Istraživanja i projektovanja za privredu
ISSN 1451-4117
DOI:10.5937/jaes0-37093
www.engineeringscience.rs

Journal of Applied Engineering Science
Vol. 20, No. 4, 2022
Original Scientific Paper
Paper number: 20(2022)4, 1022, 1175-1183

EFFECT OF ADDITIONAL GRIP ON TENSILE STRENGTH OF NON-FERROUS MATERIALS FOR SHIP

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Non-ferrous material frequently slipped failure, hard clamp surface press slip occurs, and non-metal material lacks a rigidity hold for the clamp, resulting in a slip or break before the limit strength. So as efforts to prevent this problem are carried out from additional grips to reduce the occurrence of slips to obtain an increased testing accuracy. Additional grip designs are created using material sizes specified by ASTM D638. material grip receives pressure equal to 106.4 MPa, so to prevent deformation, stainless material is chosen as additional grip. This test is to determine the quality of the materials used for the ship. In this research, a test using additional grip was developed to improve technology for the test. Continued data analysis and a conclusion were obtained that the tensile test using tools has a high success rate. Rubber and fibre-reinforced plastic (FRP) specimens have a success rate of 60%. The factor causing the low success rate of wood testing is that the wood fibres have an irregular direction, so this uncertainty makes the tensile test results unsuccessful. From the tensile testing process, the ultimate stress value of specimens without grip tools is lower than tests with additional grips. The ultimate stress rubber value was 51.92%, the FRP was 16.40% more than the ultimate stress with the average value, and moreover, the tensile strength of HDPE also elongated as accepted by the rules.

Keywords: additional grip, ship, technology, non-ferrous, accuracy

1 INTRODUCTION

Before building a ship, it is necessary in the shipbuilding industry to review materials. That is, to understand the material's properties. Tensile tests, compressive tests, bending tests, and shear tests are all methods for evaluating material properties. A standard is used as a reference in conducting material testing, from preparation to acceptance criteria, in a test method. The case study was performed on a tensile testing machine capable of pulling non-Ferro material with a capacity of 20 tons. Figure 1 shows how universal testing machines (UTM) are used for ferrous materials. To determine the material characteristics of the property, a tensile test was performed [1]. Yield strength, ultimate strength, elongation, and reduction area are the outcomes [2]. Tensile tests cause issues because the machine is not designed for non-Ferro materials. The issue arises during the tensile test when a force is applied to a specimen and pressure acts on the grip. The specimen slips, and the result is incorrect. An additional grip was installed to accommodate the failure, allowing the test to be completed.

Additional grip reduces force and the potential of the specimen breaking on the clamp. The grip on the existing clamp is made of a hard material and is under high pressure. The new grip is an additional tool for testing nonferrous specimens [3]. Its working principle is to reduce stress on the steel material so that force is distributed and the material creeps freely. Material selection is obtained by measuring strain size with the P3 strain indicator instrument [4], [5].

This measurement is taken in the tensile test specimen area by installing a strain gauge sensor so that the local stress converts into a pressure magnitude [6]. Then, the tensile test was compared using an existing and additional grip on UTM. Idealization using new grips is proven to be able to obtain adequate non-ferrous material test results [7]. Fig 1. depicts the specimen standard geometry size and shape of a tensile test, with the material pulling with the load and elongation beginning until it breaks.

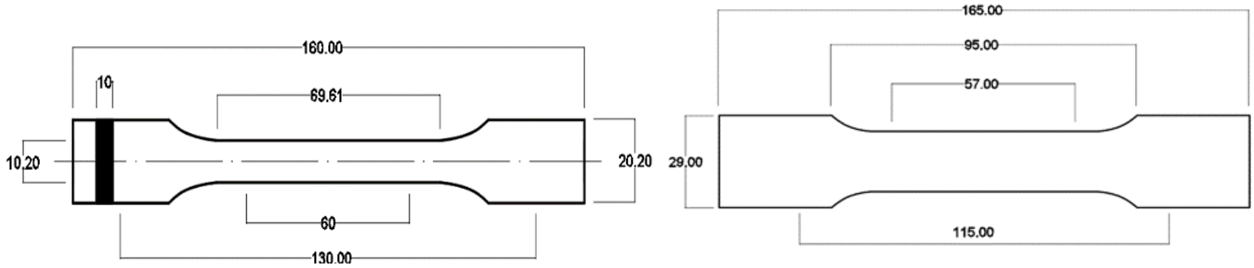


Fig 1. Dimensions of tha spesimens from ASTM D638 [8]: (a) Fiber-reinforced plastic (FRP); (b) Rubber

