The New Design of The Service Wedge Clamp Increased The Tensile Load

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Abstract. The construction materials meet the standard needed to support the safe use of electricity in consumer's homes. The Electricity house lines are part of the PLN electricity distribution line. The practicality is that so many house lines are damaged, especially the service wedge clamp which is made of thermoplastic because it cannot withstand the tension load caused by the house line cable. To overcome this issue, a service wedge clamp with an adequate tensile load is needed. This research is applied research carried out by redesign, mathematical calculations, and statistical data processing of the research object of twenty-five samples service wedge clamp. The service wedge clamp that is the object of this research only has a maximum tensile strength of 8.87 deka newtons. Based on PLN standard No. 83/1991 the required tensile strength (load) is 160 deka newtons. The problem is that the service wedge clamp body breaks to resist the pressure of the support during the pull test. To overcome this problem, a redesign was carried out and tensile strength testing was done to increase the strength of the Service wedge clamp. The new design results were carried out by adding support to the support design. The tensile strength (load) of the new design of the Service wedge clamp is increased to a maximum of 188.21 deka newtons, the result is more than the standards determined by the State Electricity Company (PLN). Design improvements have been proven to increase the strength of this thermoplastic service wedge clamp.

Keywords: Insulation, Plastic, Tensile

1 Introduction

1.1 Problems Background

The construction materials meet the standard needed to support the safe use of electricity in consumer's homes. The Electricity house lines are part of the PLN electricity distribution line. The practicality is that so many house lines are damaged, especially the service wedge clamp made of thermoplastic because it cannot withstand the pull caused by the house line cable. Following the Bali State Polytechnic as a leading center for green tourism, this research is very appropriate to ensure the safety

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of humans who use electricity, from the possibility of accidents due to damaged service wedge clams which have affected damaged electricity lines for households. To overcome this issue, a service wedge clamp with standard tensile strength is needed.

This research is applied research by carried out redesign, mathematical calculations, and statistical data processing of the research object of twenty-five samples service wedge clamp. The service wedge clamp that is the object of this research only has a maximum tensile strength of 8.87 deka newtons. Based on PLN standard No. 83/1991 the required tensile strength is 160 deka newtons. The problem is that the service wedge clamp body breaks to resist the pressure of the support during the pull test.

To overcome this problem, a redesign was carried out and tensile strength testing was done to increase the strength of the Service wedge clamp. This redesign is done to thermoplastic material. The consideration utilized thermoplastic polymeric matrices because this material has a low production cycle, lower cost of processing, and high reparability (Shubhra et al., 2013).

The new design results were carried out by adding support to the support design. However, In this new design, the thickness insulation by AC and impulse could not be applied to this service wedge clamp because like the cable fabrication process due to much low electrical breakdown strength (Cheon et al., 2006; Ying et al., 2022). This new design of service wedge clamp will not change its shape or thickness, so it will not change the thickness of the insulation, because it will be applied to power cables with AC voltage.

This research, like generally applied research, was carried out by applying related theories to solve the problems in the implementation of service wedge clamps. This research is quantitative research carried out by carrying out calculations after the design drawings have been done. The test results of this research were processed using simple statistics to obtain comprehensive research results.

1.2 Problem

How to design a new service wedge clamp to increase its tensile load while still using polypropylene material.

2 Methodology

2.1 Research Approaches and Concepts

This study is an applied research, this study focuses on finding the solutions to increase the tensile load of the service wedge clamp, so that it meets the standards specified in the State Electricity Company (PLN) standard number 83 of 1991. This study examines the efforts of the new design alternative service wedge clamp. The service wedge clamp that is the object of this research only has a maximum tensile strength of 8.87 deka newtons. Based on PLN standard No. 83/1991 the required tensile load is 160 deka newtons. The problem is that the service wedge clamp body breaks to resist the pressure of the support during the pull test.

This research was conducted at the electrical engineering workshop of the Bali State Polytechnic. This research was conducted by modifying the wedge component in the service wedge clamp, to increase the tensile load. This small modification can improve the performance of the wedge clamp service the object of this research.

2.2 Total Sample

This research was carried out by randomly taking twenty-five samples from the PT Adi Putra warehouse for each test condition. Those are two conditions of the test carried out in this research, so the total sample was twenty-five samples.

2.3 Variable Operational Definition

This study focuses on observing the magnitude of the tensile load of the service wedge clamp on the origin and the new redesign. The unit of the tensile load test is measured in Deka Newton.

