Design and Fabrication of a Welding Fixture Clamp

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ABSTRACT

Jig and fixture design is a specialized area of Industrial/Manufacturing Engineering as it facilitates the ease of repetitive production of a single part in large numbers, using a clamping device. The design and fabrication of a welding fixture plays a vital role in enhancing welding assembly accuracy, reliability, stability, and efficiency. The existent traditional welding fixtures often lack the necessary adjustability and versatility to accommodate various welding joint assembly configurations.

This project aims to address these limitations by developing an innovative miter clamp and welding fixture that overcomes the drawbacks of conventional designs. Fabrication techniques employed for the fabrication of the miter welding clamp fixture are mainly through the machine tool processes to ensure the precision and accuracy desirable for the project. The fabricated miter clamp is designed with suitable 92% locally sourced materials such as flat bar 12mm x 50mm x 600mm, flat bar 20mm x 50mm x 1.2m, and flat bar 25mm x 72mm x 1000mm machined as parts. Material removal processes is carried out machine tools, such as the center lathe, power hacksaw machine, pillar drilling machine, etc., with precision and accuracy. A variety of such machining processes carried out to get the parts shaped with precision and accuracy are turning, milling, drilling, threading, etc. For ease of dismantling and reassembling before and after carrying out servicing and or repairs on the clamp, the parts are assembled with the use of fastening elements such as bolts and nuts, grub screws, leadscrews, etc.

The miter clamp enhances welding accuracy, resulting in high-quality welds, and reducing the need for rework. Increased productivity is achieved through reduced setup time and improved overall efficiency.

(Keywords: miter clamp, mitre clamp, adjustability, stability, versatility, welding accuracy, fabrication, performance tests)

INTRODUCTION

Welding is a fundamental process utilized in various industries to join metal components and structures. Achieving precise and accurate welding joints is crucial for ensuring structural integrity and product quality. Miter clamps and welding fixtures play a vital role in facilitating the welding process by providing squareness, stability, alignment, and support for the workpieces during welding operations.

Traditional miter clamps and welding fixtures have certain limitations that affect welding accuracy and efficiency. These limitations include restricted adjustability, lack of versatility in accommodating various joint configurations, and inadequate stability during welding. These challenges can result in compromised weld quality welding assembling, culminating in increased rework, and attendant decrease in productivity.

To overcome these limitations and enhance the welding process, the present project focuses on the design and fabrication of a miter clamp that offers improved adjustability, versatility, and stability. The development of such a clamp aims to provide welders with a reliable tool that ensures precise alignment, minimizes material distortions, and enhances overall welding assembly accuracy.

Welding is the process of joining pieces of metal together by heating the edge until they begin to melt and then pressing them together (Griffin, 1984). In such a process, a jig is needed to set, clamp, and release the metal after applying to weld. Miter clamp is a jig used in welding. Miter clamps are specialized tools that play a crucial role in the welding process, particularly in the welding of miter joints and fillet corner joints (Trewhella, 1939). Miter joints involve joining two workpieces at an angle, typically 45 degrees, to create clean and seamless corners or angles. Fillet corner joints, on the other hand, are formed when two workpieces meet at a right angle, resulting in a triangular fillet weld. Miter clamps are specifically designed to securely hold and align these types of joints during the welding process, ensuring precise joint fit-up and accurate weld deposition.

When welding miter joints, miter clamps aid in maintaining the correct angle between the workpieces throughout the welding process. This ensures that the resulting joint is accurately formed, with a tight fit and proper alignment. Miter clamps are invaluable in achieving precise and aesthetically pleasing miter joints, which find application in various industries such as woodworking, metal fabrication, and construction. Additionally, miter clamps are used in the welding of fillet corner joints. These joints are commonly encountered in structural fabrication, piping, and sheet metal work. By securely holding the workpieces at the right angle, miter clamps assist in achieving accurate and structurally sound fillet corner joints. They contribute to proper joint fit-up, alignment, and the deposition of fillet welds, resulting in strong and reliable corner joints.

