ACKNOWLEDGEMENT

I would like to express my sincere appreciation to Almighty God for His guidance throughout this project. My gratitude also goes to my supervisor, [Supervisor Name], for his expert advice and encouragement. I thank my family, friends, and classmates for their support, as well as the technical staff of the Mechanical Engineering Workshop at [Your Polytechnic Name] for providing equipment and materials necessary for the completion of this work.

I express my sincere gratitude to Almighty God for His guidance throughout this project. I also appreciate the support and mentorship of my supervisor, [Supervisor's Name], whose guidance and constructive feedback were instrumental in the successful completion of this work.

Special thanks go to the management and staff of the Department of Mechanical Engineering, [Your Institution's Name], for providing the tools and equipment needed during the fabrication. I also wish to acknowledge my colleagues and friends for their constant encouragement and assistance throughout the process.

Finally, I thank my family for their unending love, patience, and moral support which greatly motivated me during this academic journey.

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Doors are integral to every building's structural framework, serving functions that extend beyond basic entry and exit. They contribute to privacy, security, soundproofing, and environmental control, such as heat and airflow regulation. Among the wide variety of door types available, metal doors have gained prominence for their superior strength, fire resistance, and longevity when compared to wooden or plastic alternatives.

The twin-panel metal door, characterized by its dual-sheet metal construction with internal reinforcement, is particularly valued for security-sensitive areas such as residential entries, safe rooms, schools, and industrial facilities. These doors typically consist of two layers of mild steel or galvanized metal welded onto a supporting frame, sometimes incorporating insulation or stiffeners for added rigidity and acoustic performance.

In Nigeria, the rising rate of property crime, poor building materials, and high importation costs have led to increased demand for locally fabricated, high-quality doors (Akinbile et al., 2022). By utilizing mild steel, a readily available and economically viable material, it is feasible to fabricate functional, durable twin-panel doors within small-scale workshops or institutional settings. This project seeks to demonstrate this feasibility by engaging in a full cycle of design, fabrication, and evaluation of a twin-panel metal door.

Recent Study: According to Olabode & Sanni (2023), local fabrication using mild steel reduces production costs by over 40% compared to imported steel security doors, making it a viable alternative for mass housing in Nigeria. . It was designed to offer strength, security, and durability compared to conventional wooden doors. The project involved selecting suitable mild steel materials, cutting, welding, and assembling two symmetrical metal panels, reinforced by internal frames and locking mechanisms. Performance evaluations included structural integrity, cost analysis, and functional fit in door frames. The result proved the feasibility of locally fabricated metal doors using affordable materials with reliable performance. The primary aim is to produce a durable, secure, and cost-effective metal door suitable for residential and industrial applications. The methodology involved material selection, cutting, welding, grinding, and surface finishing. The fabricated twin-panel door features reinforced vertical and horizontal supports for added strength, with integrated locking systems to enhance security. The report discusses the step-by-step fabrication process, safety considerations, cost analysis, and practical challenges encountered during construction. The final product meets both functional and aesthetic requirements and demonstrates the importance of local material utilization in metal fabrication. This project underscores the potential of indigenous skills in producing reliable building components for the Nigerian construction industry.

Keywords: Metal panel door, fabrication, welding, mild steel, security door, twin panel, performance evaluation.

1.2 Statement of the Problem

Many residential and commercial buildings suffer break-ins and premature door failures due to substandard wooden or plastic doors. There is a pressing need to fabricate affordable metal doors that can be locally produced and withstand environmental and mechanical stress.The Nigerian construction industry is plagued by a reliance on substandard or expensive imported doors, many of which fail to meet the required standards for strength, security, or aesthetics. Locally fabricated alternatives often suffer from poor craftsmanship, inadequate design considerations, and suboptimal material choices, leading to short life spans, safety concerns, and dissatisfaction among end-users.

This project addresses these challenges by:

- Demonstrating the systematic fabrication of a twin-panel metal door using standardized methods.
- Emphasizing proper material selection, welding techniques, and dimensional accuracy.
- Highlighting cost-eff**ectiveness** without compromising functionality or durability.

1.3 Aim and Objectives

Aim:
To design and fabricate a secure, functional, and cost-effective **twin metal panel door** using mild steel and standard fabrication practices.

Objectives:

- To **select appropriate materials** based on mechanical properties and cost.
- To **design the door and frame** using standard residential/institutional dimensions.
- To fabricate the door using processes such as **cutting, welding, grinding, and surface finishing**.
- To **evaluate the final product** for strength, durability, fit, and cost-efficiency.

