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Enhancement of Power Transfer Capability of Transmission Lines Using HTLS Conductor

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ABSTRACT: Expansion of Transmission Network is necessary to meet growing electricity demand. Normally the growth rate is 8 to12%. Sometimes due to government policies like power for all and 9 hours day time agricultural supply, the load increases abnormally. Power supply to agriculture sector in some states of India is provided in two spells of 6 hours each. Instead of two spells it was decided to provide in single spell of 9 Hours day time supply to agricultural sector in some areas. Due to this reason the Unrestricted peak demand of a state which is about 7000 MW in base year is estimated to increase upto 10800 MW in span of one year due to the overlapping of spells. In this situation, the load growth is 4 to 5 times more than normal growth rate. To meet estimated demand, the enhancement of power transfer capacity of transmission network is essential and to be done in a short time frame of 12 months. To achieve the expansion of transmission network to meet the estimated additional 3800 MW in forthcoming year necessitated the reconductoring of some existing transmission lines to instead of erection new line by avoiding Right Of Way (ROW) problem, to increase power transfer capability of network depending upon the requirement. Comparison between Aluminium Conductor Steel Reinforced(ACSR), Super Thermal Aluminium Conductor Invar Reinforced (STACIR) and Aluminium Conductor Composite Core(ACCC) conductors is made based on the power transfer capacity, transmission losses and receiving end voltage for selection of suitable conductor. The enhancement of power transfer capability, power loss and voltage profile of HTLS conductors against the conventional ACSR is discussed in detail in this paper.

KEYWORDS: ACCC-Aluminium Conductor Composite Core, ACSR – Aluminium Conductor Steel Reinforced, HTLS – High Temperature Low Sag, INVAR: a kind of Ni-Fe Alloy, STACIR (Super Thermal Aluminium Conductor Invar Reinforced), STU - State Transmission Utility.

I.INTRODUCTION

Most of the State Transmission Utilities (STU) in India are using Aluminium Conductor Steel-Reinforced (ACSR) conductors [1] for transmission lines, which are operated continuously at temperatures up to 75°C to 85°C. Above this temperature, the mechanical strength of aluminium strand layers in the conductors start reducing and the design loading factors may be compromised. In addition, at conductor above the operating temperatures, the electrical clearances may not be sufficient because of excessive sag. The construction of new transmission lines, substations will the serve the normal growth rate (which around 8 to 12%). Sometimes abnormal growth rate (sudden increase in load growth) may occur due to government policies such as 9 hours day time agricultural supply and power for all , the power flow on certain existing lines may reach or exceed its thermal loading limit .In this case the load growth is above 50 % in a particular year. To meet this kind abnormal load growth, global manufacturers has designed new conductors which can be operated at temperatures upto 200^0C without losing the mechanical properties and showing less rate of increase in sag at high temperatures. Hence, these type conductors are known as High-Temperature Low-Sag (HTLS) conductors.

II.NECESSITY FOR THE ENHANCEMENT OF TRANSMISSION CAPACITY

The sudden projected demand of around 50% in one year due to government schemes like power for all, 9 hours day time agricultural supply necessitated the need for enhancement of transmission capacity. Further, the time span given for the expansion of network i.e. 12 months, is major constraint for network expansion. Normally the construction of new lines and substations will take time construction 2 to 3 years. Right of Way problem is a major hurdle in

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construction of new lines. Based on the line loading and ROW problem, 9 Nos. of lines are selected in particular network for the enhancement of power transfer capacity with reconductoring.

To expand the transmission network in short time span various ways like stringing of 2nd circuit, augmentation of power transformer capacity and reconductoring of lines[2-4] are explored. In this paper the enhancement of power transfer capacity by reconductoring the existing lines is presented. In the following sections, the merits of reconductoring of transmission lines with STACIR [5] and ACCC HTLS conductor [6-7] are discussed.

III. BREIF NOTES ON ACSR, STACIR (HTLS) and ACCC (HTLS) conductors

The above three types of conductors are made up of two cores
i)Inner core
ii)Outer core
The inner core of conductor is meant to provide mechanical strength to the conductor and outer core is for carrying current.

ACSR Panther

The Aluminium Conductor Steel Reinforced (ACSR) conductor is most commonly and widely used in transmission network. ACSR normally consists of 7 or more layers as inner core and aluminium layers on outer core. Thickness of layers and Size of the conductor decides the current carrying capacity of conductor. These conductors operate between 75^{o}c to 85^{o}c.