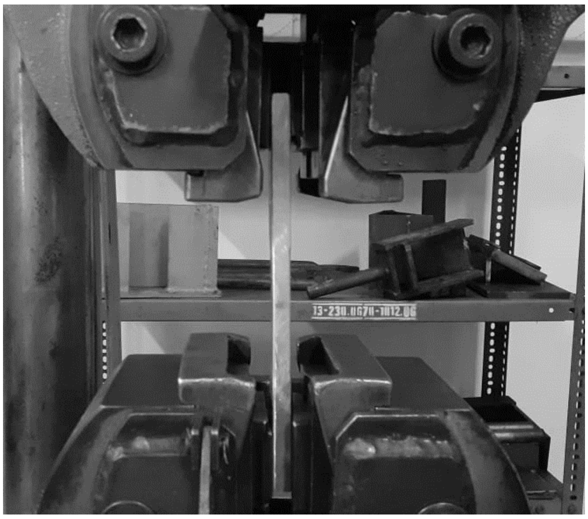


Fig 2. Existing Grip of UTM

Fig 2. Universal Testing Machine (UTM) and existing grip that is used for ferrous materials. It also tests non-ferrous materials rarely. Issues that occur when non-Ferro specimens are subjected to a tension load and the specimen breaks when grip act. A pressure work on grip presses the specimen and the surface is also harder than the sample of experiments. Therefore, additional grip is required to improve the tensile strength of nonferrous material. This research aims to compare tests of the existing grip from UTM with the new additional grip. Hence, the test is to observe the yield strength and tensile strength difference.

2 DESIGN GRIP PROCESS

The development of additional grip UTM for non-ferrous materials in tensile tests is adaptive to the characteristics of the material. Non-ferrous materials often break on existing during the tensile test, making it necessary to improve the existing test. Selection-based material for the additional grip used current data from the previous grip pressure. Grip pressure was measured using P3-strain indicator instruments to obtain a precision local pressure that acts on the surfaces of a specimen. Fig 3. shows that the maximum strain on the upper grip and the lower grip is almost the same magnitude. The test uses a load at a load scale of 2 tonnes for each material to get a clear picture of the test results. The maximum strain result as a function used to determine stress, which is measured in microstrain units, should be multiplied by the elasticity modulus.

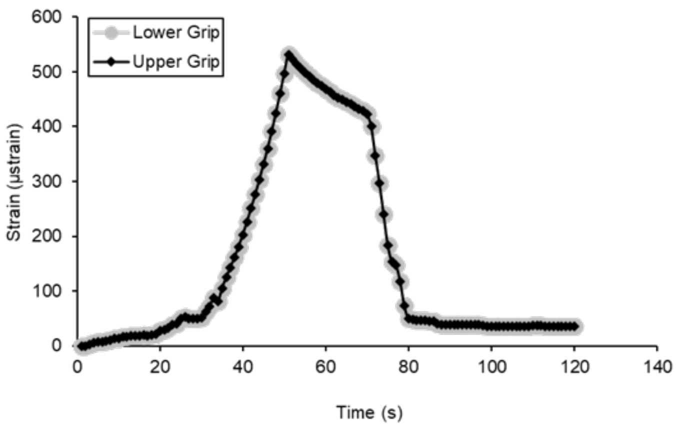


Fig 3. Pressure Measurement Graph

Considering that material under tension load to the material produces strain and converts stress, it is represented in Formula (1) as follows [9], [10]:

$$\sigma_n = \mu_s . E \quad (1)$$

In Formulas (1), σn is the local stress area of interest, or stress produced by μs strain at the load work multiple with E, or modulus of the material. Perform the test using a steel specimen to know the best result for existing grip pressure. This test load is performed using a steel specimen to know the best result from existing grip pressure. Pressure stress outputs several data values of strain and converts them into that shown in Table 1.

