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Measurement of Geometric And Functional Accuracy With ISO 1710 Standard on Feasibility of Welding Bending Test Equipment

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ABSTRACT

A bending test tool is a machine used for the bending strength testing process to determine the mechanical properties of metal materials and welded joints. The frame, hydraulics, and specimen mounts are examples of essential machine elements in bending test machines. The ISO 1710 standard, which is applied in functional and geometric testing of bending test equipment, is expected to help analyze the test to become more accurate the test results. The expected accurate category is the size, shape, and pressure applied to the specimen as desired. Testing includes functional on the frame by comparing actual dimensions and design, welding strength by comparing manual calculations and actual welding tests, and testing cylinder strength by comparing manual calculation of cylinder selection with the actual operation of cylinders on bending test equipment, and geometric testing, namely measuring flatness with deviations. Permissible straightness had a value of 0.02mm per 1000mm, straightness with an allowable deviation of 0.025mm per 300mm, and straightness 85 ° – 90 ° in welded joint bending test equipment. The geometrical test results of flatness measurement at datum A using a water pass are stated not to exceed the permitted limits with a flatness result of 0 °, the alignment test of the frame against datum A using a water pass is still in accordance with the allowable deviation limits with the test results of the right side 89.7 ° and the left side 89.8 °, the test the alignment of the cylinder with the dial gauge is stated to be still in accordance with the permissible deviation with the results of the X-axis 0 mm and Y-axis 0 mm. measuring ruler with the results of each predetermined measurement point is 800 mm, geometric deviations were found on the flatness test of the specimen jig holder in the longitudinal and transverse directions, namely 0.2 ° or 0.88 mm on the backside of the stand or the third measurement, this is probably due to because the thickness of the diameter welded mount, it is highly recommended to re-weld so that the test results are in accordance with the permitted deviation. The results of the functional testing of the bending test equipment are stated to be able to carry out tests with an accuracy of 95-99% with details of the comparison of the dimensions of the frame with the actual test, the functional testing of the frame based on the strength of the welding, and the functional testing of the cylinder is still below the allowable limit.

Keywords: Bending test equipment, ISO 1710 ,Geometric accuracy test, Functional accuracy test

1. INTRODUCTION

Indonesia is currently experiencing very rapid industrial growth, where each province has a new company every year. Based on data from the Ministry of Industry, the manufacturing industry is targeted to grow 4.8% -5.3% in 2020. A large number of companies has undoubtedly led to tighter competition[1].

The company must generate various advantages not to hinder the company's growth or things that can reduce consumer confidence, maintaining product quality. For example, in metal manufacturing and metal foundry companies, the products produced must go through several testing stages, one of which is the bending test. In order to achieve the target quality standards, the company uses particular standards, such as ASTM, JIS, ISO, and others. A bending test tool is a machine used for the bending strength testing process to determine the mechanical properties of metal materials and welded joints. The bending test machine or device will exert a compressive force through the plunger on the test material or specimen to the point where the specimen is brittle. In the operation of the bending test equipment, the operator must have adequate expertise and concentration. Likewise, with the bending test equipment, the accuracy and reliability of the bending test equipment performance is essential in producing products with very high quality and must have good accuracy.

Geometric accuracy testing is needed to determine the differences in the specifications of the tools produced with the geometric specifications listed in the technical drawing. If there is a difference between the measurement results and the technical drawing specifications, actions must be taken to improve and maintain quality—products (means of production). Geometric specifications include dimensions (dimensions), shape (form), position (position), and surface smoothness (smoothness) of the product.

The bending test tool's functional test is carried out to find out whether there is a difference between the calculation when designing and the actual one. Functional testing is also to determine whether each component is fit for use or not. Components can be suitable for use if the material and component performance is still under the permitted standards. This test is carried out to meet the operator's safety factor and the product's quality as a result of the test[2-3].

Welding can also be defined as the joining of two metals of the same type or not by heating (melting) the metal below or above its melting point, accompanied by or without pressure, and accompanied or not accompanied by filler metal. There are five basic types of joints in welding. The five joints include: butt joints, lap joints, T-joints, edge joints, and corner joints[4-5].

