MATERIAL SAVING TO OPTIMIZE THE MANUFACTURING COST OF MEDIUM VOLTAGE AERIAL BUNCHED CABLES

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Abstract - *This paper presents an efficient procedure to reduce the production cost of manufacturing medium voltage aerial bunched cable by reducing the conductor material and insulation material. The medium voltage aerial bunch cable consists of three cores separately insulated to transfer three phases. These cores made of aluminum strands are compacted by twisting. This reduces the diameter of each strand which will in turn reduce the diameter of the bunched cable considerably. It was observed that there were minor losses in the power transmitted. Around 7kg of Aluminum was saved while producing cable of length one km. As load is carried by messenger in the cable, this technique will not produce any loss in the mechanical properties. Optimizing production is a way to increase productivity and by this work we are trying to achieve optimization of production by varying the properties of a cable conductor without affecting its required output. The insulation material is saved both in the insulation of core and the insulation for the bunch.*

Key Words: ABC Cables, Core, XLPE, Semicon, bunched cables, laying up

1.INTRODUCTION

The Need for energy is increasing day by day India has become third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation. With the rise in electricity production, the need for transmission lines and cables are also increasing. The spread of high voltage transmission lines is such that it can from a square matrix of area 36.8km^2 entire area of the country. The length of transmission lines is 10, 558, 177 km as on 31- March 2015 in the country. Even with this the power is not transmitted effectively. This is due to the cost increased in making the transmission lines are made mainly by aluminum. The aluminum strands are chosen for its excellent conductivity, low weight and considerably low cost. The bunch cables use steel for making messenger to give the required strength required to support the weight without struggling the aluminum due to its ductility. This gives the conductor overall high tensile stress. Therefore, it is high time to reduce the cost for transmission cables. We propose a method of reducing the diameter of the core by compacting and hence reducing its diameter. The reduction in diameter will reduce the amount of core material and thereby reduces the insulation material.

1.1 MATERIAL PROPERTIES OF ALUMINIUM

Thermal Conductivity(0-100°C)(Cal/cms°C)	0.57
Co-efficient of linear expansion (0-100°C)(×10-6/°C)	23.5
Electrical Resistivity at 20°C(Ω.cm)	2.69
Density (g/cm^3)	2.6898
Modulus of elasticity (GPa)	68.3
Poisson Ratio	0.34

Table -1: Material properties

Aluminum use in utility grid transmission and distributor network increased rapidly. The metal half of the equivalent capacity of copper and was advantageous for the construction steps puling wire, suspension and support

Aluminum has also been adapted for use as rigid conduit is a tubing system used for protection and routing of electric wire unlike steel conduit, rigid aluminum does not spark, resist corrosion and will not rust.

1.2 AERIAL BUNCHED CABLE

Aerial Bundled Cable are overhead power lines using several insulated phase conductors bundled tighter together usually with abate neutral conductor, this contract with traditional practice of using an insulated conductor separated by air gaps. This variation of overhead power lines utilize the same principle as bundled conductor, expect that they are close together to the point of touching by each conductor is surrounded by insulator layer. It has various like

- In comparison to bare overhead power distribution lines, ABC has very high reliability in maintaining services because power and neutral conductors are insulated with the best dielectric medium,
- Less fault rate on account of good protection against line and ground faults by high winds or falling trees or birds especially in hilly areas & forests as encountered in rural distribution networks.
- High insulation resistance to earth in all seasons and polluted atmospheres. Negligible leakage currents and low losses.

Multiple circuits of Power and Telephone cables could be strung in the same set of poles or any other supports like walls etc.

2. SPECIMEN SPECIFICATION AND TESTING

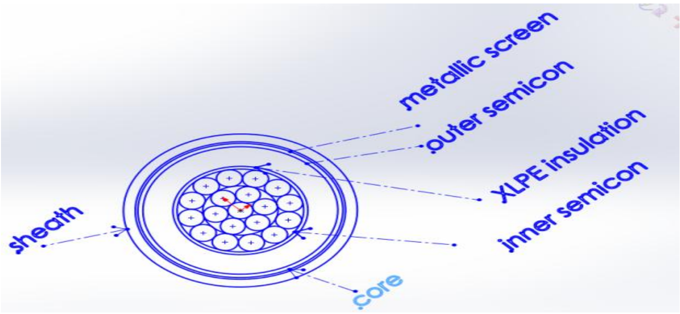

Fig-1 Bunched cable

Conductor	Material – Aluminum Shape – Circular compact Conductor diameter – 12.9+0.01 mm Conductor Resistance - 0.248 Ω / km at 20º C Weight – 951.71 kg/km
Insulation	Material – XLPE component Thickness – 3.57 mm Weight – 553 kg/km
Insulation Screen	Material – Semi conductive components Thickness –0.6 mm Weight – 151.35 kg/km
Metallic Screen	Material – copper tape Thickness – 30.045 Weight –105.88 kg/km Width of tap – 50mm Overlap – 6 to 7 mm

