STUDY OF MECHANICAL PROPERTIES OF PROTOTYPE OPTICAL PHASE CONDUCTOR FOR TROPICAL CLIMATE CONDITIONS IN INDONESIA

Samsudi Rahardjo[1], Solechan[2]

** Laboratory of Production Process, Mechanical Engineering Faculty, Universitas Muhammadiyah Semarang*
Jl. Kasipah 12 Semarang, Jawa Tengah, Indonesia
E-mail : samraharjo2@gmail.com

Abstract

Marginal areas especially rural communities still lack electrical lighting and telecommunications facilities. To access the electrical and telecommunications networks required huge costs because there is no infrastructure. To overcome this problem the government is targeting the national electrical capacity 57 thousand Megawatts in 2016 by appointing the State Electricity Company. Target national of Java-Bali distribution network throughout 27.779 km. PLN uses electricity transmission line from the plant to the substation through the tower-tower SUTT and SUTET. This study makes OPPC cable used for extra high voltage power conductors and internet network data that has reliable performance and durable. These goals will be achieved when the known characteristics and mechanical properties OPPC cable. Making cables OPPC by varying the amount of reinforcing steel galvanized wire and twisting torsional stress magnitude for analyzing mechanical properties ranging impact strength and tensile. The mechanical properties of artificial OPPC cable when compared with mechanical properties that are owned by the ACSR cable and commercial OPPC should be equal or close to its value before the applied field. The results of material testing OPPC cable diameter of 3 cm for Type-voltage torsional twisting 36/6/24 RBS 50% have the impact strength and tensile highest of 112.27 kN and 61.26 MPa. While the impact strength and tensile cables that OPPC least 3 cm in diameter with a voltage selection of the type of 36/6/24 RBS 25% of 63.24 kN and 36.36 MPa. The tensile strength and impact influenced the amount of galvanized steel wire and twisting torsional stress. The more galvanized steel wire and high torsional twisting voltage, proportional to the impact strength and tensile increased. When compared to ACSR cable and commercial OPPC, impact strength and tensile cables made OPPC nearing kekuatanya value, where the tensile strength and impact ACSR cable with voltage torsional twisting RBS 50% by 117 kNfrom 61.26 MPa, cables for commercial OPPC 116 kN from 63 MPa and un affected by ellectrical induction.

Keywords: **Aluminium, wire, twist, fiber optics, impact test.**

Introduction

Marginal areas especially rural communities still lack electrical lighting and telecommunications facilities. To access the electrical and telecommunications networks required huge costs because there is no infrastructure (Www.tvonenews.tv, 2012). Overcome the government is targeting the national electrical capacity 57 thousand Megawatts in 2016 by appointing State Electricity Company (Tempo, 2009). National targets of distribution electricity Java-Bali distribution network along the 27,779 km (Jakarta newspaper, 2009). PLN uses electricity transmission line from the plant to the substation through the tower-tower Air Channel High Voltage (SUTT) and the Air Line Extra High Voltage (SUTET).

Conductor used type ACSR (aluminum Conductor Steel Reinforced) which berlilit wire with fiber core steel as reinforcement in the middle of a layer of aluminum fibers (Williams, 1990). Weakness ACSR not stand the heat and high electrical conductivity (Pabla, 1994). While the ACCR (Aluminum Conductor Composite Reinforced), which consists of a core of aluminum alloy matrix fibers surrounded by fiber aluminum zirconium content. Conductivity properties, tensile strength and high heat resistance but did not leave the nature of light (Suprihadi, 2007). ACCR conductor can operate continuously at temperatures of 210^{o}C to 240^{o}C in an emergency, so it will increase the capacity of the distribution of two to three times greater than using conventional conductors (3M corporation, 2003).

In line with the times will be urgent demands need for electricity and the need for communication of information particularly the Internet data, now developed terintergritas conductor cable called OPPC (optical phase conductor) composed of aluminum wire for the first layer surrounding the galvanized steel pipes and steel hollow that in the insert optical fiber wrapped in insulation to protect the hot temperatures with increasing current voltage (Girbig, 2005).

The main function of the transmission network OPPC airways are as channel power from central power to substations, while the fiber optic telecommunications networks both telephone and data networks. Conductor OPPC supposedly able to conduct electricity, is resistant to changes in temperature, pressure and pull force resistance from rain and wind. Then the data necessary mechanical and electrical properties of electricity wires and cables used in optical Telkom Indonesia influenced the climate, topography and current loading on the performance of mechanical work cable channels OPPC.

At the beginning of the study and the known characteristics of the mechanical properties of each material OPPC basic cable. While in this study, to determine the mechanical properties of the cable OPPC tensile and impact tests in comparison with cable and OPPC SUTET. Hopefully this research provide significant distribution for State-Owned Enterprises (SOEs), particularly electricity company (PLN) and TELKOM to use OPPC cable.