Geometric metrology functions to measure whether geometric characters still meet geometric specifications, namely references in the form of geometric tolerances. A measuring instrument is a tool that shows the amount of compressive strength that occurs in the test object[6-11]. In this experiment, the functional testing of the bending test equipment is testing using The ISO 1710 standard to determine the functionality and the accuracy of the measurement result.

2. METHOD

The research description can be seen in the following flowchart:

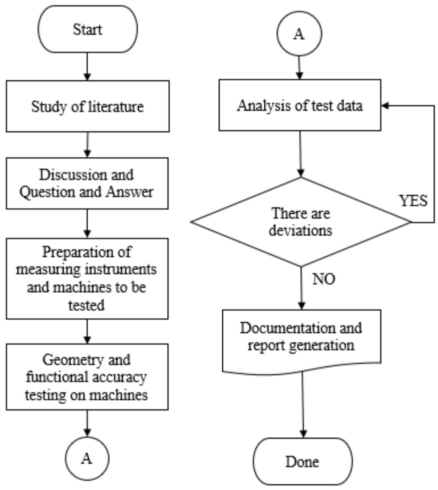


Figure 1. Flow diagram

The machine that will be used in functional and geometric testing is a welding joint bending test machine with the specifications shown below :

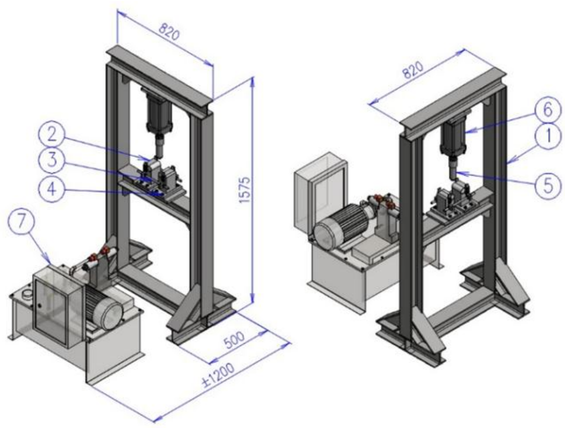


Figure 2. Welding joint bending test equipment

Details:
1. Standing frame
2. Jig specimen
3. Bolt lock adjuster
4. Bolt bottom clamp
5. Pounch
6. Cylinder hydraulic
7. Hydraulic system

In this test, a measuring instrument with ISO 1710 standards is used[12]:
1. Dial Indicator
2. Waterpass
3. Elbow ruler
4. Calipers
5. Measuring meter

2.1 Geometry Accuracy and Functional Testing in Machines

2.1.1. Geometry accuracy testing

The process of testing the geometric accuracy of the welding joint bending test equipment includes[13]:

1. Flatness testing on datum A is like figure 3

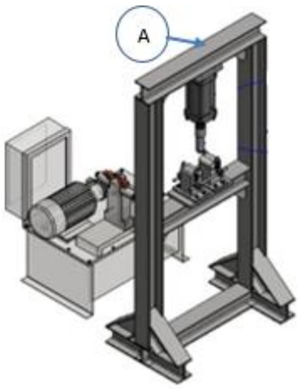


Figure 3. Datum A on the machine

Flatness test on datum A in the longitudinal direction serves as a reference for determining geometry in other parts because if datum A is outside the standard it can cause the pusher not to be perpendicular to the jig. The test result parameter to be observed is the flatness measurement result.

Testing steps:

a. Prepare the equipment to be used (in this test using a spirit level)

b. Clean the area to be measured

c. Place the waterpass in a longitudinal direction in the area to be measured

d. Take measurements according to the parameters used (allowable tolerance 0 – 0,02 mm for a measuring distance of 300 mm)

2. Testing the alignment of the frame against datum A. Testing of the alignment of the frame against datum A is carried out so that it becomes datum B which will be used for testing hydraulic components. The test result parameter to be observed is the result of perpendicular measurement.