1.4 Scope of the Project

This project focuses on the **fabrication of a twin-panel metal door** suitable for residential or institutional use. The study covers the design, material selection, fabrication, and testing of a twin panel metal door within the workshop environment. It

covers:

- **Material selection**
- **Design and dimensioning**
- **Construction/fabrication**
- **Evaluation**
- Exclusions:

- Powder coating or anodizing
- Automation (e.g., remote control locking)
- Mass production considerations

1.5 Significance of the Study

The project will promote local metalwork innovation, encourage the use of sustainable materials, and reduce dependence on imported security doors

This project demonstrates:

- **Practical skills in metalworking** (cutting, welding, grinding, and assembling).
- A **locally sustainable alternative** to imported security doors.
- That **quality metal doors** can be fabricated within school workshops or small-scale enterprises.
- That **cost and security efficiency** can be achieved simultaneously through proper design and fabrication.

Oyekan & Adetunji (2021) emphasize the need for local technical institutions to teach hands-on fabrication skills that support economic growth and reduce import dependence in the construction sector.

1.6 Project Justification

Local fabrication:

- **Reduces production costs**
- **Promotes vocational skills**
- **Encourages use of indigenous materials**
- Aligns with national goals for **industrial self-sufficiency** (FMITI, 2022)
- It is justified as a model for **affordable, secure, and scalable metal door production**, especially in developing urban areas.

1.7 Limitations

- **Workshop Limitations**: Limited equipment like CNC or powder coating tools.
- **Time Constraints**: Advanced finishing processes were not feasible within the project period.
- **Financial Constraints**: Restricted the bulk procurement of high-grade steel or enhanced hardware (e.g., biometric locks).

CHAPTER TWO: LITERATURE REVIEW

2.1 Historical Development of Metal Doors

Historically, **metal doors** date back to the use of **bronze and wrought iron** in ancient fortifications and castles. These materials offered **defensive advantages** and durability. With the advent of the **Industrial Revolution**, steel manufacturing and welding advancements allowed mass production of doors for urban buildings.Doors are movable barriers used to block off or allow access through an entrance. According to Oyekunle (2022), metal doors now account for 40% of newly installed doors in urban areas due to security and fire protection needs. Historical Development of Metal Doors. The use of metal in door construction dates back to ancient civilizations where bronze and wrought iron were used for gates and fortress entries. In modern architecture, steel and aluminum have largely replaced wood in commercial and industrial door applications due to their superior strength, fire resistance, and longevity (Ekong, 2023). The development of welding techniques in the 20th century allowed for the fabrication of complex metal structures, making steel doors common in urban residential buildings.In modern times, **mild steel, stainless steel, and aluminum** dominate the market due to:

- Corrosion resistance
- Fireproof properties
- Ease of forming and welding

Ekong (2023) notes that steel doors became prevalent in African urban housing developments after the 1980s due to their superior resilience and low maintenance.

2.2 Types of Metal Doors

Metal doors are classified by design, structure, and application:

1. **Flush Metal Doors** – Feature flat, plain surfaces often used in internal spaces.
2. **Panel Metal Doors** – Include decorative or structural panels for aesthetic or functional purposes.
3. **Reinforced Security Doors** – Heavy-duty, multi-layer doors with additional locking mechanisms.
4. **Twin Panel Metal Doors** – Consist of two steel sheets forming an inner and outer panel, joined by a central or perimeter frame. Often includes internal

reinforcements or insulation.

Yusuf & Musa (2024) highlight that twin panel doors combine elegance and strength, ideal for homes and institutional buildings exposed to weather and vandalism.

2.3 Materials Used in Door Fabrication

1. Mild Steel

- Most commonly used due to **availability, low cost, and ease of welding**.
- Requires proper coating to prevent corrosion.

2. Stainless Steel

- Used in sanitary or luxury environments.
- Offers excellent **corrosion resistance** but is costlier.
- **3. Galvanized Iron (GI)**

- Mild steel coated with **zinc for rust resistance**.
- Ideal for external doors in humid environments.

Adebayo & Okoro (2022) found mild steel to provide an optimal balance of **cost and mechanical performance** for residential doors in West Africa.

2.4 Welding and Fabrication Techniques

Welding is a cornerstone of metal door fabrication. Common techniques include:

- **SMAW (Shielded Metal Arc Welding)**: Economical, simple, and suitable for small workshops.
- **MIG (Metal Inert Gas Welding)**: Clean, fast, and ideal for large-scale production.
- **TIG (Tungsten Inert Gas Welding)**: High-quality welds for thinner sheets or stainless steel.