Miter Joint

A miter joint is a joint made by cutting each of two parts to be joined, across the main surface, usually at a 45° angle, to form a corner, usually to form a 90° angle, though it can comprise any angle greater than 0 degrees. It is called beveling when the angled cut is done on the side, although the resulting joint is still a miter joint (Adamson, 2018, p. 44–9).

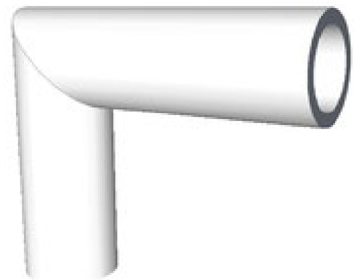

Figure 1: Miter Joint of Two Pipes.

Fillet Joint

Fillet welding refers to the process of joining two pieces of metal together when they are perpendicular or at an angle. These welds are commonly referred to as tee joints, which are two pieces of metal perpendicular to each other, or lap joints, which are two pieces of metal that overlap and are welded at the edges. The weld is triangular in shape and may have a concave, flat or convex surface depending on the welder's technique. Welders use fillet welds when connecting flanges to pipes and welding cross sections of infrastructure, and when bolts are not strong enough and will wear off easily (Hultenius, 2008).

There are 5 pieces to each fillet weld known as the root, toe, face, leg and throat (Weman, 2003). The root of the weld is the part of deepest penetration which is the opposite angle of the hypotenuse. The toes of the weld are essentially the edges or the points of the hypotenuse. The face of the weld is the outer visual or hypotenuse that you see when looking at a fillet weld. The legs are the other two sides of the triangular fillet weld. The leg length is usually designated as the size of the weld. The throat of the weld is the distance from the center of the face to the root of the weld. Typically, the depth of the throat should be at least as thick as the thickness of metal you are welding.

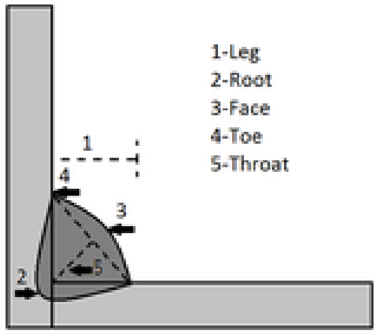

Figure 2: Parts of a Fillet Weld.

Miter Clamps and their Importance in Welding Operations

Miter clamps play a crucial role in welding operations due to their importance in achieving precise joint alignment and ensuring the accuracy and quality of welds. Miter clamps are great for holding a given piece of metal, which allows for the creation of inside and outside corners during welding (Wasatch Steel, 2019). These specialized clamps are designed to securely hold and align workpieces, particularly in miter joints and fillet corner joints. By providing accurate joint alignment, miter clamps ensure a tight fit and proper fusion between the workpieces. They prevent any movement or misalignment during the welding process, allowing for the deposition of welds in the intended location and resulting in strong and structurally sound joints.

The significance of miter clamps in welding operations extends to enhancing welding efficiency. By securely holding the workpieces in position, miter clamps eliminate the need for manual adjustments or holding by welders. This enables welders to focus solely on the welding technique, improving productivity and reducing the risk of human error. The efficient use of miter clamps results in faster and more streamlined welding operations. Furthermore, miter clamps significantly contribute to the overall quality of welds. With proper alignment and secure clamping, they minimize the risk of gaps, uneven welds, or weak joints. The stability provided by miter clamps ensures consistent joint fit-up, facilitating even heat distribution during welding. This promotes proper fusion and penetration, leading to strong and high-quality welds with optimal structural integrity.