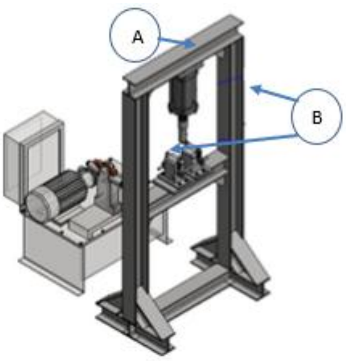


Figure 4. Testing of the straightness of the frame

Testing steps:

a. Prepare the equipment to be used (in this test using a spirit level or elbow ruler)

b. Clean the area to be measured

c. Place the waterpass vertically in the right and left side of the frame area

d. Take measurements according to the parameters used (allowable deviation 85 ° – 90 °)

3. Cylinder straightness test. The cylinder alignment test is carried out so that the hydraulic components do not leak so that the resulting compressive force can match the predetermined design. The test result parameter that will be observed is the straightness measurement result.

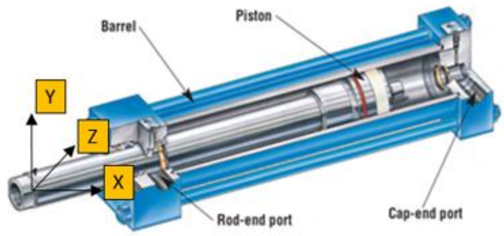


Figure 5. Hydraulic Component

Testing steps:

a. Prepare the equipment to be used (in this test using a dial indicator)

b. Installing a magnetic block on datum B

c. Place the measuring needle in the X, Y cylinder plane then move the cylinder up and down

d. Take measurements according to the parameters used (allowable deviation 0 – 0,025 mm for tests as far as 300 mm)

4. Tests for the perpendicularity of the cylinder against the jig. This test is carried out to prevent the bending test results that are not up to standard because the effect of the cylinder is not perpendicular to the jig. The test result parameter to be observed is the result of perpendicular measurement. Testing steps:

a. Prepare the equipment to be used (in this test using a spirit level and measuring meter)

b. Clean the area to be measured

c. Take measurements according to the parameters used (allowable deviation 85 ° – 90 °)

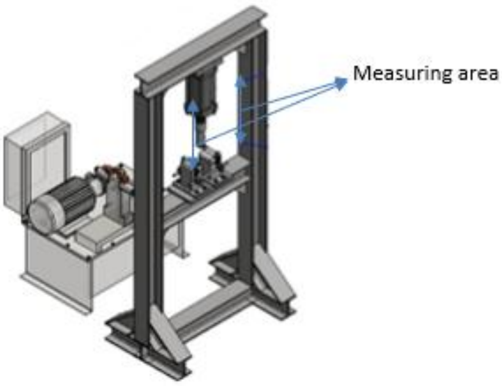


Figure 6. Measurement of angled cylinder

5. Testing the flatness of the specimen holder or specimen jig in the longitudinal and transverse directions.

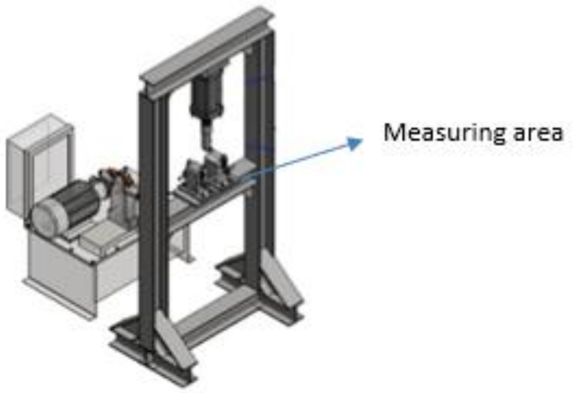


Figure 6. The jig holder to be measured

The measuring instrument used is a water pass, placed in a long and transverse direction. The test result parameter to be observed is the flatness measurement result. Testing steps:

a. Prepare the equipment used

b. The area to be measured is cleaned and marked to divide the size into several parts because the length of the water pass is limited to the work table or specimen jig in the longitudinal and transverse directions.

c. Place the water pass on the work table in the longitudinal and transverse direction

d. Take measurements according to the parameters used (allowable tolerance 0 – 0,4 mm or 0,1 ° for a measuring distance of 300 mm)

2.1.2. Functional accuracy testing

The functional testing of the welding joint bending test equipment includes:

