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# Design and Analysis of Fixture for Welding Casing Components of Cross-Flow Turbine

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**Abstract.** The purpose of this research is to improve the quality of the turbine casing product by using the welding fixture. The method used was to design and make welding fixture of turbine casing welding, test the straightness, alignment, straightness, and analyzes the deviation of measurement results. Based on the design result of welding fixture assembling of cross-flow turbine casing component, it had been obtained prototype welding fixture which can facilitate the assembling process of cross-flow turbine casing component. The conclusions of this research are the quality of cross-flow turbine casing products can be increased along with the small geometry deviations in the cross-flow turbine runners by using a fastening tool. The maximum deviation of the straightness of the turbine wall is 1.6 (wall A) and 0.85 (wall B). The process of assembling the components of the turbine runner is shorter by using a faster welding assembly tool with a better level of accuracy.

## 1. Introduction

The use of a fixture has a direct impact on welding quality, productivity, and costs. The purpose of the fixture is to reduce distortion so as to reduce production losses and also produce lead times for welding, positioning, and containment of parts. Various residual stresses generated when welding is responsible for distortion. Preheating, peening, post-welding heat treatment, relieving stress with natural aging, eliminating vibration tension are a number of ways to control residual stress.

The residual stress of welding affects the integrity of the structure and is one of the greatest unknown pressure. Residual stresses are difficult to measure and estimate theoretically but are often significant when compared to the pressure of the service they put. Loss of performance in corrosion, fatigue, and fracture are the causes of high tensile stresses [1, 2].

Jig and Fixture is a tool used in machining processes in order to produce more accurate parts duplication. Jig and Fixture are selected and designed in accordance with the shape of parts and machining processes to be processed. One type of Fixture used for welding process is Welding Fixture. This type of tool served to support the workpiece when the welding process operates [3, 4].

The manufacture and assembly of micro-hydro turbine components are carried out using conventional machining processes such as electric welding processes, lathe processes, drilling processes, grinding processes etc. One component of the micro-hydro turbine is a turbine casing. The manufacture of turbine casing components is a phase that focuses on the tolerance of shapes that must be fulfilled on a single element. Form tolerances related to the nature of components are straightness, alignment, straightness, etc. While the turbine casing component assembly is a phase that focuses on orientation tolerance, location tolerance, and alignment tolerance, which must be met in the related



elements. Related elements must take into account their attributes for a given tolerance such as alignment tolerance, stability tolerance, etc [3].

The use of improper tools can make the welding process is inhibited. Operators will have difficulty installing two components to be welded so that the product produced is not accurate. The welding equipment used today requires the operator to hold the tool during the welding process. This results in a product defect because the workpiece will easily slide so that welding is not correct. This has an impact on the long adjustment time and increased production costs. One way that can be done to reduce this is to do the design and selection of the right product equipment [3].

Several studies report that jigs are widely used to assist the welding process to avoid rotation distortion in the front of the welding heat source. A methodological approach to the design of welding equipment for robotic cells in spot welding of car bodies based on the principle of modularity. Regarding welding deformation control, there are several reports relating to external constraints and burdens [5]. Park et al. [6] investigate angular distortion and residual stress under various pre-tension conditions by changing the direction and magnitude of the pre-stress voltage. Schenk et al. [7] studied the effects of clamping on buckling distortion and angular distortion for overlapping joints and T-shape fillet joints. They found that residual stresses and welding distortion were strongly influenced by clamping conditions. Shateryana et al. [8] investigated the constraint effects on welding deformation and residual stress on aluminum alloy lap joints under three local U-shaped equipment types by performing 3D finite element analysis. Ziaee et al. [9] studied the effect of boundary conditions on buckling mode during thin plate welding. It was found that external constraints can increase buckling resistance but cannot eliminate buckling.

Welding the turbine casing with a simple tool causes difficulty in controlling the dimensions or uniformity of the shape, and requires high costs and a longtime during assembly. To get a uniform product and in accordance with the basic size, accurate and precise assembly process with an accelerator system is needed to avoid mistakes in assembling these components [3]. The quality of the cross-flow turbine runner product can be improved along with the small deviation of geometry in the turbine runner by using tools. The assembling process of turbine runner components has a shorter time by using welding assembly tools faster with better accuracy. Based on the results achieved in this study it is advisable to optimize this tool in the manufacture of cross-flow turbine runner components [3]. Welding equipment can be used as a tool for the production of the front engine mounting component welding process. The use of welding equipment can help to provide welding production process solutions from the time side, ease of work and production process speed [4].