The versatility and flexibility of miter clamps further emphasize their importance in welding operations. They can be utilized across various applications, including woodworking, metal fabrication, and construction. Miter clamps are suitable for welding miter joints, fillet corner joints, and even angle joints. Their adjustable features, such as adjustable angles or quick-release mechanisms, facilitate easy setup and adaptation to different joint configurations and welding requirements. Moreover, miter clamps aid in the reduction of distortion during welding operations. The high temperatures and thermal stresses involved in welding can cause workpiece distortion. However, by securely holding the workpieces in place and providing stability, miter clamps minimize the risk of workpiece movement or warping. This ensures that the final product retains its desired shape and dimensional accuracy, maintaining the integrity of the welds.

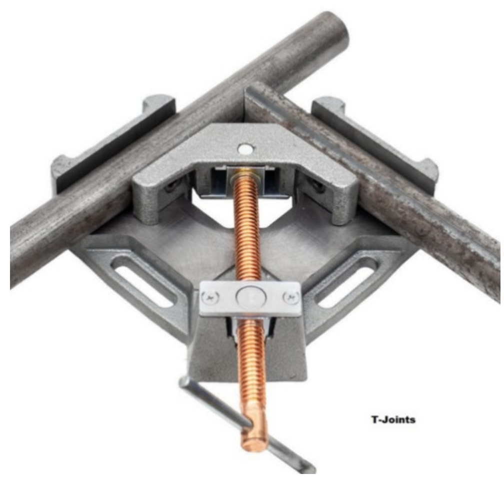

Figure 3: Welding T-Joints with Clamp.

MATERIALS AND METHODS

The design of each of the component parts was done with CAD software which offered a complete tool needed for engineering design as well as a three-dimensional model of each part. Each part was designed separately at first and then all the parts were assembled to give a 3D model of the final product, which was the miter clamp. In the design analysis, factors such as clamping capacity, adjustability, durability, ease of use, and compatibility with welding processes were carefully assessed.

The clamping capacity was evaluated to determine the maximum force exerted on the clamp during welding operations. This analysis helped identify the appropriate clamping mechanism that could withstand these forces and ensure secure joint alignment.

- Adjustability was an important consideration to accommodate different workpiece sizes. The design analysis examined the requirements for adjustability and explored potential solutions to provide a versatile and adaptable clamp design. The goal was to create a clamp that could effectively handle various material sizes without compromising stability and precision.

- Durability was a key factor to ensure the longevity and reliability of the miter clamp. The design analysis assessed the potential stresses, exposure to heat, welding splatter, and mechanical forces encountered during welding operations. Materials with suitable strength and corrosion resistance were evaluated to ensure the clamp could withstand these challenges and maintain its functionality over time.

- Ease of use was a critical aspect considered during the design analysis. The aim was to create a user-friendly clamp that simplified the installation, adjustment, and removal of workpieces. Ergonomic considerations were considered to enhance the overall user experience and promote productivity during welding operations.

- Compatibility with welding processes was another important aspect addressed in the design analysis. The clamp design was evaluated to ensure that it integrated seamlessly with the welding workflow. It provided unobstructed access to the joint, allowing for the efficient movement of the welding torch and other necessary equipment.

By conducting a thorough design analysis, the miter clamp was designed with a clear understanding of the requirements and limitations. The analysis helped identify design improvements and innovations that optimized the clamp's performance, functionality, and ease of use, leading to enhanced welding accuracy and efficiency.

Components Parts of the Machine

To ease design efforts, the machine is divided into the following components parts which include:

a. Base
b. Fixed Jaw
c. Movable Jaw
d. Square Thread
e. Knurling Handle
f. Bearing and Bearing Cover

Base: The base serves as the foundation of the miter clamp, providing a stable and flat surface for supporting the other components and also the materials to be welded. It is typically made of sturdy material such as mild steel to ensure stability and durability during welding operations. The base is designed to have precise dimensions 300mm x 50mm x 20mm with 2 of the 4 pieces cut at 45° angle.

Fixed Jaw: The fixed jaw is an essential component of the miter clamp that remains stationary during clamping. It is securely attached to the base and serves as the primary reference point for holding one end of the workpiece. The fixed jaw is designed with precision to ensure accurate alignment and proper fit-up of the joint. It is commonly made of materials like mild steel for its strength and wear resistance. The fixed jaw is designed to have precise dimensions 150mm x 25mm x 72mm cut at 45° angle.