1. Testing comparison of frame dimensions with actual. This test is necessary because if the dimensions of the frame are not in accordance with the design, the supporting components will not function as planned and the results of the bending test will not be accurate. In this test, the parameters observed are the measurement results of the frame dimensions.
2. Functional testing of the frame by testing the strength of the frame welding by comparing manual calculations and actual test results. The test result parameter to be observed is the resistance of the frame to a given pressure.
3. Cylindrical functional testing by comparing manual calculations and actual test results. The parameter of the test results to be observed is the resistance of the cylinder to a given pressure.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Geometry accuracy test result.

A. Flatness test results on datum A

Figure 7. Measurement of datum A with a waterpass

Measurements in the horizontal plane of datum A were carried out according to the test steps described in the research methodology and used a water pass measuring instrument with a measuring instrument length of 250 mm and a measuring distance of 820 mm. The waterpass meter uses degrees (°) so it must be converted into millimeters (mm) so that it is the same as the ISO 1710 standard. In this measurement, the allowable level deviation is 0 – 0,02 mm for a distance of 300 mm. Based on the Pythagorean formula, the degrees converted into millimeters are as follows[14].

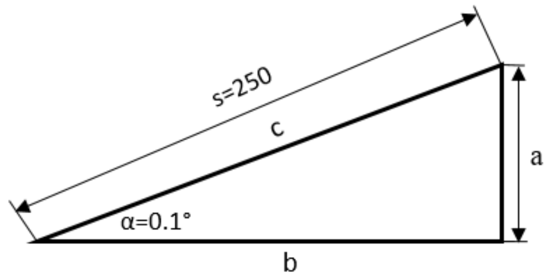
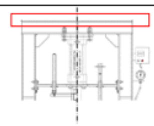


Figure 8. Calculation base of Pythagorean formula

Table 1. Flatness measurement results in datum A.

No	Diagram	Penyimpangan yang diizinkan	Jarak [mm]	Hasil pengujian	*Convert* ke mm
1		0-0.02 mm per 1000 mm	0-250	0°	0
2			250-500	0°	0
3			500-750	0°	0
4			750-820	0°	0

B.Testing the perpendicularity of the frame against datum A.

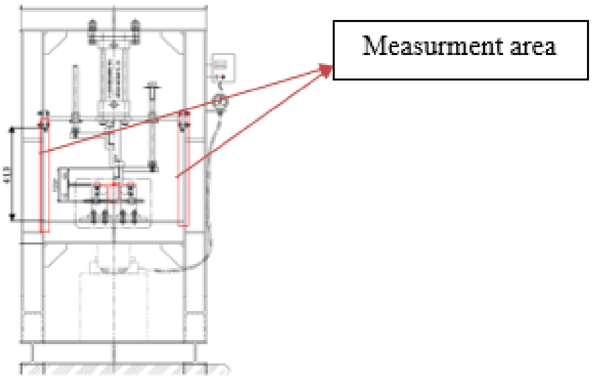


Figure 9. An alignment area of measurement

The measurement of perpendicularity is carried out on the right and left side frames as shown in (Fig.9] with research steps that have referred to the methodology. According to ISO 1710 the gradual deviation of the measurement direction should not be more than 90° or the range of 85 ° – 90°.

