FLYWHEEL: JURNAL TEKNIK MESIN UNTIRTA

Home page journal: http://jurnal.untirta.ac.id/index.php/jwl

Design of Universal Jig for Standardization and Efficiency of Frame Production Chopper Motorcycle

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ARTICLE INFO

Received: 29/08/2024
Revision: 28/07/2025
Accepted: 07/08/2025
Available online: 08/08/2025

ABSTRACT

This study presents the design and implementation of a modular universal jig to enhance the precision and efficiency of chopper motorcycle frame fabrication. The jig system features adjustable and repositionable components that accommodate various custom frame geometries. The manufacturing process involves material selection, precision measurement, machining, assembly, calibration, and TIG welding. Comparative analysis shows that the use of the universal jig reduces total production time from 971 hours to 320 hours, achieving a 66.5% reduction. The jig also minimizes dimensional errors and material waste, contributing to higher product consistency. These results demonstrate the effectiveness of the proposed jig in improving fabrication workflow for custom motorcycle workshops.

Keywords: *frame, jig, chopper, time efficiency*

1. INTRODUCTION

Custom motorcycle frame fabrication requires high dimensional precision and repeatability to ensure safety and quality. Chopper motorcycles, known for their distinct elongated design and low-profile geometry, pose unique manufacturing challenges due to their non-standard frame specifications. In small-scale or artisanal workshops, maintaining accuracy in welding alignment and structural integrity becomes a significant concern, especially without standardized tooling. Jigs have long been recognized as essential fixtures in frame manufacturing to address these challenges (1–7).

Transitioning from softail (suspension-equipped) to hardtail (rigid) chopper frames presents considerable manufacturing challenges, especially when lacking dimensional references. In artisanal settings, this often results in material waste and time inefficiencies due to trial-and-error approaches. Therefore, a standardized fixture such as a frame jig becomes essential to ensure consistent outcomes (8–11).

Previous studies on jig systems have focused on fixed-type configurations designed for single-model production. For instance, Bhosale et al. designed jigs specifically for generator base frames (7), while Fyona et al. proposed jigs for bicycle brake shoe manufacturing (12). Although these studies demonstrated improvements in efficiency and accuracy, the lack of flexibility in frame geometry adaptation limits their application in custom vehicle fabrication. Othman et al. introduced a jig mechanism for wheel rim alignment, but the concept was not extended to multi-point frame assembly (6).

Despite these advancements, limited research has addressed the development of modular and adjustable jigs that accommodate diverse frame geometries in custom motorcycle production. To fill this gap, this study aims to design and evaluate a universal jig that enables frame alignment accuracy,

reduces production time, and increases adaptability across various chopper frame types.

This study contributes to the development of a flexible jig system that maintains frame alignment during welding, minimizes dimensional shifts due to thermal distortion, and supports varying frame sizes from standard to custom configurations.

2. METHODOLOGY

The flow of making a universal jig in making a Chopper motorcycle frame starts with a literature study and field study. Then proceed with the design by looking for initial design reference sources. After that the design is adjusted to the condition of the destination frame, namely the chopper frame. Followed by the selection of raw materials. Raw materials consist of several types, namely iron pipes, solid axles and iron plates. The next step is the measurement process, as shown in Figure 1.

Figure 1. Measuring material vernier calipers

The measurement process aims to determine the length of the required raw material and will be cut according to size. The cutting process uses a cutting grinder. After cutting to size, the machining/turning process is carried out on solid axles. Turning with the aim of reducing the diameter of the solid axle according to the needs of the Jig. The ready materials are assembled in the appropriate order.

The assembly process uses wrenches and bolt nuts. When it is confirmed that the position of the material is appropriate and stable, the welding process begins. Welding using TIG welding. Welding is carried out per section and it takes time for the welds to mature and be strong. After all materials have been welded, the jig calibration process is first carried out. The calibration process is carried out to maintain size and reduce the risk of errors. Before the finishing process, a final checking process is carried out for size. If the dimensions are correct, finishing is carried out with hand grinding and sandpaper are shown in Figure 2.