Table 1 Experiment data of the pressure test existing grip to obtain working load at the clamp

Grip	Strain (μ_s)	Modulus Young (E)	Time step (s)	Stress (MPa)
Lower Grip	532 x 10^{-6}	200 x 10^9	50	106.40
Upper Grip	529 x 10^{-6}	200 x 10^9	55	105.80
		Deviation (%)		0.56

The result of this experiment is used as a parameter to select the base material of the new grip. Additional grip is produced with stainless steel to prevent local deformation when gripping and corrosion. To install, an additional grip design has been adjusted with the existing clamp. Moreover, the UTM in this case acts as the boundary to determine the dimension of grip, and design of the new grip was shown in Fig 4.

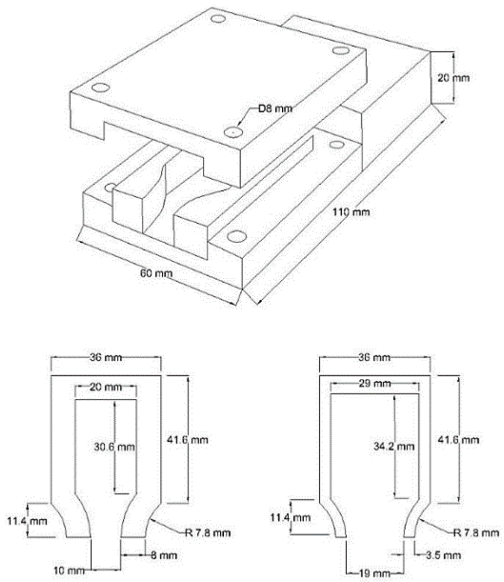


Fig 4. Additional Grip Design

The effect of the grip method on tensile testing affects the results of the characteristics of the test material. In more detail in terms of testing, the accuracy of the pressure on the grip is determined based on the surface roughness [11]. Therefore, failure can occur if the pressure on the grip surface is too great. New grip designs are processed by milling and Computer Numerical Control (CNC) cutting to obtain the precision of the design. General procedures are taken to tensile material on the destructive test that is shown in Fig 5.

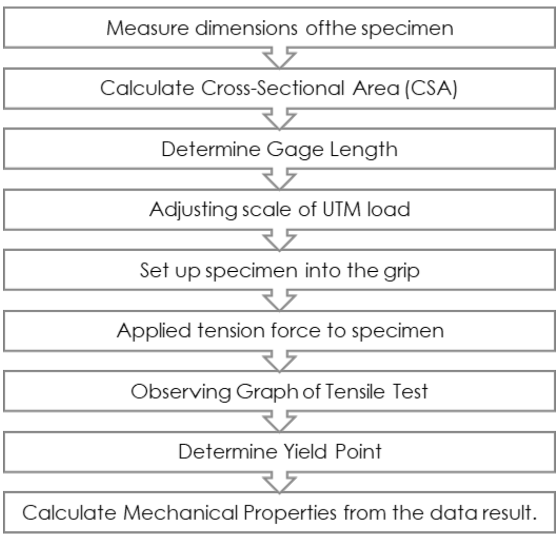


Fig 5. General Methods of Tensile Test [12]– [14]

A tensile test process starts while the loads are generated in the specimen. Tensile testing of material properties to determine elongation percentage, tensile and ultimate strength The determination of test results was calculated with several formulas to acquire the characteristics. However, the tensile test while extracting mechanical properties of the material used to calculate the characteristics of materials used several equations (2–5) as follows [1]:

$$\sigma_{ult} = \frac{F_{ult}}{A_0} \quad (2)$$

$$\sigma_{yield} = \frac{F_{yield}}{A_0} \quad (3)$$

In Equations (2-3), σ_{ult} and σ_{yield} shall be taken to ensure strength of the materials that unit is N/mm2 gainded from measurement force F divided by A_0 or Cross-Sectional Area, then to obtain ε (elongation) see from final length L_u of the gauge length minus by initial length L_0 and divided with L_0 unit unit given in percentage (%) [14], [15].

$$\varepsilon = \frac{L_u - L_0}{L_0} .100 \quad (4)$$

$$R_a = \frac{A_0 - A_u}{A_0} .100 \quad (5)$$

R_a or Reductional of area represents a decrease in sectional area in gauge length area. Elongation and Ra should be determined to determine if material characteristics are ductile or brittle. Stress and strain diagrams in Figure 6 illustrate more clearly the conditions of formulation that have been satisfied.