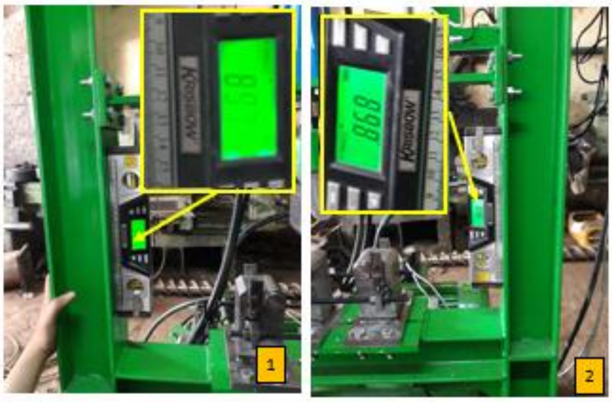


Figure 10. (1) Right side measurement. (2) Left side measurement

C. Cylinder straightness test

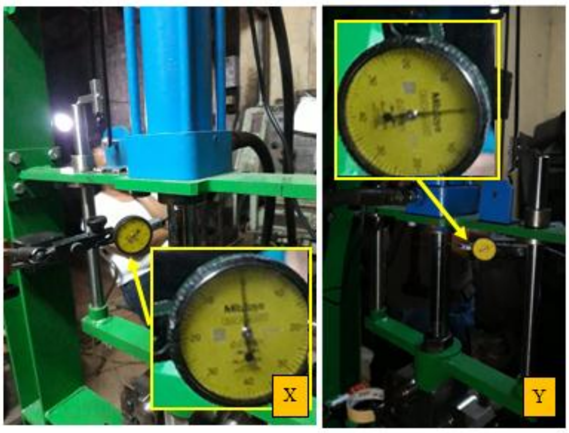


Figure 11. Alignment measurement with a dial gauge

The measurement of cylinder straightness was carried out by means of the test steps listed in the research methodology with the permitted ISO 1710 standard, namely 0 – 0,025 mm for a measuring distance of 300 mm. The levelness measurement uses a dial gauge and is divided into two parts of the measurement, namely the X and Y sides as shown in the (Fig.11].

Table 2. Results of measurement of straightness

No	Jarak pengukuran (mm)	Hasil pengukuran sumbu X (mm)	Hasil pengukuran Sumbu Y (mm)
1	0-25	0	0
2	25-50	0	0
3	50-75	0	0
4	75-100	0	0
5	100-125	0	0
6	125-150	0	0

It can be seen in Table 2 that there are no geometric deviations in the cylinder because the resulting measurement value is 0 mm at a distance of 0 – 150 mm. So that the cylinder is fit for use. If the cylinder alignment deviation is more than 0,025 mm it will cause leakage and shock when the cylinder operates. Things that affect cylinder alignment are the installation of a cylinder holder to the upper frame and the service life of the cylinder[15].

D. Tests for perpendicularity to the cylinder against the specimen jig

The measurement of the perpendicularity of the cylinder against the jig was carried out using a magnetic level and the test steps were as in the research methodology. The waterpass is installed at an angle with the right and left sides touching the pusher or suppressor side connected to the cylinder and touching the specimen jig bearings. Measurements are taken from the right and the left. The allowable measurement deviation is 85° – 90°. The measurement process is as shown in (Fig.12].

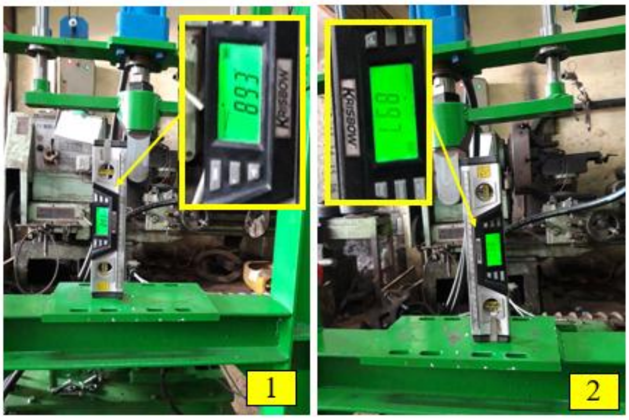


Figure 12. Alignment measurement with a waterpass

From the measurement results listed in Table 3, it can be concluded that the alignment of the cylinder to the specimen holder is still within the deviation limit. The thing that causes the measurement results to be imperfect is the possibility that the welding diameter on the jig holder is too thick or the result of the pusher lathe is not perfect.