The effect of the jig position is limited and the distance to the welding deformation can be reduced by the fastening device in the plate welding, the three-way jig constraint has a large influence on the component deformation. Normal jig direction constraints effectively reduce the distortion angle of the compressive force and shrinkage. In general, angular distortion can be reduced by jig position and smaller distances [10]. The control style can increase flexibility in the car bodywork process when compared to conventional law use [11]. The Joint Jig Assembling System can stabilize the connecting process because the AJJ system uses many components such as angular joints, adaptive PC bolts, expanding mandrel, and modular search. With the AJJ system, it can be operated efficiently and comprehensively, so as to reduce production costs [12].

Based on the results that have been carried out by several researchers, it can be concluded that fixture (production equipment) can improve the efficiency of the component assembly process. The purpose of this research is to improve the quality of the turbine casing products using welding fixture equipment.

## **2. Experimental Procedures**

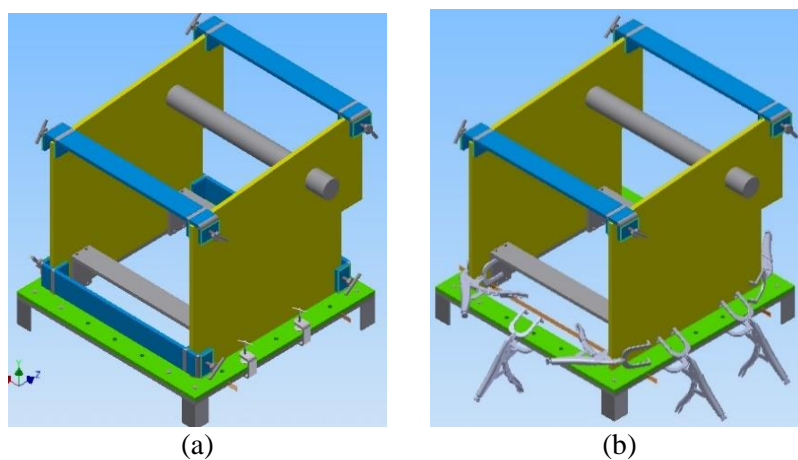
### *2.1. Materials and equipment*

The materials and components used to make the turbine welding tool are: 1). Steel Streep plate 10x50x600 mm, 2). Steel plate 400x500x10 mm, 3). steel elbow 40x40x6000 mm, 4). steel shaft 50x1000 mm, and 5). Bolts, M10x60 mm. The equipment used to make the accelerator and turbine

casing components is 1). Lathe, 2). CNC milling machine, 3). Drilling machine, 4). The bending machine, 5). Cutting machine, 6). A grinding machine, 7). Electric welding machine, 8). A dial indicator, and 9). Chuck.

### 2.2. Design method

Jig and fixture for welding is a series consisting of standard tapping, fastening pen, retaining and all integrated into a functioning unity. Some things to consider in the design of tools such as the operator to take a good welding position, fixture should be easy and fast in its use, the design should be easy and cheap, fixture must be able to provide leeway on the workpiece to move in one direction, and grafting should be prepared for various welding operations [3]. Based on several considerations in planning the tool system, it has been designed welding fastening system as shown in Figure 1.

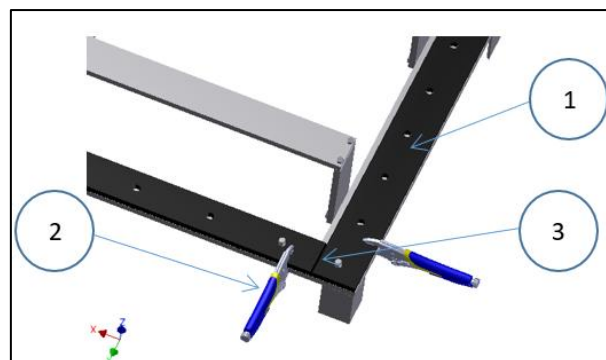


**Figure 1.** Cross-flow turbine casing tools with a) first design and b) second design.

Based on the above two designs, the first design was chosen with the consideration of easy and cheap made, flexible in use, and welding operators easy in welding position taking.