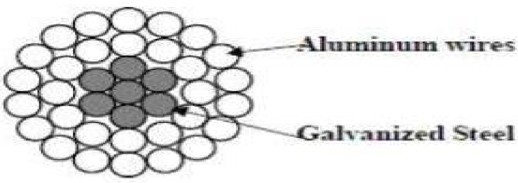

Fig 1. ACSR Conductor

STACIR Panther equivalent (HTLS)

These conductors are made up of Aluminium Clad Invar (a special Fe-Ni alloy with low thermal expansion coefficient) for the inner core and super thermal resistant aluminium alloy wires for the outer core. These conductors will maintain mechanical strength of the conductor with continuous rating upto 210^{0}C.

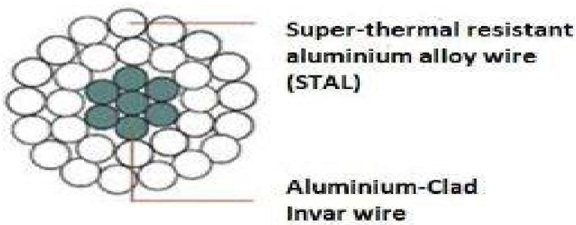

Fig.2. STACIR Conductor

ACCC (HTLS)

ACCC conductor consists of hybrid carbon and fibre glass as inner layer. The composite core surrounded by fully annealed aluminium strands in trapezoidal shape as outer layer. Low tension and less stress on structures. Very low sag, extremely strong composite core, 50% stronger than steel. This is made of high conductivity alloy.

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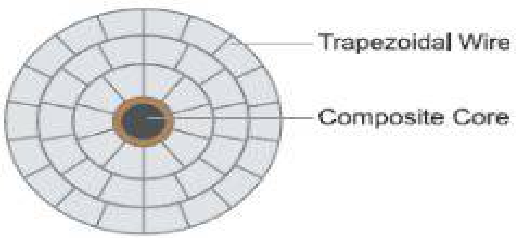

Fig.3. ACCC conductor

IV.COMPARISION of ACSR Panther, STACIR Panther equivalent AND ACCC Casablanca CONDUCTOR

Table .I Comparison of ACSR Panther, STACIR Panther equivalent and ACCC Casablanca Conductor

S. No.	Parameter	ACSR	STACIR	ACCC
1	Conductor mean diameter in mm	21	21	20.5
2	Weight in kg/km	0.974	0.963	0.875
3	Maximum Operating Temperature ^{O}C	85	210	200
4	Maximum Current carrying capacity in Amp	366	1014	1120
5	Cost comparison	1	5.9	3.6
6	DC resistance in Ω/Km at 20^{O}C	0.139	0.1312	0.1024
7	Sag comparison @ span 350 Mtrs	1.0	1.124	0.833

The current carrying capacity above three conductors against temperature and power (at 0.9 Power Factor) against temperature are shown in the following Fig.4 and Fig.5.

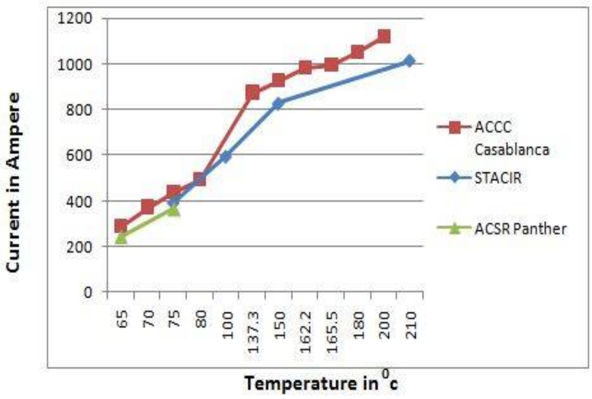

Fig.4 Current Carrying Capacity in Ampere Vs temperature in ^{0}c

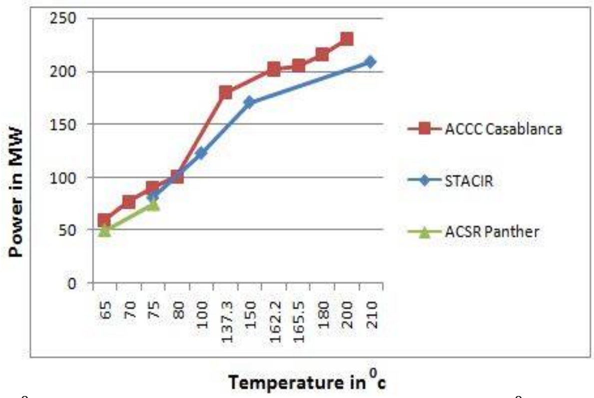

Fig.5 Power in MW Vs Temperature in ^{0}c

The practical (realistic) data is collected from a STU which is under implementation of 9 Hours day time Power Supply to agricultural sector during the 2016-17. Accordingly, it was decided to strengthen the transmission system to meet to additional estimated load for extending 9 Hours agricultural supply during day time, sufficiency of infrastructure was reviewed to cater the agricultural load in addition up to the normal loads during the day time. Base year considered is 2015-16 and Horizon year is 2016-17. The details of lines to reconductored are shown in Table-II.