Table 3. The results of the measurement of the perpendicularity of the cylinder with the specimen holder

No	Penyimpangan yang diizinkan	Pengukuran 1 (Kiri)	Pengukuran 2 (Kanan)
1	85°-90°	89.3°	89.7°

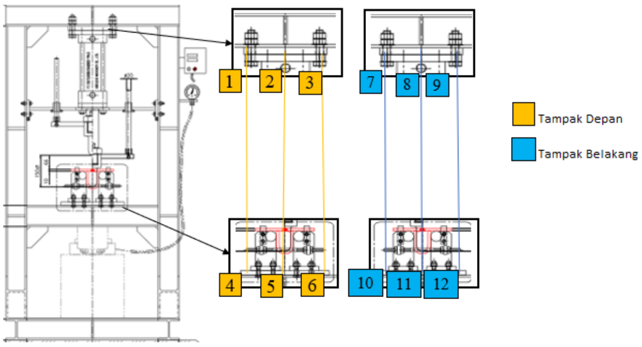


Figure 13. Measuring side with measuring ruler

Measurement of the alignment of the cylinder to the specimen jig is also carried out using a measuring meter, by pulling the measuring meter from the center point of the cylinder holder size to the center side of the specimen jig holder as shown in (Fig.13). Then from the middle side of each holder measured to the right and to the left by 50 mm, then measured again from the right and left points of each cylinder holder and specimen jig. In measuring the front and back of the stand using a measuring meter, the same measurement results were obtained, namely 800 mm from each side, the measurement process is as shown in (Fig.14). So that the cylinder can be said to be perpendicular to the specimen holder because it has gone through two stages of measurement with the results not exceeding the permitted limits. [16]

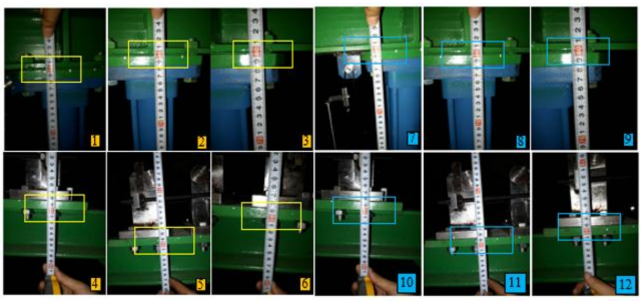


Figure 14. Measurement process with measuring ruler

Table 4. Measurement results with a measuring ruler

No	Hasil pengukuran (mm)
1	800
2	800
3	800
4	800
5	800
6	800
7	800
8	800
9	800
10	800
11	800
12	800

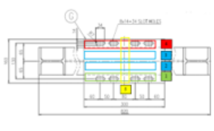
E. Testing the flatness of the workspace or jigsaw specimen in the longitudinal and horizontal directions

In this measurement, it is intended that the specimen jig holder is flat so that when the specimen jig is attached to the bending test tool and the operation process is carried out, the resulting compressive force will be perpendicular to the specimen so that it produces a U-shaped specimen and can see the cracks in the specimen for testing the results of the test.

Figure 15. Flat measurement with waterpass

From Table 5 the resulting measurement data can be seen that there are deviations in subject 1 and subject 4 with a deviation value of 0,88 mm. This is probably due to the thickness of the weld diameter. So that if the specimen jig is still installed and the bending test process is carried out on the specimen to find out the welding defect, it will cause the cylinder not to press evenly on the gluing side of the test specimen.

Table 5. The results of flatness measurement

No	Diagram	Penyimpangan yang diizinkan	Subjek	Hasil Pengukuran	Convert ke mm
1		0-0.4 mm per 300 mm	1	0.2° (⟶)	0.88
2			2	0.1° (⟶)	0.44
3			3	0.1° (⟶)	0.44
4			4	0.2° (⟶)	0.88
5			5	0.1° (⟵)	0.44

3.1.2.Functional accuracy test result.

