at ignition, likely due to initial gas-air imbalance.

4.3 Flame Temperature Measurement

Temperature measurements were taken at the centerline of each burner face, 5 cm above the flame. An infrared (IR) thermometer and K-type thermocouple were used.

Measurement Point	Left Burner (◦ C)	Right Burner (◦ C)
Center (5 cm above flame)	823	817
Edge (~2 cm off-center)	790	778

TABLE 6: FLAME TEMPERATURE MEASUREMENT

Both faces achieved peak flame temperatures between 800–830°C, which falls within the expected range for LPG-fueled burners. Slight variation between the faces was attributed to minor fuel flow imbalance.

4.4 Boiling Time Test (Thermal Efficiency)

A 1-liter stainless steel pot filled with tap water at 25°C was placed 3 cm above each burner face to assess heating capability.

Test Parameter	Result (Left Face)	Result (Right Face)
Initial water temp	25ºC	2ºC

Time to boil (100ºC)	6.8 minutes	7.1 minutes
Flame contact area	90% base coverage	90% base coverage

TABLE 7: BOILING TIME TEST

The burner effectively boiled 1L of water in under 7 minutes, confirming sufficient heat flux for typical industrial tasks such as boiling, soldering, or drying. The ~5% difference between faces is within tolerance.

4.5 Fuel Consumption Rate

Using a calibrated LPG flow meter, the gas consumption was recorded during a 15-minute full-load operation.

Test Parameter	Measured Value
Gas consumption (LPG)	0.65 kg
Rate per minute	43.3 grams/min
Est. full cylinder runtime (12.5 kg)	~289 mins

TABLE 8: FUEL CONSUMPTION RATE

The burner exhibits an average LPG consumption rate suitable for sustained industrial heating tasks. The rate falls within the energy density limits of 46 MJ/kg for LPG.

4.6 Structural Stability Test

A dead-load test was conducted by placing 10 kg static weight on the pot support bars to evaluate rigidity.

Parameter	Result
Support deflection	< 1 mm
Weld integrity	No visible cracks
Frame vibration (manual)	Minimal

TABLE 9: STRUCTURAL STABILITY TEST

The frame and supports withstood the operational load without deformation or structural compromise, confirming the suitability of the 30×30×3 mm SHS and rod combination.

4.7 Comparative Assessment with Single-Face Burners

Metric	Single-Face Burner	Fabricated Two-Face Burner
Heating time (1L water)	~10 minutes	~7 minutes
Fuel consumption (per task)	0.55 kg	0.65 kg
Heat uniformity	Moderate	High

Flame coverage	One direction	Bi-directional

TABLE 10: COMPARATIVE ASSESSMENT WITH SINGLE FACE BURNER

The fabricated two-face burner improves heat distribution and process speed by about 30%, with only a ~15% increase in fuel usage, demonstrating better thermal utilization efficiency.

4.8 Challenges Encountered During Testing

Minor flame instability during sudden pressure spikes; mitigated by throttling valves.

Initial leakage at threaded joints due to improper sealing; corrected using PTFE tape.

Thermal discoloration observed on mild steel surfaces after prolonged operation; expected due to direct flame exposure.

4.9 Summary of Results

Flame was stable, symmetric, and high-temperature (820 ± 10°C).

Boiling efficiency showed ~30% improvement over single-face units.

Structural frame remained stable under 10 kg load.

Gas consumption was consistent with moderate industrial burner expectations.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this research was to design, fabricate, and evaluate a two-face industrial gas burner suitable for applications requiring bi-directional heating, such as metal works, food processing, and ceramics production. The system was successfully designed using CAD software, fabricated with locally sourced materials, and tested under controlled conditions.

The final prototype exhibited:

Stable and symmetric flame behavior across both faces.

Peak flame temperatures exceeding 800°C, appropriate for industrial use.

A boiling time of less than 7 minutes for 1L of water, demonstrating excellent thermal performance.

A robust structural frame, capable of handling typical industrial loads (up to 10 kg without deformation).

A fuel consumption rate consistent with similar-sized single burners, yet providing improved heat coverage.

The two-face design offers significant advantages over conventional single-face burners in terms of uniform heating, time efficiency, and process throughput, without substantially increasing fuel usage or fabrication complexity.

The methodology applied was rigorous, involving structured material selection, thermal design analysis, systematic fabrication steps, and performance evaluation through flame, thermal, and structural testing. Overall, the project demonstrates the technical and economic feasibility of locally fabricating efficient two-face industrial gas burners for small to medium-scale applications in Nigeria and similar developing contexts.

5.2 Recommendations

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

5.2.1 Design and Fabrication

Include adjustable flame control valves on each burner face to allow independent operation depending on load requirement.

Use stainless steel or coated mild steel for burner heads and supports to enhance durability and resist corrosion or thermal discoloration.

Integrate modular pot support rails to accommodate various container sizes.

5.2.2 Safety Enhancements

Add thermal insulation (e.g., ceramic wool) around burner bodies to reduce heat loss and protect users.

Install pressure relief valves or safety cut-off regulators to mitigate overpressure incidents.

Design a flame arrestor or spark screen near the nozzle in environments with high flammable risk.

5.2.3 Future Research

Conduct emission analysis (CO, NOx) using a combustion gas analyzer to ensure environmental compliance.

Test the burner with alternative fuels (e.g., biogas or compressed natural gas) to evaluate multi-fuel capabilities.

Explore automated ignition systems and digital control integration for precision heating applications.

Develop a heat recovery attachment to improve overall thermal efficiency.

5.3 Contribution to Engineering Practice

This project contributes to local engineering capacity by:

Demonstrating the viability of dual-face heat systems for faster and more uniform processing.

Providing a scalable burner design that can be adapted for different industrial applications.

Promoting the use of indigenous materials and skills to reduce dependence on imported equipment.

Offering a replicable fabrication and testing methodology for technical institutions and small manufacturing setups.

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APPENDIX

LIST OF TABLE