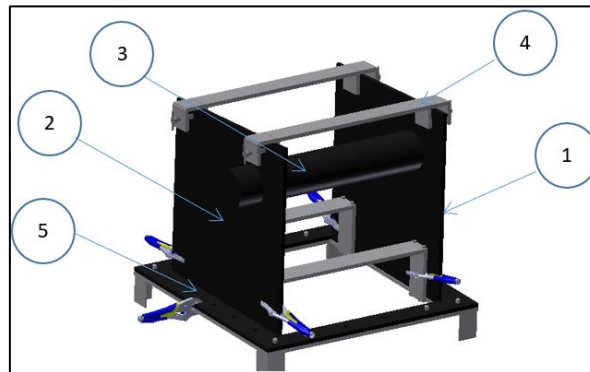
### 2.3. Assembly process

The turbine casing assembly procedure is carried out in two stages: the assembly of the base frame and the installation of the casing wall. The following is an illustration of the following sequence of assembly stages with the numbering. The assembly phase of the base frame is (Figure 2); a). The base frame plate is conditioned on the pins on the fixture table, b). Block both base frame components close to the connection, c). Welding is done on the connection between components. This procedure is performed on each connection that is on the cross-flow turbine casing base frame.



**Figure 2.** The base frame assembly stage

Stage of casing wall installation. The assembly procedure that needs to be done in the casing wall installation process is (Figure 3): a). Install the A casing wall on the fixture table then grip it with the clamp on both the front and back ends of the wall, b). Install the casing wall B on the fixture table and grip it like the casing wall A, c). Inserting a shaft in a hole in the casing walls to adjust the alignment of the holes between walls, d). Installing the clamp of the upper wall at the upper end of the wall of the casing, and e). Calm down the base frame next to the casing wall, then welding between the base frame and the casing walls.



**Figure 3.** Stage of the turbine casing assembly

#### *2.4. Measurement process*

Turbine casing measurements are carried out to determine the straightness of the casing wall to the base frame casing, measurements are taken during assembly before welding and after welding. Measurements before welding are carried out by measuring the distance between walls using calipers and measuring the distance between walls at some point (Figure 4). Turbine casing measurements are carried out to determine the straightness of the casing wall to the base frame casing, measurements are taken during assembly before welding and after welding. Measures before welding are carried out by walls at some point (Figure 4).



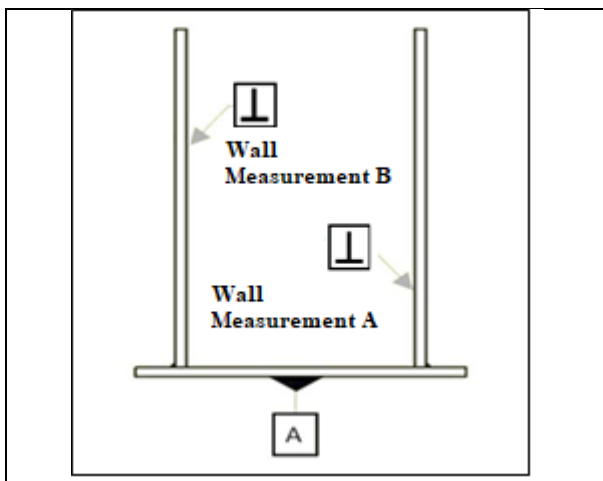
**Figure 4.** Measurement before welded

The measurement after welding is done by two methods, namely measuring the distance between walls and calipers and measuring the straightness of the lines and alignment of the walls using a dial indicator on a CNC mill machine. Measurement of the distance between walls after welding is done at the points that have been measured before welding. Follows the measurement process after the welding process (Figure 5).



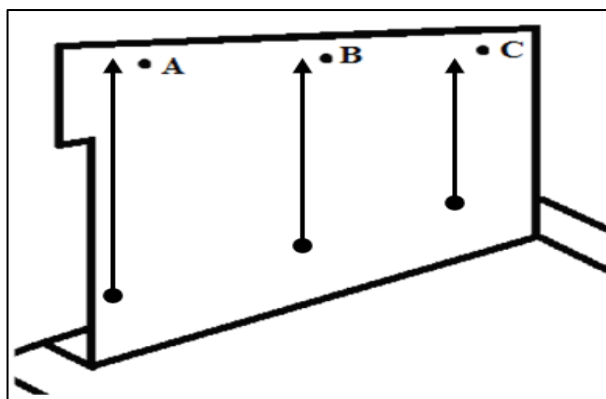
**Figure 5.** Measurement after welded

Straightness measurement and alignment of the casing after welding is carried out on both walls according to the design demands that are to be achieved (Figure 6).



**Figure 6.** The point of measurement of the straightness of the wall

Measurements were made on the casing walls with instruments measuring instruments in the form of dial indicators and carried out at points A, B, and C to the base frame (Figure 7). Figure 8 shows the process of measuring casing walls in CNC mill machines.