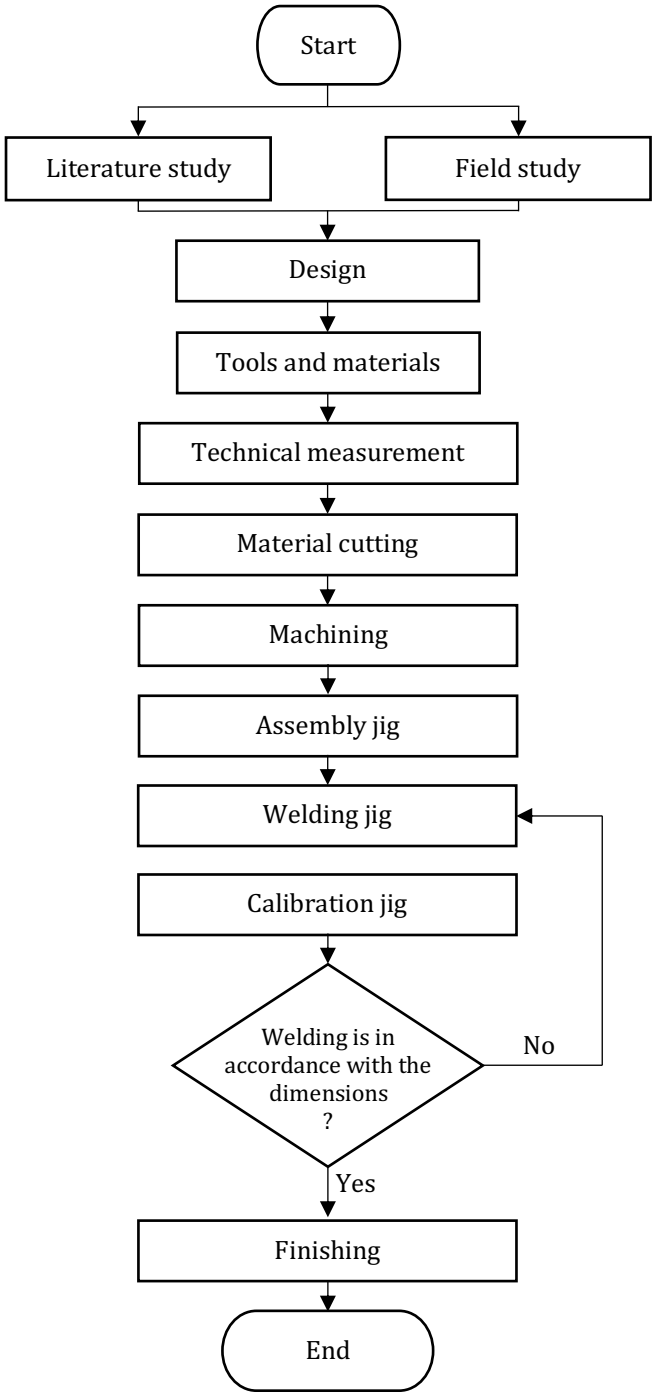

Figure 2. Flowchart of universal jig design

A CAD drawing of the jig design is provided in Figure 3. The main beam measures 1930 mm in length, with a front vertical jig component of 950 mm and a rear alignment section of 550 mm. The frame uses square steel tubing (50 mm × 50 mm) to provide stability, and all joints are designed for modular attachment using bolt-fastened connections. These design choices ensure ease of frame alignment, repeatability, and adaptability to different chopper geometries.