A. Testing comparison of frame dimensions with actual

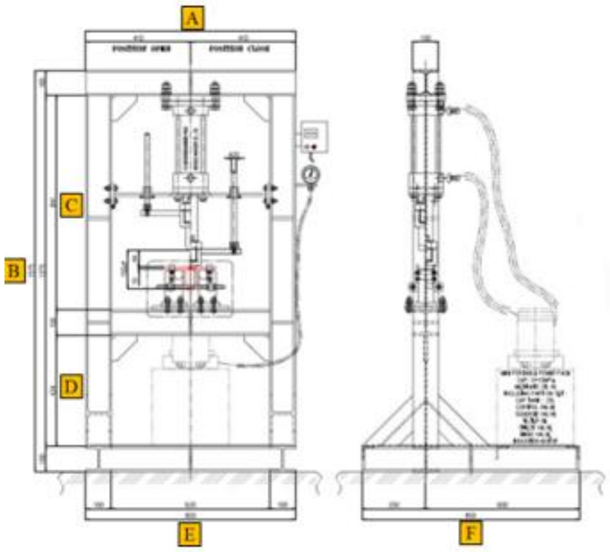


Figure 16. Measurement area

The actual measurements on the frame are taken when the machine is finished assembly. This measurement is carried out so that there is no dimensional shift in other components which can cause the accuracy of the weld joint bending test results to decrease. The parameters in this test are the dimensions of the design or drawing of the bending test equipment. The measurement area follows the design or working drawing that has been designed by the designer. From the measurement process the actual dimensions are shown in Table 6.

Table 6. The actual measurement result is in mm.

Point Check	A	B	C	D	E	F
Size	500-1000	1000-2000	500-1000	200-500	500-1000	500-1000
Toleransi	±3.0	±4.5	±3.0	±2.5	±3.0	±3.0
Ukuran pada gambar	820	1576	841	434	820	850
Ukuran aktual	821	1576	842	455	821	852

The actual measurement results of frame dimensions can be seen in Table 6, where there is no actual size that passes the tolerance so that the bending test frame does not need to be re-assembled and can be continued to carry out testing on other components.

B. Frame functional testing based on welding strength

1. Manual calculation of welding strength on the frame
   Manual calculations are required to determine the design before the fabrication process is carried out and as a parameter to carry out functional feasibility testing when the fabrication process has been completed[17].

   It is known as follows:

   $F_1 = 39200N;\ F1'' = 19600N$ $\ell = 100\ mm$
   $F_2 = 39200N;\ F2'' = 19600N$ $b = 100\ mm$
   $L_1 = 410mm$ $h = 8\ mm$
   $L_6 = 310mm$ $\tau_{izin} = 40MPa$
   $\sigma_{izin} = 163.3MPa$

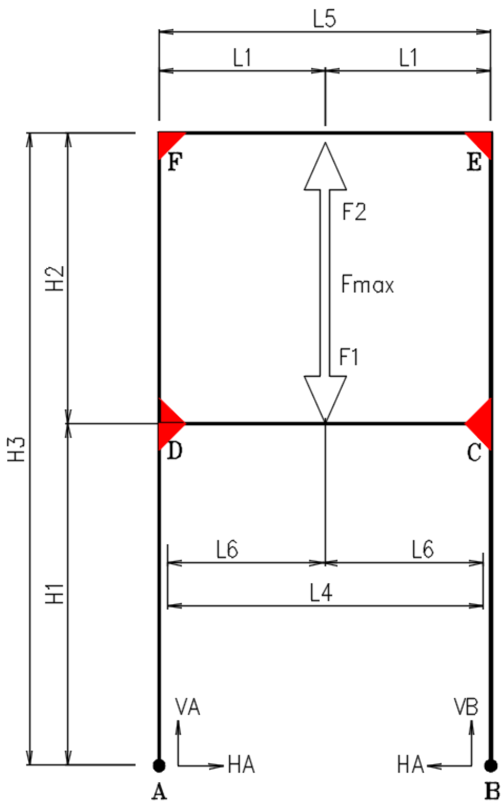


Figure 17. Identify the welding strength of the frame

Calculating Weld Strength in Areas F and E

$$\sigma = \frac{0.707.F2''}{l.h}\sqrt{1+\frac{4.L1^2}{b^2}}$$

$$= \frac{0.707x19600}{100x8}\sqrt{1+\frac{4x410^2}{100^2}}$$

$= 17.32\ x\ 8.26$

$= 143\ MPa < 163.3\ MPa\ (ok)$

$$\tau = \frac{0.707.F2''}{h.l}$$

$$= \frac{0.707x19600}{8x100}$$

$= 17.3MPa < 40Mpa\ (ok)$

Calculating Weld Strength in Areas C and D

$$\sigma = \frac{0.707.F1''}{l.h}\sqrt{1+\frac{4.L6^2}{b^2}}$$

$$= \frac{0.707x19600}{100x8}\sqrt{1+\frac{4x310^2}{100^2}}$$

= 17.32 x 6.28

= 108 MPa <163.3 MPa (ok)

$$\tau = \frac{0.707.F1''}{h.l}$$

$$= \frac{0.707x19600}{8x100}$$

= 17.3MPa < 40Mpa (ok)

From the results of the manual calculation of the gluing strength with the known values of force, size and stress, it is stated that it is still within safe limits because it is still below the normal values of stress and the allowed shear stress.