2.4 Tested

In this study, two tensile load tests were carried out to test the ten and fifty sample service wedge clamps. The first test was performed on ten pieces of samples of service wedge clamp in initial conditions. The second test was carried out on fifty pieces of samples of service wedge clamp with additional support thickness according to the calculation results with added tolerance. To measure the tensile strength of the service wedge clam made of thermoplastic, a tensile galvanometer was used in this study (Hariharan et al., 2017).

2.5 Data Analysis

In this study, data obtained from drawing design and the test results are processed quantitatively. Data is processed mathematically by the process of multiplication, dividing, plus or minus. The data is also processed statistically by finding the smallest, average, and maximum values from all the data if the minimum, average, and maximum such as at time and resolution.

3 Result and Discussion

Mathematical calculations, pictures, tables, graphs, and explanatory descriptions present the results of this research. The results of this research presented the initial conditions of the service wedge clamp test data. Based on the test results, observations, and analysis of initial conditions, redesign drawings will be carried out to find a new design. Based on the design drawings, mathematical calculations will be carried out to continue refining the design drawings. The final redesign drawings were implemented for mold modifications to manufacture the new service wedge clamp. This redesign was performed without changing the production process to maintain the optimization of process parameters for high product quality such as warpage, shrinkage, and weld line reduction (Kitayama, 2022). New service wedge clamps are tested for tensile load performance by a tensile meter galvanometer (Gabriel et al., 2021; Amorim et al., 2023). Based on the test results, observations and analysis of the performance of the new service wedge clamp were carried out. The new design of devices must allow the clamping of workpieces to be done quickly, have simple construction, and be cheap while positioning and installing errors to be minimal (Ying et al., 2022).

The service wedge clamp is a low-voltage electric power distribution system component. This component is placed on the base pole of the consumer's house line and the duck standard pole on the rooftop. The State Electricity Company (PLN) in Indonesia has construction standards to regulate the technical installation of house line distribution and component specification standards as below.

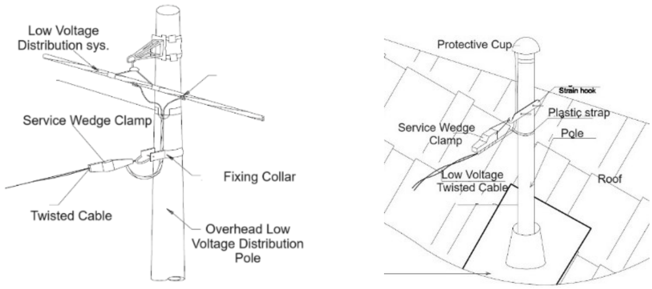

Figure 1. Household distribution line

Ideally, a tool such as a service wedge clamp has a very large tensile load, to withstand the tensile stress of the conductor and weight. The newly designed well must available limited space and meet the tensile load without reducing the material structure because this type of polypropylene plastic has the advantage of being recyclable so it is environmentally friendly (D'ambrières, 2019). Plastic recycling can lower the plastic carbon footprint by one quarter compared to no recycling (Klotz et al., 2023).

Polypropylene was chosen in this design because of several advantages, especially its high electrical insulation resistance and good tensile strength. Previous research found that the tensile strength of polypropylene reached as low as 29 N/mm^2 (Shubhra et al., 2013). The tensile strength of a thermoplastic material is determined by tensile load and the size of the material being designed as specified in the equation below.

$$Tensile\ Strength = \frac{B\ (Newton)}{A\ (mm^2)} \tag{1}$$

Where :

B = Tensile load (N)

A = Tensile Area (mm^2)

Paying attention to the formula above, the amount of tensile strength of a material is determined by the tensile load of the material and the area of the material that resists the tensile strength. Its characterization under tensile is thus quite important, to improve the material or structures made from it, better in service (Dundar et al., 2021).

3.1 Result

In a simple tensile test, a sample is typically pulled to its breaking point to determine the ultimate tensile strength of the material (Yalcin, 2021). In this research tensile strength testing is carried out by loading the screw span which is pulled by rotating the screw, the tensile load results are measured with a tensile meter, as shown in Figure 2.

Figure 2. Tensile strength simulation test

Testing ten samples service wedge clamp samples, in the manner shown in Figure 2, obtained data as Table 1.

Table 1. The initial tensile load test of the service wedge clamp

Samples	Tensile load (Deka Newton)			
	Test	Average	Max	Min
1	8.22	8.724	8.87	8.22
2	8.73	8.724	8.87	8.22
3	8.87	8.724	8.87	8.22
4	8.85	8.724	8.87	8.22
5	8.82	8.724	8.87	8.22
6	8.85	8.724	8.87	8.22
7	8.45	8.724	8.87	8.22
8	8.74	8.724	8.87	8.22
9	8.86	8.724	8.87	8.22
10	8.85	8.724	8.87	8.22

What is presented in Table 1 above can also be presented in graphical form. Graphic presentation will be easier for readers to understand. The initial test results of the service wedge clamp are also presented in graphic form as presented below.