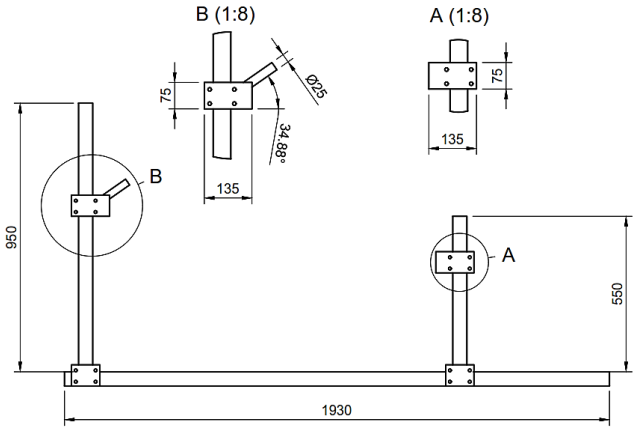

Figure 3. Technical drawing of universal jig

Jigs are often used in manufacturing processes to improve accuracy, repeatability, and safety, and they can also have a significant impact on process time. The factors of jigless manufacturing process:

1. Setup time is longer: Workers need to manually align and position the workpiece, which can be time-consuming and prone to errors.
2. Process time is longer: Each step of the process takes longer because the worker needs to be careful to ensure accuracy.
3. Scrap rate is higher: Errors in alignment or positioning can lead to scrapped parts.
4. Safety risks are higher: Workers are more likely to injure themselves when working with parts that are not properly secured (17–19).

On the other hand, the chopper chassis manufacturing process with a jig has advantages:

1. Setup time is shorter: The jig quickly and easily positions the workpiece, saving time.
2. Process time is shorter: Workers can focus on completing the task without worrying about alignment, which speeds up the process.
3. Scrap rate is lower: The jig ensures accurate placement of the workpiece, reducing the risk of errors.
4. Safety risks are lower: The jig holds the workpiece in place, reducing the risk of worker injury (20,21).

Measurement is also the most important process in preparation for making universal jigs. With a valid measurement, the jig can be used to form the frame according to the original frame size and produce a maximum product. Measurements use a vernier gauge to measure and distinguish the size of the material. The meter is also used for measuring the length of the pipe as desired (22).

Cutting the material is done after a predetermined measurement process. Cutting using a cutting grinder. The advantage of cutting grinder is that the level of precision is more valid than hand grinding. In addition to the precision of cutting materials using cutting grinders is very fast compared to other cutting tools.

Turning is done after measuring and cutting solid axles. Then the solid axle material is lathed using a lathe. Solid axles are lathed according to the shape of the kenee and the size of the universal jig. The process of assembling pipe and knee materials is carried out to form a jig. Pipes and knees are assembled in the right order and locked using tools such as pass keys and ring keys so as not to miss during the welding process. Always recheck after the assembly process to avoid negligence.

Welding is done after assembling the materials and rechecking the installed materials to form the jig. The welding process uses TIG Argon welding. Things that need to be considered before welding are tapering tungsten, adjusting the amperage of the machine as needed, combining materials with a point weld prefix or with the term Tack weld are shown in Figure 4.

Figure 4. Welding process

Jig calibration is done before the finishing process on the jig. Calibration is done to maintain the precision of the jig. The tools used to calibrate the jig are as follows: Thread, Waterpas, Vernier Calliper. The finishing process is the final part of the universal jig manufacturing process. The tools used for finishing are hand grinder, mini grinder, sandpaper and file. Finishing is the most important process in making universal jigs because this stage determines the results of the initial process to the end.

The method proposed in this study introduces a modular and adjustable universal jig design that differentiates it from previously established techniques. Unlike earlier research which focused on fixed jigs tailored to specific frame models (6,7,12), this method emphasizes the development of repositionable jig points, allowing users to adapt the jig to multiple motorcycle frame designs without disassembling the entire structure. This feature improves time efficiency, reduces the frequency of recalibration, and enhances the overall flexibility of the jig.

3. RESULTS AND DISCUSSION

The results and discussion of the universal jig building design that will be made, the purpose of this tool design is to prove whether the design designed is as expected or not.