Table – 2: Specifications

Productivity and cost of cable depends mainly on internal cost and external cost such as cost of raw material, labor cost and other cost. Productivity can be increased by optimizing the amount of raw material used. Aluminum is used as the conductor core of the cable. The properties of the cable vary along with change in dimension of the core conductor which directly affects the mechanical and electrical properties of the medium voltage aerial bunched cable. The aluminum core thickness must be directly corresponding to the resistance. The cable must be produced in the safe range of resistance. Core diameter was reduced in subsequent trials and various test such as partial discharge test, high voltage test, hot set test etc. which helps in evaluating the quality of the cable products

3. RESULTS AND DISCUSSIONS

Productivity and cost depends mainly on internal cost and external cost such as cost of raw material, labor cost and other cost. We identified that productivity can be increased by optimizing the amount of raw material used. Aluminum is used as the conductor core of the cable. The properties of the cable vary along with change in dimension of the core conductor which directly affects the mechanical and electrical properties of the medium voltage aerial bunched cable. The aluminum core thickness must be directly corresponding to the resistance. The cable must be produced in the safe range of resistance. Core diameter was reduced in subsequent trials and various test such as partial discharge test, high voltage test, hot set test etc. which helps in evaluating the quality of the cable products.

PARAMETERS	FORMER SPECIMEN	FIRST TRIAL	SECOND TRIAL	THIRD TRIAL	FOURTH TRIAL
Number of conductors	19	19	19	19	19
Conductor diameter	3.01	2.99	2.97	2.96	2.95
Core diameter	13	12.96	12.87	12.80	12.72
Breaking load in newton	1145	1116.3	1112.7	1104.9	1095.2
Tensile load in N/mm²	160.59	158.99	158.23	157.61	157.56
Resistance Ω/km	0.214	0.226	0.23	0.238	0.245

Table-3 Trials

Diameter of the single strand of aluminum conductor used was of 3.01 mm diameter the single strand of the conductor was tested in the universal testing machine. The breaking load and tensile strength was determined and was found to be in the safe range. Resistance of the single conductor was tested in the micro ohmmeter.

The measured resistance was 2.14 Ω/m which is in between the desired range. 19 strands of conductors which 3.01 mm diameter were twisted in the required pattern and was compact to a core diameter 13 mm. Insulating layer such as inner semicon, XLPE and outer semicon was coated by the process of triple extrusion the insulation coated wire was cured in the water bath. Specimen of 1 m length was placed in hot set apparatus test evaluates the strength of insulations coating provided. The one-meter specimen was placed inside the hot set apparatus. The temperature inside the chamber was increased and was raised to specified temperature. Insulation coating must withstand the temperature without disintegration. The cable passed the hot set test.

In the first trial the diameter of the single strand of the conductor was reduced by 0.02 mm. conductor of 2.99mm diameter was obtained from the wire drawing machine by adjusting the size of the extruding die. The wire with 2.99 mm was then subjected to similar test as mentioned above. The breaking load and tensile strength was found to be satisfactory. Ohm meter reads a resistance of 0.226 Ω/km and the cable also passed the hotset test. In the second trial the diameter of the single conductor was further decreased to 2.97 mm diameter and was compact to core conductor with 12.83 mm diameter. Reading of universal testing machine was in the safe range with the breaking load equal to 1112.17 N and tensile strength equal to 158.23 N/mm². Ohm meter reading was observed as 0.23 Ω/km. Thus there was a save in amount of aluminum. Accordingly, the amount of inner semicon, XLPE and outer semicon was reduced. The cable specimen passed the hot set test. In the third trial the diameter of the conductor was reduced to 2.96 mm. After the above mentioned test the breaking load was found to be 1104.9 N and tensile strength was found to be 157.61 N/mm². The ohm meter reading was found to be 0.238 Ω/km and was found within the range.

In the fourth trail the diameter was found to be 2.95 mm and compact to core diameter of 12.72 mm. Testing were conducted on one-meter specimen and the resistance was observed as 0.245 Ω/km which was above the required resistance limit. Further reduction in the diameter will result in the increasing resistance which is not acceptable. Thus trails cannot be accepted above the diameter mentioned earlier which is within the resistance limit.

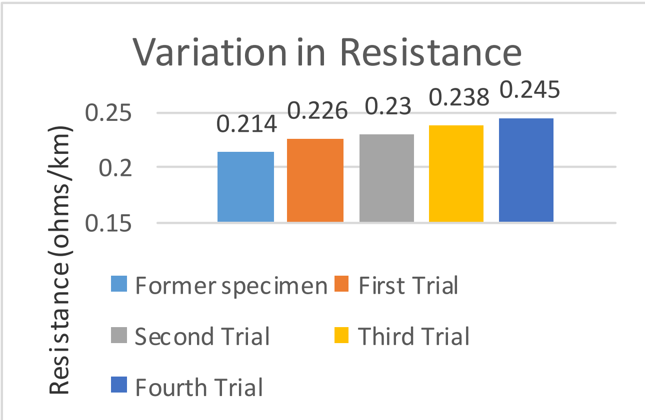

Chart- 1 Variation in Resistance

The above graph shows that the different values of resistance corresponding to different trials performed in each trial the core conductor diameter was varied. The former specimen had a resistance value of 0.214 ohm per km. The diameter of the core was then decreased for the upcoming trials and their corresponding resistance values are as shown above. The fourth and last trial shown the value of resistance as 0.245 ohm per km which is above the limit that is 0.238 ohm per km and hence the last trial cannot be considered for further calculation that is diameter of 2.95 cannot be considered.