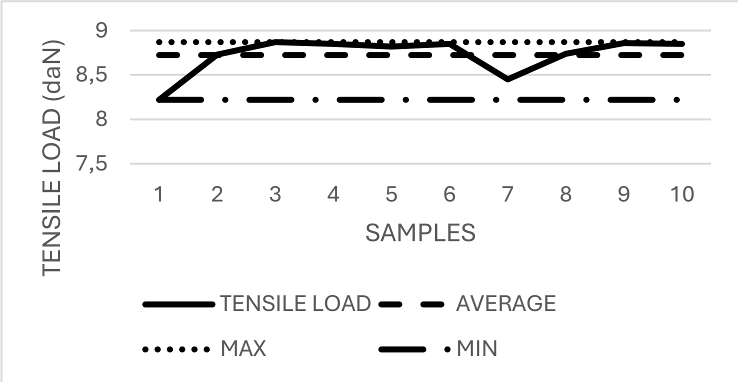

Figure 3. Graph of the initial tensile load test of service wedge clamp

Based on the data presented in Table 1 and graph in Figure 3 above, it is known that the initial condition is that the maximum tensile load is 8.87 Deka Newtons, the average is 8.724 Deka Newtons, the minimum is 8.2 Deka Newtons. This data shows that the tensile load of 160 Deka Newtons has not been reached. Redesign needs to be carried out to achieve tensile load according to requirements. To carry out a redesign, it is necessary to visually check for damage to the service wedge clamp parts after the tensile load test, according to the initial design below.

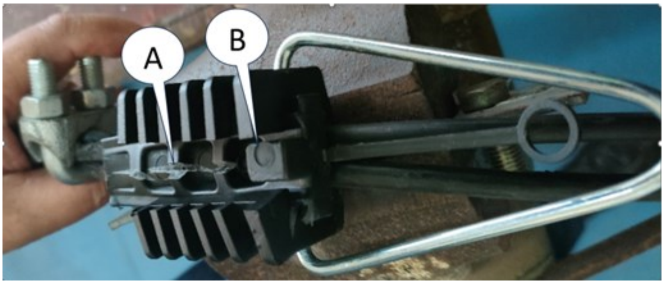

Figure 4. The broken service wedge clamp during the tensile strength test

Figure 4 above shows a break in the wedge blade at point A. The wedge blade broke because it resisted the outward pressure of the twisted cable it was clamping after the wedge was dragged into the service wedge clamp groove as shown in point B. Based on observations of the figure above, an analysis of the causes of the wedge clamp breaking can be carried out. The wedge has 2 functions, namely (1) clamping the twisted cable so that it does not separate from the service wedge clamp body, (2) holding the cable so that it does not get dragged due to the tensile load. The wedge breaking at point A occurred after the wedge was dragged into the service wedge clamp body at point B. It can be concluded that the wedge dragging affects the wedge breaking at point A, so a redesign is needed so the wedge doesn't drag again. The image below shows the wedge shape's initial design condition and the redesign's results.

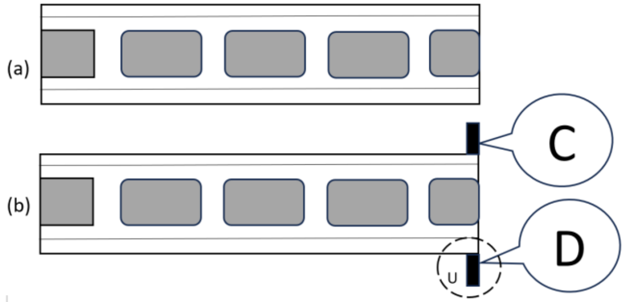

Figure 5. The shape's (a) initial design and (b) the new redesign

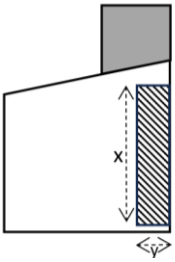

Figure 6. The side view shape of the new redesign

Figure 5 presents that the new design is carried out by adding two supports C and D to the wedge. The two supports prevent the wedge from dragging into the service wedge clamp body. The side view of the D wedge as indicated by the U circle, is shown in Figure 6. The size of the support determines the strength to withstand the tensile load. To determine the x and y sizes of supports C and D are carried out using Equation 2 as below.