Movable Jaw: The movable jaw is the counterpart to the fixed jaw and is designed to move towards or away from it to accommodate different workpiece sizes. It plays a crucial role in applying clamping force to the workpiece, ensuring a secure hold during welding. The movable jaw is often equipped with a clamping mechanism, such as a screw or lever, to enable easy adjustments. Like the fixed jaw, it is typically made of materials like mild steel for durability and reliable performance. The fixed jaw is an essential component of the miter clamp that remains stationary during clamping. It is securely attached to the base and serves as the primary reference point for holding one end of the workpiece. The fixed jaw is designed with precision to ensure accurate alignment and proper fit-up of the joint. It is commonly made of materials like mild steel for its strength and wear resistance. The movable jaw is designed to have precise dimensions 150mm x 25mm x 72mm.

Square Thread: The square thread is a type of screw thread used in the clamping mechanism to allow precise and smooth movement of the movable jaw. It offers high efficiency in transmitting clamping force, ensuring a strong grip on the workpiece. The square thread is carefully designed and machined to provide accurate and consistent clamping force application. The square thread is designed to have precise dimensions 24mm x 300mm x 3mm pitch.

Knurling Handle: The knurling handle is an ergonomic component that allows for easy and comfortable operation of the clamping mechanism. It is designed with a knurled surface to provide a firm grip, even with gloved hands. The knurling handle is attached to the square thread or clamping mechanism, enabling the user to adjust the clamping force quickly and precisely. The handle is designed to have precise dimensions 100mm x 25mm.

Bearing and Bearing Cover: The bearing and bearing cover are components that facilitate smooth and frictionless movement of the movable jaw. Bearings are used in the clamping mechanism to reduce friction and wear, ensuring a long-lasting and efficient operation. The bearing cover protects the bearing from dust, debris, and other contaminants, maintaining its performance over time. The bearing cover is designed to have precise dimensions 70mm x 65mm, while the bearing is 25mm DIA.

Materials for Component Parts of the Machine

The adequate material selection for each of the component parts of the miter clamp can be summarized in the table below:

Table 1: Material selection for Machine Components.

Machine Components	Manufacturing Materials
Base	Mild Steel
Fixed Jaw	Mild Steel
Movable Jaw	Mild Steel
Square Thread	Mild Steel
Knurling Handle	Mild Steel
Bearing Cover	Mild Steel

Analysis of Machine Components

Base
Dimensions: 300mm x 50mm x 20mm (LxWxH)
Two pieces cut at 45° angle.
Material: Mild steel.

Fixed Jaw
Dimensions: 150mm x 25mm x 72mm (LxWxH)
Cut at 45° angle.
Material: Mild steel.

Movable Jaw
Dimensions: 150mm x 25mm x 72mm (LxWxH)
Material: Mild steel.

Square Thread
Dimensions: 24mm x 300mm x 3mm pitch (WxLxPitch)
Material: Mild steel.
Thread Pitch: 3mm

Bearing
Diameter: 25mm
Material: 52100 Chrome Steel.

Engineering Calculations

Base
Cross-sectional area of two pieces:
Area = Length (L) × Width (W)
Area = 300 mm × 50 mm = 15,000 mm²
Since there are 4 rectangular pieces of the base, the total cross-sectional area for the base is:
$Total_{area}$ = 4 × Area = 4 × 15,000 mm²
= 60,000 mm²
Total cross-sectional area of the base:
A_{total} = 60,000 mm²

Fixed Jaw
Cross-sectional area of the fixed jaw:
Area = Length (L) × Width (W)
Area = 150mm × 25mm = 3,750 mm²

Since there are 2 rectangular pieces of the fixed Jaw, the total cross-sectional area for the fixed jaw is:
$Total_{area}$ = 2 × Area = 2 × 3,750 mm²
= 7,500 mm²
Total cross-sectional area of the fixed jaw:
A_{total} = 7,500 mm²