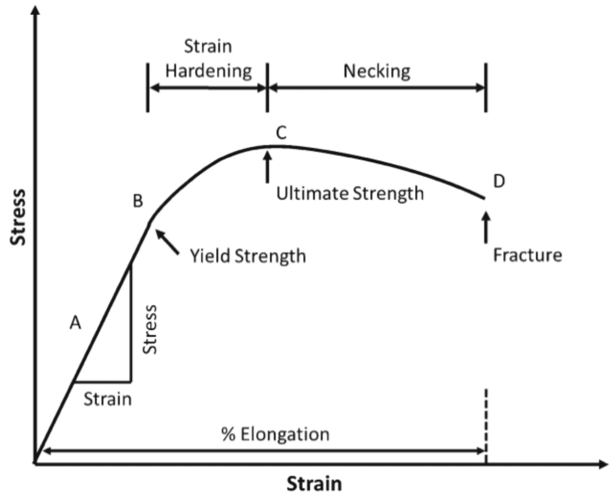


Fig 6. Stress Strain Curves [14]

Stress-strain diagrams explain the phenomenon of fracture stages of material, while force acting on material stress should occur and elongate (A) until the elastic zone ends (B), then enter the plastic zone (C), material is not capable of returning to the first form and continues to stretch during load on the top of the point material reaches breaking point (C) and material breaks (D). Stress units are force divided by area, and strain is nondimensional. The size and shape of stress-strain diagrams determine the point of yield, ultimate, and fracture point of material diagrams, which are affected by several factors such as composition, heat and conditioning, prior history of plastic deformation, strain rate of test, temperature, orientation of applied stress relative to the test specimen structure, and material dimension [16] [17] To prove the performance of the additional grip, two types of non-ferrous materials were tested, namely rubber, FRP, and High-Density Polyethylene (HDPE). Experiments were carried out to the ASTM D-638 standard. The number of specimens that were used for the tensile test is summarised in Table 2.

Table 2 Total of specimens

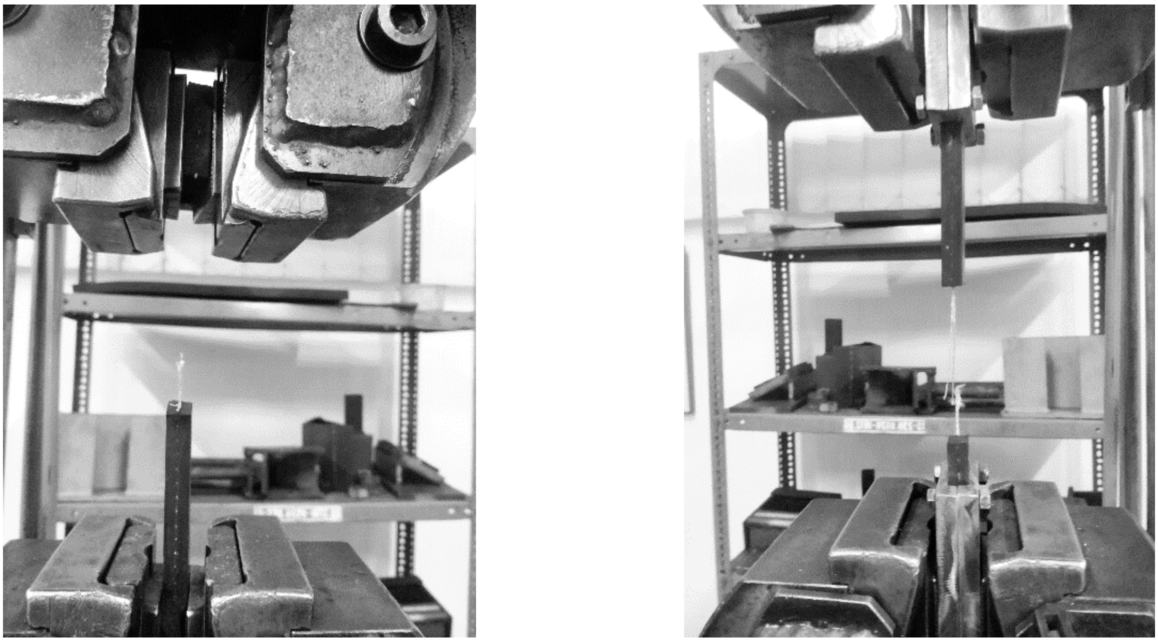
Material types	Number of specimens	
	Existing Grip	Additional Grip
FRP	5	5
RUBBER	5	5
HDPE	3	3

All the test pieces will be run using the UTM machine to obtain comparison test results.