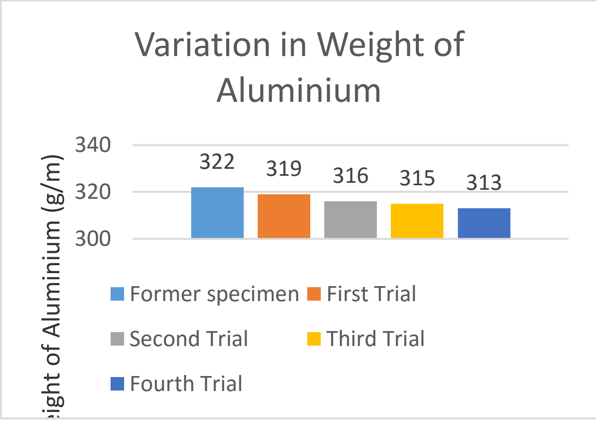

Chart- 2 Variation in weight of aluminum

The above graph shows the variation in weight aluminum for different trials conducted. The weight of former specimens was 322g/m and as the graph of shows for corresponding trials the weight of aluminum was reduced for the first trial the value come down to 319 g/m further reduction in diameter again reduce the weight of aluminum specimen and since we cannot consider the fifth trial the fourth trial value of 315 g/m. Further reduction in diameter again reduce the weight of aluminum specimen and since we cannot consider the fourth trial value 0f 350 g/m was selected as per calculations after the fourth trial difference in weight was 7*3 = 21 kg/km.

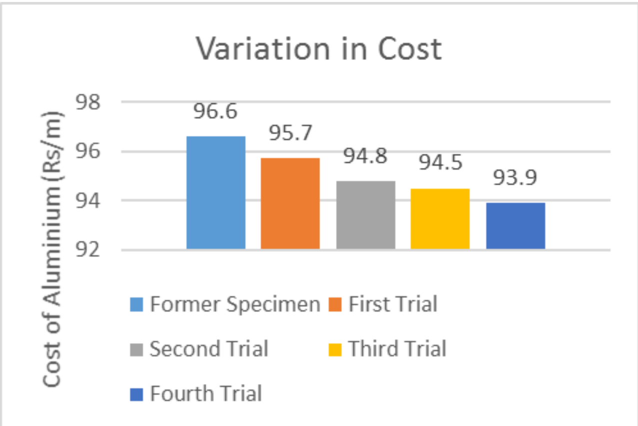

Chart-3 variation in cost

The above graph shows the cost of aluminum per meter for the different trials conducted. The cost of aluminum used for production was reduced after the forth trials. The former specimen used for production cost = 96.6 Rs/m . The first trial reduced the weight of aluminum and thus the cost for the aluminum used and was found to be 95.7 Rs/m. The fourth trial cannot be considered and the third trial cost of aluminum was selected is 94.5Rs/m.

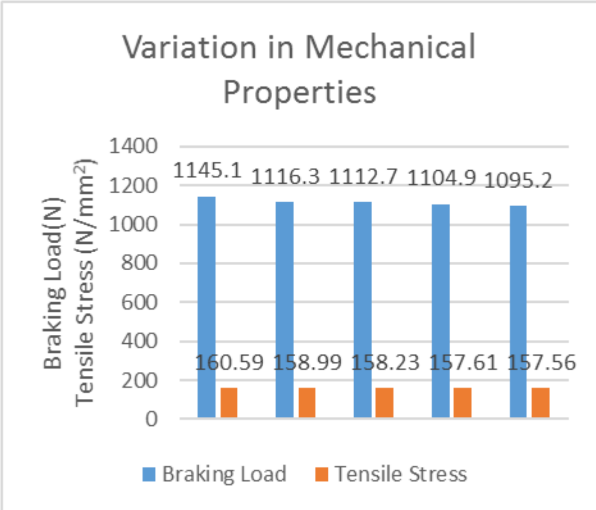

Chart – 4 Variation in mechanical properties

The above graph shows the different values of breaking load and tensile stress for the different trials. The graph shows that there is not much variation in breaking load and tensile stress which is a good property to have. Since a messenger wire is send along the main cable the above readings are all within the limit and is more than satisfactory values to have. the final trial gave us a breaking load value of 1104.9(N) and tensile stress of 157.61(N/mm).

4. CONCLUSION

The reduction in the diameter of the individual conductor and thus the overall core diameter resulted in the save of the material considerably. This in turn reduced the insulation material, xlpe material and thereby reduced the cost. Thus a twofold reduction in cost is obtained. The cables proved safe in testing. However, the resistance showed a slight increase but within the limits of aluminum and from the readings noted down the most suitable resistance was selected and the corresponding diameter was selected. The volume of insulating material and xlpe material saved on different layers reduced the material and production cost.

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