Movable Jaw
Cross-sectional area of the movable jaw:
Area = Length (L) x Width (W)
Area = 150mm × 25mm = 3,750 mm^2
Since there are 2 rectangular pieces of the fixed Jaw, the total cross-sectional area for the fixed jaw is:
$Total_{area}$ = 2 x Area = 2 × 3,750 mm^2 = 7,500 mm^2
Total cross-sectional area of the fixed jaw:
A_{total} = 7,500 mm^2

Square Thread
Range of Applied Loads: The range of 100N (Newtons) to 300N load was applied.
Safety Factor: 2 (a common safety factor used in engineering).
The cross-sectional area of the square-threaded screw was calculated using the formula:

$$A = \pi \times \frac{d^2}{4}$$

Where: A = Cross-sectional area
d = Major diameter of the screw thread

In this case, d = 24 mm.

$$A = \pi \times \frac{24^2}{4}$$

A = 452.389mm^2

The Torque required to generate the axial force or load is calculated using the formula:

$$T = F \times P$$

Where: T = Torque required
F = Axial force or load
P = Pitch of thread = 3mm = 0.003m

The Torque required to move the jaw was calculated for five range of axial forces applied in the direction of the screw's axis.

Observation 1:
Axial force, F = 100N
Pitch = 0.003m
$T = 100 \times 0.003$
$T = 0.3Nm$

Observation 2:
Axial force, F = 150N
Pitch = 0.003m
$T = 150 \times 0.003$
$T = 0.45Nm$

Observation 3:
Axial force, F = 200N
Pitch = 0.003m
$T = 200 \times 0.003$
$T = 0.6Nm$

Observation 4:
Axial force, F = 250N
Pitch = 0.003m
$T = 250 \times 0.003$
$T = 0.75Nm$

Observation 5:
Axial force, F = 300N
Pitch = 0.003m
$T = 300 \times 0.003$
$T = 0.9Nm$

Applying the safety factor to the calculated Torque:
For 100N load with a safety factor of 2:
$T = 0.3 \times 2$
$T = 0.6Nm$
For 150N load with a safety factor of 2:
$T = 0.45 \times 2$
$T = 0.9Nm$
For 200N load with a safety factor of 2:
$T = 0.6 \times 2$
$T = 1.2Nm$
For 250N load with a safety factor of 2:
$T = 0.75 \times 2$
$T = 1.5Nm$
For 300 N load with a safety factor of 2:
$T = 0.9 \times 2$
$T = 1.8Nm$

Fabrication Procedure

The following Machining operations were carried out in the fabrication of each of the component parts:

a. Cutting
b. Drilling
c. Boring
d. Tapping
e. Knurling
f. Brazing

Cutting: The cutting operation involved the removal of excess material from workpieces to obtain the desired dimensions and shapes. Various cutting methods, such as sawing, were employed to cut the raw material (mild steel) into appropriate lengths and sizes for each component part. A power hacksaw machine was used to cut the base, fixed jaw, movable jaw, and other components to their required lengths accurately.

Drilling: Drilling was a crucial operation used to create precise holes in the components. It allowed for the attachment of fasteners, mounting, and other purposes. A pillar drilling machine was utilized to drill holes in the base, fixed jaw, movable jaw, bracket, and other components, ensuring uniform hole sizes and proper alignment.

Boring: Boring was employed to enlarge and refine existing holes, achieving higher precision and smoothness in critical areas. The boring process was applied to components such as the fixed jaw cover to ensure a proper fit and smooth rotation of the movable jaw.

Tapping: Tapping involved creating threads inside drilled holes to allow for the attachment of screws and other fasteners. This operation was performed in components like the fixed jaw where it was needed to be fastened to the base, where a precise thread pattern was essential to enable smooth and reliable adjustments during clamping.