3 RESULT AND DISCUSSION

3.1 Effect of Tensile Strength on FRP and Rubber

The differences in installation and results of the two clamps on a universal tensile machine have been shown in Fig 7. hence a value from the experiments carried out differently. It was able to observe from the majority of test pieces failure in the clamp caused by the working pressure on the grip.



(a) (b)

Fig 7. Comparison tensile test results: (a) existing grip, (b) new additional grip.

Fracture of the material in the clamp results in significant differences in tensile and ultimate strength. The accuracy of the test decreases when using the existing grip. Then in Figure (b), it was able to explain that the break is in the gauge length area. Hence, the tensile test results are more precise. The data from the tensile test results are explained in Table 3.

Table 3 Comparison experiment data ultimate strength using additional grip and Existing grip.

Specimens	Ultimate Strength of FRP (MPa) [18], [19]		Ultimate Strength of Rubber (MPa) [20]	
	Existing Grip	Additional Grip	Existing Grip	Additional Grip
1	70.224	87.624	1.054	3.347
2	84.924	89.295	1.792	4.119
3	71.572	83.797	2.022	4.119
4	71.572	94.749	1.031	2.573
5	70.224	94.927	2.155	2.593

The additional grip performed in this study consists of an experiment of non-ferrous material and is uncertain exactly how much more accurate than the existing grip. A phenomenon is currently occurring because of the loss of pressure acting on clamped material, which means it can stretch more freely than existing conditions. The explanation of data experiments effectively demonstrates observation understanding using a graphic that is shown in Fig 8.