Manufacturing of cable OPPC

Initial studies has found the data base for each material OPPC cable. Continued research is to analyze the mechanical properties of the cable with a cable SUTET OPPC dikomparasikan used in Indonesia and OPPC. Extensive measures can be seen in **Fig. 1** Flow diagram of the study. For the materials used are:

a. Aluminium wire Series AAC 1010

Aluminum wire with diameter 3 mm has a chemical element Al of 99.10%, specific gravity of 2.7 g/cm^3, the density of 2.685 kg/m^3 and has a melting point of 660^{o}C. Lightweight properties, corrosion resistance, electrical conductivity and good heat, easily formed through the process of forming and machining (AA, 1999). Low hardness Al at 43.66 HVN, tensile have 90.66 MPa and torsional tests 117.63 MPa

b. Galvanized steel wire

Galvanized steel wire is used as reinforcement OPPC wires with a diameter of 2 mm. Having a chemical element Fe and 99.35 wt% wt% elemental C 0084 while the surface layer of galvanized steel pipe has an element of Zn 99 021 wt%. This entry classification of low-carbon steel that is very soft with a tensile strength of 41-51 kg/mm2 (Wiryosumarto, 2000).

c. Fiber Optics

Fiber optics using single mode fiber ITU-T G.652 type with tensile strength of 39.66 MPa and 56 MPa torsional test. Outside of the rubber protector that serves to protect the optical fiber from the magnetic induction or other outside interference.

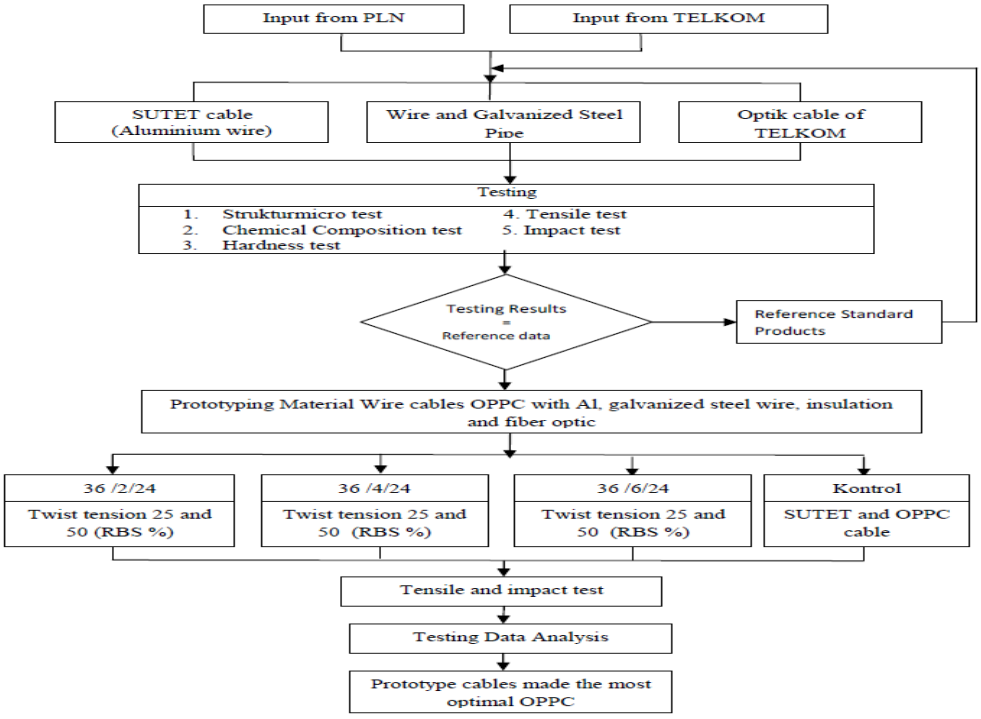

Fig 1. flow chart of manufacturing of OPPC cable

d. PVC insulator (Polivinilclorida)

PVC is very flexible isolator with temperature resistance of 70-105^{o}C, 44.4 MPa tensile strength and impact strength of 293 J / m. This is placed beyond the limit of optical fiber between Al wire with fiber optic own with a smooth surface.

e. polypropylene yarn

Fiber optics besides wrapped PVC insulation also protected polypropylene yarn, serves as a reinforcement and insulation. Polypropylene yarn is spun shaped crystalline polymers resulting from the polymerization of propylene gas with a melting point of 130-171°C

All material is prepared to make use OPPC cable twisting machines that have been varied. Cable manufacturing process is shown in **Fig. 2** by varying the amount of reinforcing steel and wire twisting torsional stress.