3.1. Design and dimension

The universal jig consists of a front jig and a back jig. The front jig supports the steering wheel, down tube, and back bone. While the rear jig supports the axle plate and spine. The design of universal jigs requires special processes and tools to facilitate the manufacture of Chopper motorcycle frames (reference). Jig making with the intention that the frame made can patent all sizes and precision. The following process is carried out in the manufacture of universal jigs (23,24).

The material preparation process is fundamental to starting the manufacture of universal jigs. The things that the material preparation process does are as follows the raw materials needed for making universal jigs are: iron pipes, solid axles and iron plates.

a. The part where the steering wheel is assembled and to adjust the height of the steering wheel. This part has a length of 95 cm.
b. The lower part is the link between the front and the rear. This part is the core of determining the center of the frame that will be made as well as being a place for the lower frame pipe holder. Its length is 193 cm.
c. The rear part of the jig functions for assembling the axle plate and adjusting the height and length of the rear frame dimensions, has a length of 55 cm are shown in Figure 5.

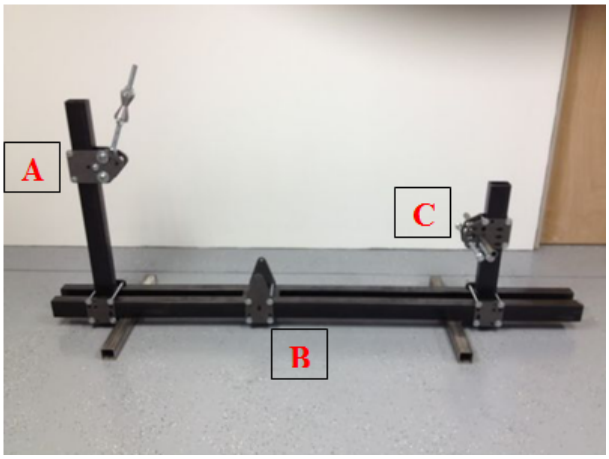

Figure 5. Jig universal

Figure 6 shows the application of the universal jig in the actual process of chopper motorcycle frame assembly. The front and rear supports of the jig have been adjusted to align precisely with the steering head and rear axle mount points of the frame. The use of adjustable fixtures on both ends of the jig allows flexibility in accommodating varying frame lengths and angles, demonstrating the jig's adaptability across different chopper geometries.

Figure 6. Application of the universal jig with chopper frame

During this stage, dimensional consistency is ensured by locking the frame in multiple anchor points using bolts and adjustable brackets. The image also illustrates the ergonomic height and accessibility of the jig, enabling the operator to perform fitting and welding tasks efficiently and safely.

The successful mounting and alignment of the frame confirm that the jig performs its intended function: maintaining geometric accuracy, minimizing human error, and reducing the risk of post-welding distortions. This visual validation reinforces the data findings on time efficiency and accuracy improvements presented in the previous section.

3.2. Processing time

Processing time refers to the total time it takes to convert raw materials into finished goods. This includes the time spent on tasks like setting up machinery, machining parts, assembling components, and finishing the product. Common factors include complexity of the task, available resources, workload, efficiency of the process. Processing time is an important metric in many industries, as it can impact factors such as productivity, quality, and customer satisfaction. By understanding and optimizing processing times, organizations can improve their overall efficiency and effectiveness are shown in Table 1 (25,26).

The significant reduction in processing time — from 971 hours to 320 hours — clearly demonstrates the effectiveness of the newly applied

modular jig methodology. This outcome stems from improvements introduced in the jig's design, specifically its adjustability for different frame types and reduced recalibration requirements. In contrast to conventional fixed jigs used in previous studies (6,7,12), this universal jig offers higher flexibility and precision without compromising setup integrity. The measurable time savings and minimized material waste confirm that the applied methodology provides a practical solution for improving custom motorcycle frame production.