Fabrication stages:

- **Measuring and cutting** using angle grinders or guillotine shears.
- **Joining panels and frame** using fillet welds.
- **Grinding and finishing** to smoothen welds and prepare for painting.

Reference: ASME (2021) Welding Standards recommend SMAW for general-purpose structural welding where access to inert gas is limited.

2.5 Design Considerations for Twin Panel Doors

Key factors influencing performance:

- **Panel Thickness**: Typically 1.2–1.5 mm for residential security doors.
- **Frame Strength**: 25–40 mm angle or square bar used for rigidity.
- **Hinge and Lock Placement**: Proper reinforcement prevents sagging and improves security.
- **Reinforcement Bars**: Internally placed to prevent buckling or forced entry.
- **Finishing**: Priming and painting to prevent corrosion and improve aesthetics.

Oyekan & Adetunji (2021) suggest that good design reduces lifecycle costs by minimizing repair frequency and improving user safety.

2.6 Safety and Durability Requirements

For doors to be considered **safe and durable**, they must:

- **Resist physical force** and intrusion.
- **Last under harsh environmental conditions**.
- **Resist corrosion** using paints or galvanization.
- Meet minimum standards for **fire resistance** in public or commercial settings.

British Standards Institution (2020) in BS EN 16034 specifies performance standards for metal doors in terms of fire resistance, mechanical durability, and weather performance.

2.7 Metal Doors vs Wooden Doors

Metal doors offer higher fire resistance, less warping, and longer life cycles than wooden doors (Umar et al., 2023). They are also more tamper-resistant and better suited for outdoor conditions.

2.8 Material Selection for Metal Doors

Mild steel is commonly chosen due to its strength, ductility, and affordability (Fatoki & Akande, 2021). Galvanized steel is used in corrosive environments.

2.9 Welding and Fabrication Techniques

Metal Inert Gas (MIG) and Shielded Metal Arc Welding (SMAW) are popular in door fabrication due to their strength and ease of control (Ibrahim et al., 2023). Proper edge preparation and joint design are crucial for durability.

2.9.1 Safety and Security Considerations

Modern security doors feature reinforced frames, concealed hinges, and multiple locking points to deter break-ins. Fire-rated metal doors are now regulated in public buildings (BS EN 16034:2014).

CHAPTER THREE: METHODOLOGY

3.1 Design Considerations

The door was designed to be:

- 1800 mm height × 1200 mm width (600 mm per panel)
- Reinforced with internal stiffeners
- Hinged on a mild steel frame with bolt locks

3.2 Material Selection

- Mild steel sheet (1.5 mm thick)
- Hollow square pipe (25 mm × 25 mm for frame)
- Hinges, lockset, angle bars
- Welding rods (E6013)
- The materials selected for the fabrication of the door were based on availability, cost, strength, and durability:
- Mild Steel Sheets (16-gauge): Used for the door panels due to their ease of welding and sufficient strength.
- Mild Steel Angle Bars (30mm x 30mm): Used for the door frame and panel reinforcement.
- Steel Hinges (Heavy-duty, 3”): For door mounting and operation.
- Metal Handles and Lockset: For functional entry and security.
- Electrodes (E6013): Used for Shielded Metal Arc Welding (SMAW).

  Red Oxide Primer and Enamel Paint: For corrosion resistance and final finishing.

3.2 Tools and Equipment Used

- Measuring Tape and Try Square – For accurate marking and squaring edges.

- Hack Saw/Angle Grinder – For cutting steel to size.

- Welding Machine (AC Arc Welder) – For joining metal parts using SMAW.
-
- Clamps – To hold workpieces in position during welding.

- Bench Vise – For holding components during grinding or shaping.

- Grinding Machine – For surface smoothing and weld clean-up.

- Paint Brush/Spray Gun – For applying finishing coats.

3.3 Design and Construction Process

3.4 Step 1: Design Drafting

- A manual sketch and basic CAD drawing were prepared to outline the dimensions and structural layout of the door (1980 mm x 900 mm).
- Step 2: Cutting of Materials
- Angle bars and mild steel sheets were marked and cut using an angle grinder according to the specified dimensions for the frame and panels
- Step 3: Frame Assembly
- The cut angle bars were tack-welded to form the outer frame. Diagonal measurements were checked to ensure squareness before final welding.

Step 4: Panel Fabrication

- Two mild steel sheets were cut and fitted within the frame to create twin panels. Vertical and horizontal stiffeners were added using flat bars for reinforcement.