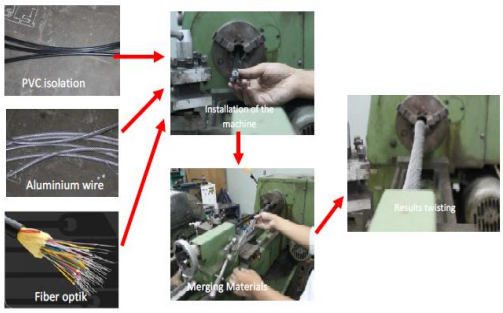

Fig. 2. Steps of twisting OPPC cable

The process of twisting with a load of 25 and 50% RBS (rated breaking strength) using steel wire reinforcement varied from 2, 4 and 6. Shaped OPPC cable 3 cm in diameter are shown in **Fig. 3**, the subsequent formation of tensile and impact test specimens. The impact test according to ASTM D256-00 or SNI 07-0408-1989 for specimen form shown in **Fig. 4**. Both ends of the test bars cast with tin alloy with tapered shapes (conical).

Impact specimen length 80 cm with casting the lead as the holder up to 8 cm on both ends of the cable. The impact test using a universal testing machine Machine WE-100B models were modified with vertical specimen position with shock loads 120 kN. The amount of shock loads during graduation slump as the amount that can be sustained impact loads.

Fig. 3. (a) Results OPPC twisting wires with a diameter of 3 cm (b) The number of galvanized steel wire reinforcement

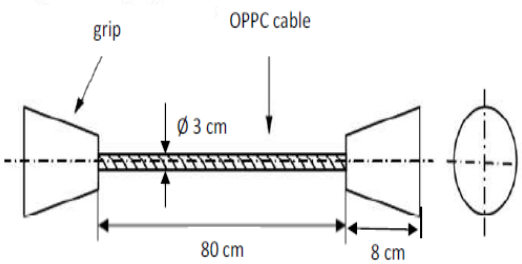

Fig. 4. The impact test specimens and tensile (SNI 07-0408, 1989)

Tensile test specimens with impact testing and durability testing distinguishes bearing OPPC cable until the cable broke. Reference testing using the Indonesian National Standard (SNI) 08-0409-1989. Withdrawal

speed of 0.5 mm / min and 5000 Newton load. During the withdrawal for each interval of 3 seconds recorded in memory computer universal testing machine Machine Model WE-100B and writing manual values.

Results and discussion

Data of impact and tensile test results made OPPC cable will compared with cable and cable SUTET OPPC commercial. OPPC cable twisting and twisting loads varied amount of galvanized wire reinforcement, which certainly has different mechanical properties. The following discussion of the results of testing to be performed.

Impact test

The test results impact OPPC cable shown in **Table 1**. Improve strength galvanized steel wire impact loads, the more galvanized steel wire, power impact loads will rise. Galvanized steel wire has HVN 134.66 hardness and tensile strength of 45 kg/mm2 (Raharjo, 2012). When compared to other basic material, for better mechanical strength withstand impact loads.

The results of the test data cable OPPC 3 cm in diameter which has the power of the most high-impact weight-bearing on the cable type OPPC 36/6/24 for galvanized steel wire reinforcement more. It is also influenced by twisting torsional stress and the effect is very large.

Table 1. Result of Impact test of OPPC cable

Twist tension (RBS %)	Strength of Impact Test (kN)			
	OPPC cable (Ø 3)			SUTET cable (ACSR)
	36 /2/24	36 /4/24	36/6/24	
load 25 (RBS %)	63,24	81,45	103,11	110
load 50 (RBS %)	67,33	85,56	112,27	117

explanation : a) 36 /2/24 : 30 wire aluminium, 2 galvanis steel, 24 fiber optic
b) 36 /4/24 : 30 wire aluminium, 4 galvanis steel, 24 fiber optic
c) 36 /6/24 : 30 wire aluminium, 6 galvanis steel, 24 fiber optic

For torsional stress RBS 25% have impact strength RBS 103.11 kN while 50% of 112.27 kN 9.16 kN happens difference can be seen in **Fig. 5**. tension produces a large torsional twisting OPPC cable twisting tighter and tidy, a little empty cavities on the cable wires will affect the impact strength (Suprihadi, 2007).

