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Analysis of High Temperature Low Sag Conductors used for High Voltage Transmission

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Abstract

Presently there is a continuous demand for the electric power consumption across the globe, however with the existing distribution lines are reaching critical limits of ampacity and sag, it has become difficult in finding corridors to construct new overhead lines in many industrialized countries including India. Replacing the existing ACSR conductors with high temperature high current low sag (HTLS) conductors almost of the same diameter is one of the recent methods. The present work a parametric study is conducted for steady state surface temperature, thermal time constant, change of emissivity, absorptivity etc for various ACSR and HTLS conductors using the developed computer code which is in accordance with IEEE Std.738. Some experimental study is also conducted and the results obtained are presented.

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Keywords: HTLS conductors; ampacity;ACSR; low sag;Simulation; Experimentation

1. Introduction

The increase in power requirement is becoming a great challenge for the utilities in terms of cost and capacity where the existing lines have reached their maximum limit. One of the solutions is the installation of a parallel structure like the existing towers, but this is not an economical solution. The other way to find a cost-effective and more viable solution is in adopting high temperature low sag (HTLS) conductors for distribution systems [1]. These conductors are different from conventional conductors in terms of material or structure or both.

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The significance of HTLS conductors is they can carry 2.5 times the current that of the conventional ACSR conductors of same size and can withstand higher temperature (>200°C) with less sag.

One of the several advantages of HTLS over conventional ACSR is by re-conductoring an existing line with HTLS conductor the power delivery capacity can be increased. But an HTLS conductor for long transmission is not recommended as it will cause higher voltage drop and power loss due to high current. So increasing voltage level will be wise. Several HTLS projects are being planned and implemented throughout the world including India [1, 2].

The study of HTLS conductor was first initiated by Douglass [3] explaining the practical applications used for Connecticut Light and Power Company. Later Alwar et al [4] have discussed about conventional ACSR conductors and the composite core conductors for low sag at high temperature. IEEE Standard 738 [5] explains several factors that affect the temperature of bare overhead conductor. The equations to find the current temperature relationship are given in this standard. Several researchers [6-9] discussed about the emissivity, radial temperature distribution, corrosion and effective radial thermal conductivity in bare solid and stranded conductors. Ravi Gorur [10] characterised the composite cores for HTLS conductors and studied surface temperature vs. time curve, core temperature with current, with emissivity, absorptivity, thermal conductivity etc in accordance with IEEE Std 738[5]. Further Harvey and others [11-15] studied temperature creep and sag-tension performance of HTLS conductors. Recent IEEE Standard 1283[16] gives the guidelines for determining the effects of high temperature operation on conductors, connectors and accessories. It describes possible adverse impact on operating overhead transmission line at high temperatures. Gerald et al [17] discussed about how HTLS conductors can be a solution to the ever increasing power demand. A technical report [18] describes the structure and properties of aluminium conductor composite reinforced (ACCR) conductors. Researchers [19-24] have used different models for calculation of various parameters for HTLS conductors. Recently several planned projects [25] using HTLS conductors are being implemented in the country. Hence this work was initiated with the view that the data obtained will be useful for further implementation of projects as well as in enhancing the current literature.

2. Simulation Study

In the present work, simulation studies are carried based on IEEE-738 Standard [5]. The study consist of a developed Matlab code to simulate: Surface temperature variation with time for a given current level, variation of surface temperature with different parameters like ambient temperature, absorptivity and emissivity of the conductor material, variation of temperature along the radius of the conductor etc. Separately (i) a graphic user interface (GUI) is developed for use in optimal design of different transmission and distribution accessories to be used for HTLS conductors which simulates temperature variation with current and different parameters also (ii) Simulation of magnetic field near the conductor due to increased current in case of HTLS conductors is attempted.

The technical details of various types of HTLS and ACSR conductors used for the present work are given in table 1 below:

Table. 1. Specification of conductors used for simulation

Details	ACSR	HTLS1	HTLS2	HTLS3	HTLS4
Overall Dia (mm)	28.12	28.14	28.62	28.118	31.77
Resistance per length at 25deg C (ohm/km)	0.0728	0.0554	0.0674	0.0702	0.0431
Resistance per length at 75deg C (ohm/km)	0.0869	0.0662	0.0741	0.0843	0.0511
Heat Capacity per length (W-sec /m-C)	1309	756	1177	1296	1495

Following assumptions were made for the estimation of current and temperature:
Ambient Temperature=40 degree centigrade; Velocity of wind=.61 meter/sec; Absorptivity=.5;
Angle of the flow of wind with conductor axis=90 degree; Emissivity=.5; Day number of the year=161;
Altitude=0 meters; Latitude=43; Azimuth of line=90 degree; Time of the day=11 a.m.