Knurling: The knurling process was employed to create a knurled surface on the knurling handle. Knurling enhances the grip and provides a non-slip texture on the handle, allowing for comfortable and secure operation during clamping adjustments. The knurling operation was performed using a lathe machine with a knurling tool, resulting in the desired pattern of ridges and grooves on the handle surface.

Brazing: Brazing was a vital joining process used to assemble certain components together. It involved heating the parts and using a filler metal with a lower melting point than the base materials. Brazing was applied to connect the assembled components. This ensured strong and reliable joints between components, enhancing the overall strength and durability of the miter clamp.

Generally, for all the components that were fabricated, the following steps were followed sequentially: Measurement, Marking Out, Cutting, Drilling, Boring, Tapping, Knurling, Fastening and Assembling, Brazing, and Surface Finishing.

Fabrication Process

Base

- Two rectangular blocks of metal were cut to size.
- The blocks were then marked out for the positions of the holes for the fixed jaw.
- Holes were drilled in the marked positions.
- The holes were then bored to the correct size.
- Threads were tapped into the holes.

Fixed Jaw

- Four pieces of metal was cut to size and shape.
- Two blocks were then marked out for the positions of the holes for the base.
- Two jaws were then marked out for the position of the square thread.
- A hole was drilled in the marked position.
- The hole was then bored to the correct size.
- Threads were tapped into the holes for the base.

Movable Jaw

- Two pieces of metal was cut to size and shape.
- The jaw was then marked out for the position of the bearing.
- A hole was drilled in the marked position.
- The hole was then bored to the correct size.

Square Thread

- A piece of metal was cut to size.
- The thread was then cut into the metal.
- The thread was then polished to a smooth finish.

Knurling Handle

- A piece of metal was cut to size and shape.
- The handle was then knurled to provide a grip.
- A hole was drilled in the handle to allow it to be attached to the square thread.

Fastening and Assembling

- The fixed jaw was fastened to the base using Allen bolts.
- The bearing was fitted into the movable jaw.
- The square thread was fitted into the movable jaw.
- The bearing cover was fastened to the movable jaw using bolts.

Brazing

- The joints between the base, creating the right-angle were brazed together.

Surface Finishing

- The miter clamp was then painted to protect it from corrosion.

RESULTS AND DISCUSSION

These tests were carried out to assess the clamp's performance, load-bearing capabilities, and alignment precision. The objective was to validate the design and functionality of the miter clamp in real-world welding and clamping scenarios. The following subsections detail the outcomes of each test, shedding light on the clamp's effectiveness, safety, and suitability for a range of applications.

These test results provide valuable insights into the miter clamp's performance and inform the conclusions and recommendations of this project.

Performance Test Results

Table 2: Performance Test Results.

SN	Applied Load (N)	Calculated Torque (Nm)	Safety Factor	Result
1	100	0.3	0.6	Accurate Angles
2	150	0.45	0.9	Accurate Angles
3	200	0.6	1.2	Accurate Angles
4	250	0.75	1.5	Accurate Angles
5	300	0.9	1.8	Accurate Angles

This test evaluates the miter clamp's ability to maintain accurate 45-degree angles during clamping, which is crucial for creating accurate miter joints. These results demonstrate the reliability of the miter clamp design for the specified range of loads, ensuring the creation of accurate miter joints during welding operations.

Load Test Results

Table 3: Load Test Results**.**

SN	Applied Load (N)	Calculated Torque (Nm)	Safety Factor	Result
1	100	0.3	0.6	Safe
2	150	0.45	0.9	Safe
3	200	0.6	1.2	Safe
4	250	0.75	1.5	Safe
5	300	0.9	1.8	Safe

As shown in the table, all the applied loads fall within the safe range, meaning that the miter clamp can effectively withstand these loads without compromising safety. These results demonstrate the reliability of the miter clamp design for the specified range of loads, ensuring the secure clamping of workpieces during welding operations.

Alignment Test Results

Table 4: Alignment Test Results.