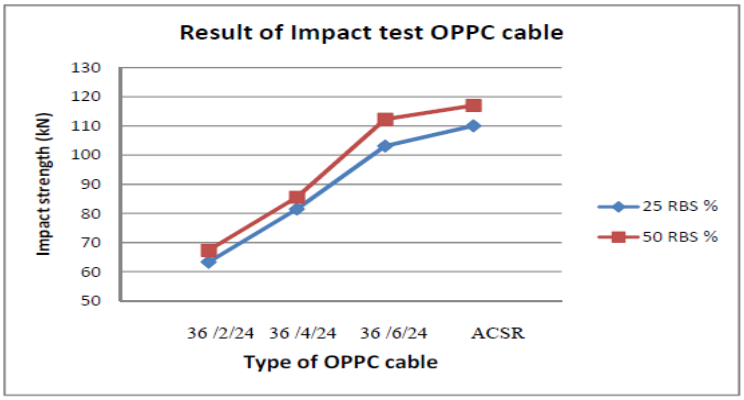

Fig. 5. Result of impact test OPPC cable

Cable has made OPPC impact strength approaching SUTET type ACSR cables are now used in Indonesia, from chart types OPPC cable twisting loads 36/6/24 with 50% RBS has a difference of impact strength of 4.73 kN, while the commercial OPPC cable by 3,75 kN (HCV cable, 2010). OPPC cables made impact strength impact strength of nearly ACSR cable and commercial OPPC, is expected to add 2-4 wire galvanized steel for impact strength equal to commercial cable and can be used in Indonesia (SPLN, 1981). Effect on the impact strength OPPC cable withstand shock loads that affected both the rain, wind and earthquakes that make the cable is damaged or broken.

Tensile **strength**

OPPC cable pull testing affects the weight of the power cord until the cord broke. Tensile test results shown in **Table 2**, explain the magnitude of the tensile strength of each type of cable manufacturing OPPC and ACSR.

The result is almost the same as the tensile impact test, the higher the impact strength, the tensile strength is higher. Ultimate tensile strength of the cable diameter of 3 cm OPPC 36/6/26 type RBS with 50% torque load because the load is supported by galvanized steel wire as much as 6 pieces with a tensile strength of 61.26 MPa, while the impact strength of 65 MPa ACSR cable which has a difference 3.74 MPa. The increase in tensile strength is also affected cable twisting torsional stress, where there is a difference between 25 and 50% RBS can be seen in **Fig. 6**.

Table 2. Result of tensile test OPPC cable

Twist tension (RBS %)	Tensile strength Test (MPa)			
	OPPC cable (Ø 3)			SUTET cable (ACSR)
	36 /2/24	36 /4/24	36 /6/24	
load 25 (RBS %)	36,36	48,35	56,05	59
load 50 (RBS %)	39,67	52,77	61,26	65

explanation : a) 36 /2/24 : 30 wire aluminium, 2 galvanis steel, 24 fiber optic
b) 36 /4/24 : 30 wire aluminium, 4 galvanis steel, 24 fiber optic
c) 36 /6/24 : 30 wire aluminium, 6 galvanis steel, 24 fiber optic

The density of aluminum wire between the cable depends OPPC voltage cable twisting. The more tightly between the aluminum wire, the tensile strength will increase as freestyle between aluminum wire pull test at smaller (Suprihadi, 2007). Tensile strength cables 36/6/26 OPPC type approach OPPC commercial cable tensile strength. The tensile strength of commercial OPPC cable has a difference of 63 MPa tensile strength of 1.74 MPa of artificial OPPC cable (HCV cable, 2010). In terms of mechanical properties approaching artificial OPPC cable ACSR cable and commercial OPPC but to test electrical and thermal test yet.

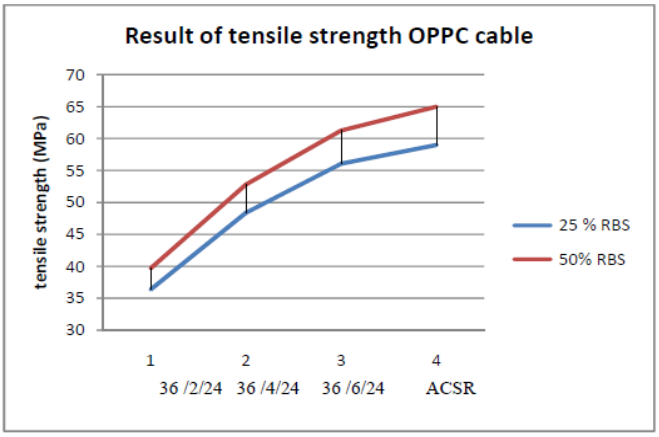

Fig. 6 Result of tensile strength OPPC cable

Conclusions

From the research that has been done, it can be concluded as follows. The impact strength and tensile cables OPPC influenced the amount of galvanized steel wire reinforcement. The more the number of galvanized steel wire reinforcement, tensile strength and higher impact. Tension greater percentage torsional twisting, impact and tensile strength also increased. The higher the voltage torsional twisting, cabling density and neatness OPPC better.

Acknowledgements

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