**Figure 7.** The point of measurement for the straightness of the casing wall



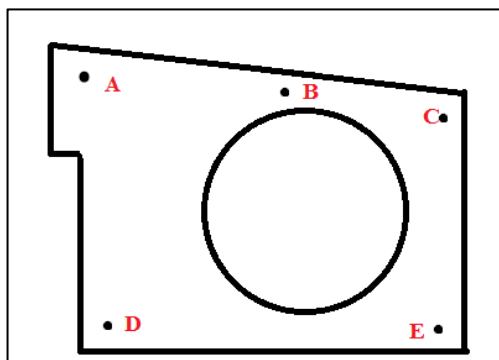


**Figure 8.** Turbine casing measurement process

### 3. Result and Discussion

The testing phase of the cross-flow turbine casing assembly aids has been carried out and can produce turbine casings that have been determined. The specimen is measured in accordance with the specified measurement procedures. Then the data obtained will be used to determine whether the chassis assembly fixture is successful in meeting the design target to be achieved.

The turbine casing measurement phase has been determined in advance where measurements are made before welding or after welding is carried out according to the specified assembly reference. The measurement before welding is only the measurement of the distance between the walls while the measurement after welding is the measurement of the distance between the walls and the measurement of the straightness of the casing walls. Measurement of distance between walls both before welding and after welding is done at points in accordance with the sketches that have been made (Figure 9).



**Figure 9.** The point of measurement of the distance between walls

Table 1 presents the data from the measurement of the distance between the discs using calipers (in mm) carried out before and after welding.

**Table 1.** Data from measurements of the distance between walls

| Point of measuring area | Before welded | After welded                   |                               |
|-------------------------|---------------|--------------------------------|-------------------------------|
|                         |               | Before the fixture is released | After the Fixture is released |
| A                       | 447.9         | 447.9                          | 450.4                         |
| B                       | 448.1         | 448.1                          | 450.5                         |
| C                       | 448.05        | 447.7                          | 449.1                         |
| D                       | 448.2         | 449.0                          | 449.7                         |
| E                       | 447.5         | 447.85                         | 448.25                        |

Based on the data obtained indicate that there is a change in the size of the distance between walls when the fixture is removed after welding, the biggest distance between walls is approximately 2 mm from the initial size (448 mm), this deviation is caused by the wall clamp at points D and E it has not been rigid to resist the deformation of the welding process so that the wall shifts and causes large deviations to occur at points A, B, and C.

Based on the data obtained indicate that there was a change in casing firmness measurements carried out on a CNC Mill machine to find out the perpendicular deviations that occurred in the casing walls after welding, and to find out whether the geometry deviations from the casing walls had met the design demands target what you want to achieve is 1.0 mm. Measurements were made at points A, B and C on each wall shown in Figure 9. Table 2 shows the geometry deviation of the casing wall against the base frame.

**Table 2.** Data on measurements of turbine casing firmness.

| Measurement Side | Measurement point | Minimum deviation (mm) | Actual Deviation (mm) |
|------------------|-------------------|------------------------|-----------------------|
| A wall           | A                 | 1.0 mm                 | 1.25                  |
|                  | B                 |                        | 1.20                  |
|                  | C                 |                        | 1.60                  |
| B wall           | A                 | 1.0 mm                 | 0.45                  |
|                  | B                 |                        | 0.73                  |
|                  | C                 |                        | 0.85                  |

Based on the measurement results above, the deviation values that occur on the two walls are different where wall A produces the biggest deviation of 1.60 mm from the allowable deviation of 1.0 mm, while the deviation generated from wall B is greatest at point C, which is 0.85 mm below the tolerance limit. which has been specified. The value of deviations that occur in wall A that are out of the tolerance limit that has been determined because the process of welding walls is not concurrently carried out on both sides which causes deformation that occurs on the wall being welded also affects the other wall.

Based on the results of testing using a casing assembly fixture and measurements made on the results of cross-flow turbine casing assembly using a casing assembly fixture, it can be concluded that the casing assembly fixture has not been able to meet the target geometric tolerance deviation to be achieved (1.0 mm).

#### 4. Conclusion

The conclusion of the research on the design of welding fixture assembly of cross-flow type micro-hydro turbine components is 1). The quality of cross-flow turbine casing products can be increased along with the small geometry deviations in the cross-flow turbine runner by using an auxiliary tool, 2). The maximum deviation of the turbine wall alignment is 1.6 (wall A) and 0.85 (wall B), and 3). The process of assembling the components of the turbine runner is shorter by using a faster welding assembly tool with a better level of accuracy.

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