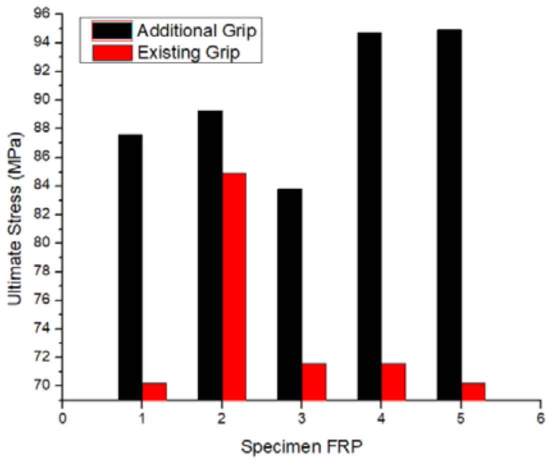


Fig 8. Deviation of tensile test results of (a) FRP

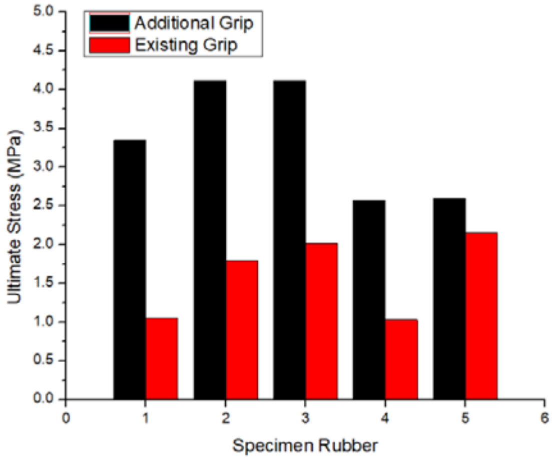


Fig 8. Deviation of tensile test results of (b) Rubber

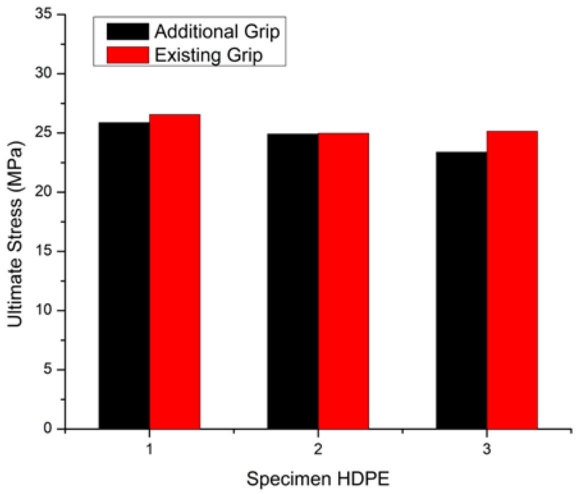


Fig 8. Deviation of tensile test results of (c) HDPE

3.2 Effect of the additional grip on HDPE material

Another effect occurs while the material test is changing by HDPE (High-Density Polyethylene). The pressure of the existing grip has a great impact due to the elongation of the material. the result of experiment is summarized in Table 3.

Table 3 Comparison experiment data ultimate strength using additional grip and Existing grip.

Specimen	Ultimate Strength of HDPE (MPa) [21]		Elongation (%) [22]		Acceptance Criteria HDPE [23]
	Existing Grip	Additional Grip	Existing Grip	Additional Grip	Ultimate (MPa); Elongation (%)
1	26.56	25.88	161	430	
2	24.98	24.91	123	440	24; 10-1500
3	25.15	24.38	155	431	

Strength value to follow the requirements by documents of mill certificated whereas the HDPE have minimum tensile strength is equal, or up to 24 MPa, therefore, the criteria is accepted.

Fig 9. shows the details of the tensile test process. The additional grip influenced the characteristics of elongation percentage when the tensile test was running. The usage of grip reduces the force that indicates the breaking cause of high pressure on the clamp of the universal tensile machine.

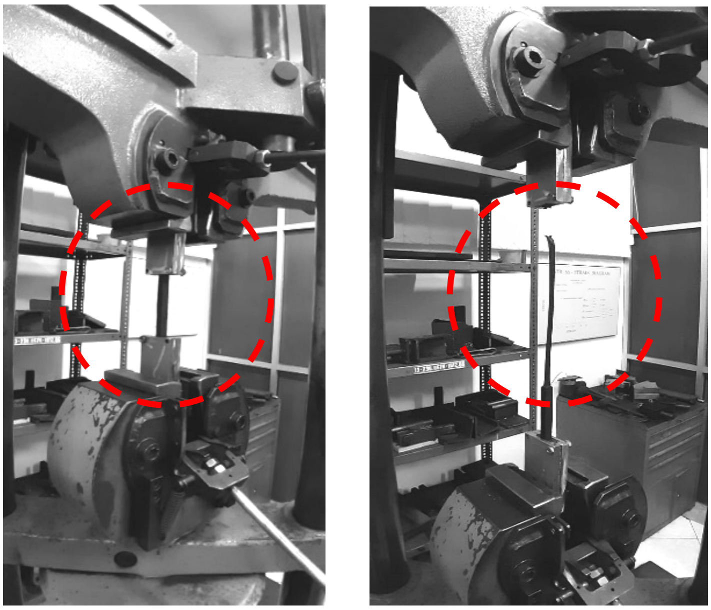


Fig 9. Comparison tensile test results: (a) existing grip, (b) new additional grip.

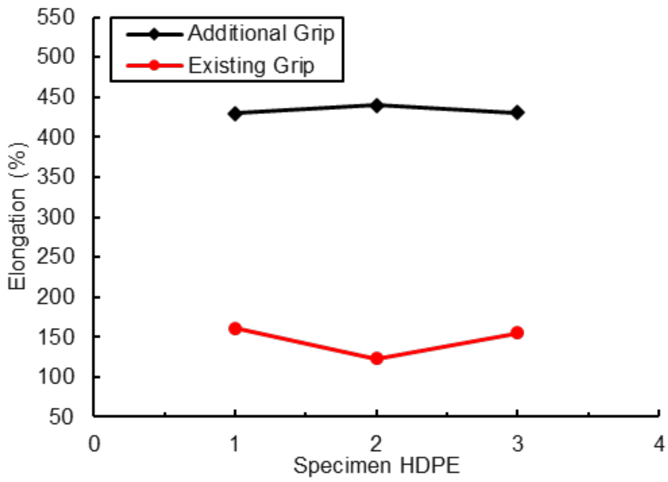


Fig 10. Deviation of tensile test results of HDPE

The response is presented in Fig 10., where the elongation of HDPE material experienced is advantageous for reaching acceptance criteria up to 50%. Therefore, the additional grip will improve the accuracy of the UTM tensile test optimally.