2. Actual testing of welding strength on the frame
   After knowing the calculation of the weld strength and the permissible limit, the bending test equipment is performed using the SS400 specimen[18].

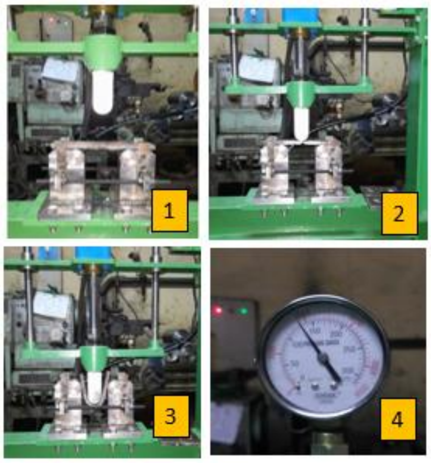


Figure 18. Testing of frame welding strength

The stages of the operation process can be seen in (Fig.18), and as follows:

a. The bending tester is turned on and the specimen is placed on the jig

b. Press the down button on the control panel and the pusher will move automatically to the lowest point then return to the original point or zero point

c. The pressure given is 130 Kg / cm^2 or 12,5 Mpa

The parameter in this test is that the specimen must be U-shaped with a given pressure of 130 Kg / cm^2 or 12,5 Mpa and there is no shift in the frame welding. From the results of the testing process, it can be concluded that the frame is very safe to use because there is no bending, deformation, deflection and buckling of the frame and according to the designer's calculations and the specimen can be in the form of a U.

C. Cylindrical functional testing

1. Manual calculation determines cylinder
   Based on the design that has been designed, here's how to determine which cylinder to use so that the cylinder can function optimally and accurately[19-23]:

   - It is known that the required Fmax is 39200 N and a pressure of 12,5 Mpa.

     $F = P \times A$

     $A = \frac{F}{p} = \frac{39200}{12.5} = 3136\ mm^2$

     The compressed area obtained is 3136 mm^2

   - Next find the cylinder diameter:

     $A = \frac{3.14 \times D^2}{4}$

     $D^2 = \frac{31336 \times 4}{3.14} = 3994,9\ mm$

     $D = \sqrt{3994.9} = 63,2\ mm$

   - Approach cylinder on the market is Bore size 63 mm

   - Hydraulic cylinder specifications: Bore size 63mm x 150 mm step *F8 – SA 2FA 63B140N 150-BOA (Horiuchi Machinery)*

2. Cylindrical functional testing
   In cylinder functional testing, the parameter that must be considered is the pressure applied to the cylinder so that the cylinder strength can be seen from the change in the shape of the cylinder after pressing the specimen. Furthermore, for the testing process with predetermined parameters, it is carried out in the manner shown in Figure 19.

Figure 19. Cylindrical functional testing

It shows that to open the fluid valve in the power pack with a pressure of 12,5 Mpa to push the SS 400 specimen. The results of the cylinder test are found to be able to push the specimen to form a U-bending shape without any leaks or cracks. on the cylinder.

4. CONCLUSIONS

The conclusions that the authors can give include the following:

a. There is a deviation from the geometric test results. From Table 5, it can be seen that there is a deviation of 0.2o in the flatness test of the specimen jig holder in subject one and subject 4; this is probably due to the thickness of the welding diameter.

b. Based on the geometric and functional testing results, the welding joint bending test tool is declared feasible to operate but must re-weld the specimen holder so that the geometric accuracy of the flatness does not pass through the permitted brickwork.

c. Based on the test results, the recommendation for improvement is to re-weld the specimen jig holder.

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