Table 1. Comparison of Processing time

No	Process	Using jig universal (hours)	Without jig universal (hours)
1	Design	48	48
2	Preparing materials	24	24
3	Measuring	24	24
4	Cutting	24	24
5	Machining	24	24
6	Assembling	48	52
7	Welding	48	55
8	Calibration	40	480
9	Finishing	40	240
	Total	320	971

Based on Figure 7, the use of the universal jig reduced the total production time from 971 hours to 320 hours, achieving a 66.5% reduction. The most significant reductions occurred in the calibration and finishing stages, decreasing from 480 to 40 hours (91.7%) and from 240 to 40 hours (83.3%), respectively. These results demonstrate that the universal jig not only enhances precision and reduces post-welding corrections, but also significantly minimizes manual adjustment, thereby improving overall workflow efficiency.

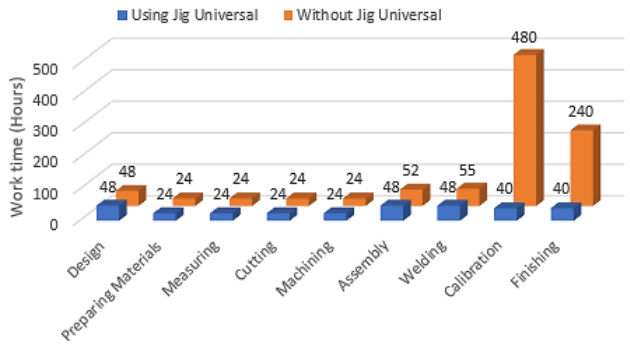

Figure 7. Comparison using jig universal and without

The shorter processing time with the universal jig is due to several factors, including:

a. Decreased setup time: universal jigs can quickly and easily position the workpiece, reducing the time needed to set up the process.
b. Increased productivity: workers can focus on the task without worrying about accuracy, thereby increasing productivity.
c. Improved quality: universal jigs help ensure accuracy, reducing the number of defective items.
d. Improved safety: universal jigs help keep workers safe by ensuring that workpieces are kept secure.
e. Cost: universal jigs can be expensive to design and manufacture.
f. Practicality: universal jigs are practical for all processes as they can be angled and dimensioned.

The advantage of the universal jig is that it can be used to make various motorcycle frames. Frames that have been made using universal jigs such as: chopper frames, bobber frames, trails, mini bikes. Its flexible and easy to adjust shape makes the universal jig very good for all types of custom motorcycles. The dimensions of the length and height of the frame size can be adjusted during the manufacturing process using a universal jig. Even the angle of the steering wheel where the front suspension is mounted can be adjusted using the front jig.

The advantages of a universal jig when used in the manufacture of Chopper motorcycle frames. Working on a Chopper frame without a jig can take 1 month and the risk of wasting a lot of material. In addition, working on a frame without a jig makes it very difficult to measure dimensions because there is no reference point and it is difficult to determine the length and height of the frame. Almost 80% of frame work without a jig is always a failure and a lot of revisions, to edit it is also time consuming and arguably less efficient. However, if you use a jig, there are definitely many advantages besides the speed of the jig work, the core point is to maintain the precision of the frame as well as the size and dimensions.

These findings confirm that the proposed universal jig design is feasible, replicable, and effective for practical implementation in small-to-medium-scale motorcycle fabrication workshops.

4. CONCLUSION

This study has successfully designed and implemented a modular universal jig that significantly enhances the efficiency and precision of chopper motorcycle frame production. The jig enables adjustable positioning for various frame types, improving flexibility without the need for major readjustments. The findings show a 66.5% reduction in total processing time—from 971 to 320 hours—alongside minimized material waste and

increased dimensional accuracy. These improvements demonstrate the effectiveness of the proposed jig system as a practical solution for custom motorcycle workshops seeking standardized yet flexible frame fabrication.

ACKNOWLEDGMENTS

Researchers would like to thank Mago Garage Salatiga for the knowledge and guidance provided for this study.

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