3.3 Breaking assesment

The success of non-ferrous material measurement in tensile testing is that data can be obtained right in the planned gauge length area. However, the fault is able to provide data input for analysis. The test results are obtained with a high degree of accuracy and precision.

Table 4 Success rate of tensile test

Test Piece	Test completed				Success Rate (%)	
	Existing Grip (A)		Additional Grip (B)			
	Sucess	Fail	Suceess	Fail	A	B
FRP	1	4	4	1	20	80
RUBBER	0	5	3	2	0	60
HDPE	3	0	3	0	100	100

Table 4. indicates that the tensile test using additional grip is in good agreement with the success rate percantage. The difference in the success rate is mainly because of the pressure working in the clamp area and is plotted in Figure 10.

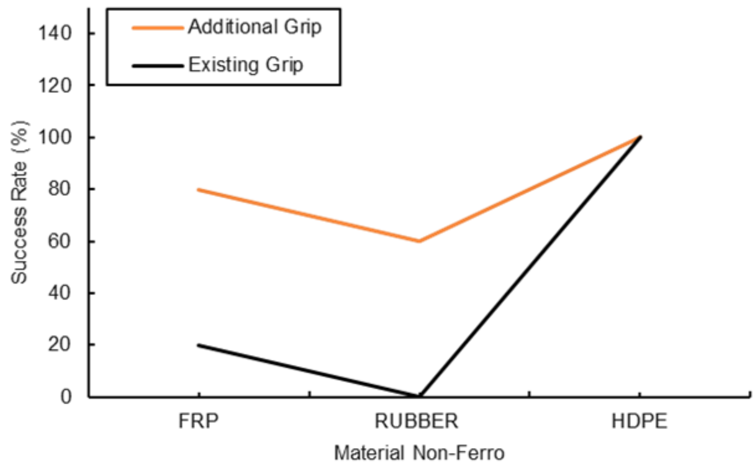


Fig 11. Deviation of tensile test results of HDPE

A preparation clamp is needed to support the success rate of testing, as evidenced by the results of the pull test with and without additional grip. Testing without using additional grip will provide additional pressure in the grip area of the material, causing faults in the grip area. This contrasts with the use of grip tools that eliminate the pressure effect around the clamped area, where the material effect can be attracted freely and broken naturally without additional pressure interference. Hence, the success rate value for both conditions is 40% for existing grip and 80% for additional grip. Additionally, experiments can be validated using numerical analysis that also affects material properties of structures, such as damage identification [24] and strength analysis on ship [25], [26].

4 CONCLUSION

The effect of additional grip on the tensile strength was performed to experiment with the non-ferrous material compared to the existing grip at relatively the same condition. The experiment data for tensile strength or ultimate strength results in the parents' condition show if the design of additional grip has better accuracy than the existing grip. The successful percentage produced by additional and existing grip is 40% for FRP and 80% for rubber. Moreover, testing with HDPE also shows good results where elongation is not affected by pressure grip when the material is pulled.

The ultimate strength calculated by formulation force divided by area obtained on gauge length area is in good agreement with that experiment performed in newer studies. Future studies are necessary to test more nonferrous specimens to observe the result.

5 ACKNOWLEDGEMENT

The authors wished to thank the Ministry of Research, Technology and BRIN for Doctoral Program Research Grant of the year 2022 with entitled “Studi kehandalan konstruksi kapal berbahan HDPE akibat beban gelombang acak with contract number 084/E5/PG.02.00.PT/2022, and 1381/PKS/ITS/2022. The authors also thank to Laboratory Ship Strength and Construction helps in experimental tests.

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Paper submitted: 22.03.2022.

Paper accepted: 18.06.2022.