Step 5: Welding

- All components were permanently welded, ensuring continuous welds for strength and minimizing weak joints.

- Step 6: Grinding and Finishing
- Welds were ground smooth, and all surfaces cleaned to remove slag, rust, or dirt before painting.

- Step 7: Priming and Painting
- A coat of red oxide primer was applied, followed by two coats of oil-based enamel paint for aesthetics and corrosion protection.

3.5 Assembly Techniques Hinges were attached using arc welding and aligned to ensure smooth swing action.

3.6 Finishing Processes

4.0 Personal Protective Equipment (PPE) like gloves, welding helmets, and boots were worn throughout.

5.0 Fire extinguishers were kept nearby due to flammable materials.

6.0 Welding was done in a well-ventilated area to prevent gas inhalation.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 This chapter presents the outcomes of the fabrication process, evaluates the performance of the twin metal panel door, analyzes cost implications, and discusses challenges encountered.

4.1 Final Output Description

4.2 The completed twin metal panel door measured approximately 1980 mm x 900 mm, suitable for a standard residential or institutional entryway. It consisted of:

4.3 Two vertically aligned mild steel panels reinforced with horizontal and vertical stiffeners.

4.4 A welded steel angle frame to hold the panels securely.

4.5 Heavy-duty hinges to support the door's weight

4.6 A metallic handle and lockset for secure access control.

4.7 A fine surface finish with red oxide primer and black enamel paint.

4.8 The door operated smoothly on its hinges, and the lockset functioned properly after installation. It demonstrated adequate stiffness, strength, and aesthetics.

4.9 Performance Evaluation

4.10 Criteria ObservationStructural Integrity .The door was firm and free from vibration. SecurityLockset and hinges were solid and secure. Aesthetic Quality Clean surface finish with uniform paint coverage. Durability Expected to withstand corrosion and wear. Swing Mechanism Smooth opening and closing without misalignment. The fabrication process successfully met the design specifications. The door was tested under standard use conditions and found to be suitable for regular residential or office use.

4.11 Cost Analysis

S N	Item	Quantity	Unit Price (₦)	Total (₦)
1	Mild Steel Sheet (1gauge)	1 sheet	30,000	30,000
2	Angle Iron (30mm x 30mm)	3 lengths	25,000	25,000
3	Welding Electrodes (E6013)	1 pack	6,500	6,500
4	Lockset and Handle	1 set	6,000	6,000
5	Hinges (Heavy-duty)	2 pieces	2,500	5000
6	Red Oxide Primer	1 liter	3000	3,000
7	Enamel Paint (Black)	1 liter	3,000	3,000
8	Grinding and Finishing Materials	—	—	5000
	Total Cost			₦83,500

This cost reflects the practical affordability of producing a standard metal door in local workshops compared to imported alternatives which may exceed ₦83,500

4.12 Challenges Encountered

Welding Defects: Initial welds had porosity due to poor electrode angle and contamination; resolved by cleaning surfaces and adjusting welding parameters.

Material Handling: Steel sheets were heavy and required teamwork during alignment.

Paint Drips: Occurred during the first coat of enamel application; corrected with controlled brushing and better mixing.

Tool Wear: The cutting disc became blunt mid-process, necessitating its replacement.Despite these challenges, the final product met functional and design expectations.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The fabrication of a twin metal panel door using mild steel was successfully carried out, demonstrating that local materials and standard workshop tools can produce secure, functional, and aesthetically appealing doors. The project involved material selection, precise measurement, cutting, welding, grinding, painting, and final assembly. The fabricated door met structural, functional, and cost-effectiveness criteria suitable for residential or institutional use.

This project enhanced practical skills in metalworking, especially in welding, finishing, and design interpretation. It also shows that local fabrication can serve as a viable alternative to expensive, imported security doors without compromising performance.

5.2 Recommendation

Based on the experiences and outcomes of this project, the following recommendations are made:Improved Finishing Techniques: Powder coating or spray painting should be considered in future projects for better aesthetic and weather protection.

. Use of Jigs and Fixtures: To improve welding alignment and productivity, jigs should be used for frame and panel assembly.

Quality Control Checks: Future projects should adopt more rigorous testing for load capacity and environmental exposure.

Training and Supervision: Students and workshop technicians should receive regular training on modern welding safety and fabrication practices.

Prototype Development: This design can be further developed into a prototype for small-scale manufacturing in local communities.

5.3 Suggestions for Further Study

Integration of automated locking mechanisms in metal doors.

Use of alternative corrosion-resistant materials like stainless steel or galvanized iron.Study of acoustic and thermal insulation in metal door panels

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