$$A\ (mm^2) = \frac{B\ (Newton)}{Tensile\ Strength} \tag{2}$$

$$A\ (mm^2) = \frac{1600}{25} = 55$$

For safety 10%

A = 55(1+10%) = 60.5 mm^2

For balance movement, the support is split into two pieces C and D, and the area for one piece is calculated at just a half of A only 30.25 mm2. The dimensions of x and y in Figure 5 can be calculated. The available space of x maximum is 8 mm2, and the dimension of y can calculated below.

y = 0.5 × A / x
y = 0.5 × 60.5 / 8 = 3.78 mm (rounded 4 mm)

Based on the figure redesign and calculation, the mold was modified. The build of a new wedge shape is shown in Figure 7.

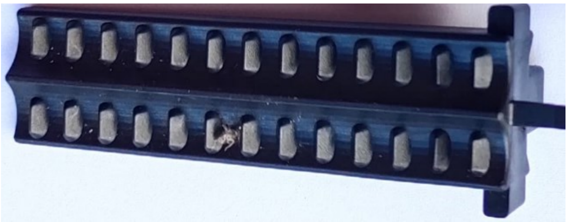

Figure 7. The new shape wedge with supports added

3.2 Discussion

The redesigned wedge was installed in the body of the service wedge clamp, to test its ability to withstand tensile loads. Testing of fifteen samples was carried out the same as the initial test, using the span screw as a load and measuring its tensile strength with a tension meter. Testing was stopped after the service wedge clamp was no longer able to withstand the tensile load, the largest tensile value displayed by the tension meter was recorded as the maximum tensile load result, as shown in Table 2.

Table 2. The tensile load test of the new service wedge clamp

Samples	Tensile load (deka newton)			
	Test	Average	Max	Min
1	188.19	186.9373	188.21	181.65
2	186.62	186.9373	188.21	181.65
3	187.65	186.9373	188.21	181.65
4	188.19	186.9373	188.21	181.65
5	186.78	186.9373	188.21	181.65
6	184.99	186.9373	188.21	181.65
7	187.43	186.9373	188.21	181.65
8	185.24	186.9373	188.21	181.65
9	188.2	186.9373	188.21	181.65
10	188.21	186.9373	188.21	181.65
11	188.18	186.9373	188.21	181.65
12	186.54	186.9373	188.21	181.65
13	181.65	186.9373	188.21	181.65
14	188.15	186.9373	188.21	181.65
15	188.04	186.9373	188.21	181.65

The data test results of the redesigned service wedge clamp, as shown in Table 2, are processed statistically and displayed in graphical form. The graphical display below makes it easier to observe the fluctuations in the values obtained in the testing process.

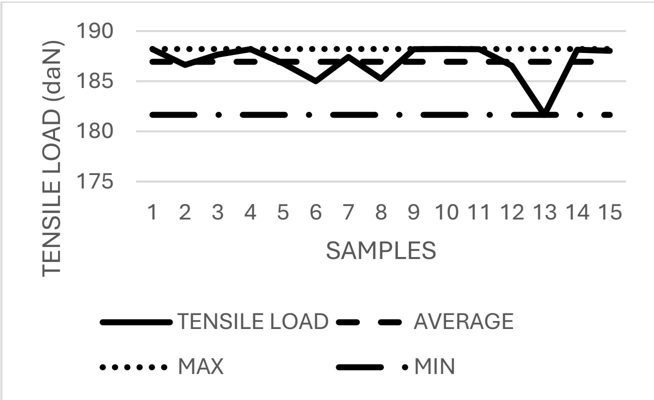

Figure 8. Graph of the tensile load test of the new service wedge clamp

Figure 8 presents a graph of the test results of the new service wedge clamp, with a minimum tensile load of 181.65 Deka Newton, and an average of 186.9373 Deka Newton. The data shows a significant increase in tensile load after redesigning the service wedge clamp. The tensile load of the new design of the Service wedge clamp is increased to a maximum of 188.21 deka newtons, this result is more than the standards determined by the State Electricity Company (PLN). Design improvements have been proven to increase the strength of this thermoplastic service wedge clamp.

4 Conclusion

The design of the service wedge clamp greatly affects its tensile load strength, a small supports in the design can improve its performance. The initial design of the service wedge clamp was only able to withstand a maximum tensile load of 8.87 Deka Newtons, the redesign has resulted in a new design with a minimum tensile load strength of 181.65 Deka Newton, and an average of 186.9373 Deka Newton, and increased to a maximum of 188.21 Deka Newtons.

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