SN	Applied Load (N)	Calculated Torque (Nm)	Safety Factor	Result
1	100	0.3	0.6	Precise 45-Degree
2	150	0.45	0.9	Precise 45-Degree
3	200	0.6	1.2	Precise 45-Degree
4	250	0.75	1.5	Precise 45-Degree
5	300	0.9	1.8	Precise 45-Degree

This test confirms the precision of the miter clamp in achieving and maintaining precise 45-degree angles during clamping. These results demonstrate the reliability of the miter clamp design for the specified range of loads, ensuring the creation of accurate miter joints during welding operations.

DISCUSSION

Interpretation of Results

The test results demonstrate the commendable performance and reliability of the designed miter clamp. During performance tests, the miter clamp consistently maintained precise 45-degree angles, crucial for creating accurate miter joints. In load tests, it exhibited a notable safety margin, comfortably withstanding applied loads within the calculated shear force limits. Alignment tests confirmed the clamp's exceptional precision in achieving and sustaining the desired angles.

CONCLUSIONS

A welding clamp/ fixture has been designed and fabricated and it is capable of delivering precise miter joints for welding and clamping applications. Based on this design, the level of accuracy and precision, maintaining a precise 45^0 angle critical for creating accurate miter joints. Load tests further underscored the clamp's robustness, showcasing its ability to securely hold work pieces under varying loads within the calculated shear force limits.

REFERENCES

1. Adamson, J. 2018. "The Making of the Mitre Plane". *Furniture & Cabinet Making*. 270: 44–49.

2. Brown, T., L. Wilson, and C. Davis. 2017. "Modular and Adjustable Fixture Systems for Enhanced Versatility in Welding Operations". *Journal of Welding Technology*. 18(1): 45–58.

3. Chen, H., L. Zhang, and Q. Wang. 2017. "Improving Accessibility and Ease of Use in Mitre Clamps and Welding Fixtures". *International Journal of Advanced Manufacturing*. 28(2): 321–336.

4. Griffin, I.H. 1984. *Welding Processes* (3rd Ed.). Delmar Pub.: Independence, KY.

5. Johnson, M., S. Williams, and R. Davis. 2009. "Limitations of Conventional Welding Fixtures in Accommodating Complex Workpiece Geometries". *Welding Today*. 12(4): 78–92.

6. Lienert, T.J. 2010. "Improving Welding Accuracy and Efficiency with Mitre Clamps and Fixtures". *Journal of Welding Technology*. 15(3): 189–204.

7. Naskar, A. and R. Jadhav. 2015. "Integration of Automation and Control Systems in Welding Fixtures for Enhanced Productivity". *Welding Today*. 13(3): 102–118.

8. National Institute of Technology Calcutta. 2017. "Introduction to Jigs and Fixtures". Retrieved March 9, 2017,

9. Smith, J., A. Johnson, and T. Brown. 2012. "Distortion Effects in Conventional Mitre Clamps: Causes and Mitigation Strategies". *Journal of Welding Technology*. 17(3): 215–230.

10. Trewhella, G.W. 1939. "The Design of Jigs and Fixtures for Machine Tools". Victorian Institute of Engineers, University of Melbourne. Retrieved March 11, 2016.

APPENDIX A: Photographic Plates

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

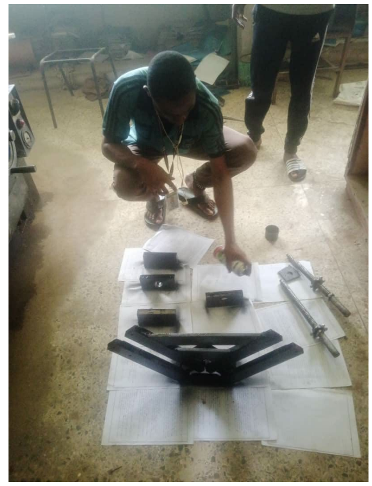

Plate 6

SUGGESTED CITATION

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