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Table II. Details of feeders

Sl.No.	Name of the 132 KV Line	Length of the line (CKM)
1	Feeder I	14
2	Feeder II	65
3	Feeder III	37.8
4	Feeder IV	0.7
5	Feeder V	57
6	Feeder VI	16.15
7	Feeder VII	26.59
8	Feeder VIII	31.5
9	Feeder IX	16.8

V.PROPOSED ALGORITHM AND CASE STUDY

In this paper the study for enhancement of power transfer capability of intra state network with HTLS conductors is carried out and different case studies were evaluated from the results load flow.

Three Nos. case studies were considered with normal network loading conditions of base year without estimated 9 hours day time agricultural load:

Case (i) ACSR Panther
Case (ii) STACIR Panther Equivalent
Case (iii) ACCC Casablanca.

Two Nos. case studies were considered with projected 9 hours day time agricultural load for the horizon year :

Case (iv) STACIR Panther Equivalent
Case (v) ACCC Casablanca

A practical intra state transmission network is considered for carrying out study. The network is spread over 3 zones and 400 kV, 220 kV and 132 kV voltage levels. The load flow studies are carried out by scaling the loads as per the projected demand of state to meet the 9 hours day time agricultural supply and sufficient generation is ensured to meet the load generation balance.

Case i). ACSR Panther with loading at base year: The power flow study also known as load-flow study is an important tool involving numerical analysis applied to a practical power system. It analyzes the power systems in normal steady-state conditions. The load flow study is important for future expansion , planning of the transmission system as well as determining the optimum operating condition of the existing system. Magnitude and phase angle of the voltage at each bus, and the real and reactive power flowing in each line are obtained from load flow study.

Case ii). STACIR Panther equivalent HTLS with loading at base year (selected 9 Nos. Feeders): The objective of placing STACIR Panther equivalent HTLS is to reduce losses and improve the Voltage profile and enhance Transfer capability of the Power System. The criteria for placement of STACIR Panther equivalent HTLS is in the lines with maximum loading conditions. The 9 Nos. lines in the system are considered in the study by replacing ACSR Panther with STACIR Panther equivalent.

Case iii). ACCC Casablanca HTLS with loading at base year (selected 9 Nos. Feeders): The objective of replacing with ACCC Casablanca conductor is to reduce losses and improve the Voltage profile and enhance Transfer Capability of the Power System. The criteria for placement of ACCC conductor is the transmission lines with maximum loading and ROW problem.

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Case iv). STACIR Panther equivalent HTLS with loading at horizon year (selected 9 Nos. Feeders). Line loading horizon year are considered 1.5 times of the loading at base year. This is a combination of Case (ii) and with additional 9 hours day agriculture estimated demand . This case enables us to determine the enhancement in the performance of the system with STACIR Panther equivalent HTLS conductor under maximum load conditions.

Case v). ACCC Casablanca HTLS with loading at horizon year (selected 9 Nos. Feeders). Line loading horizon year are considered 1.5 times(approx) of the loading at base year. This is a combination of Case (iii) and with additional 9 hours day agriculture estimated demand. This case enables us to determine the enhancement in the performance of the system with ACCC Casablanca HTLS conductor under maximum load conditions. The results of the two cases at horizon year are shown in the Fig. 9, Fig. 10 and Fig. 11.

VI. CALCULATION OF AVAILABLE POWER TRANSFER CAPACITY OF LINE

Thermal rating of conductor at specified temperature in MVA is T, Actual loading in line in MVA is L, Available Power Transfer Capacity of Line in MVA is A.

Available Power Transfer Capacity of Line (A) in MVA= Thermal rating of conductor at specified temperature (T) in MVA– Actual line loading(L) in MVA

VII. RESULT AND DISCUSSION

Simulation of Load flow studies are carried out on the PSS®E software developed by SEIMENS PTI using full newton raphson solver.

The results of the case(i),case(ii) and case(iii) for base year are shown in the Fig. 6, Fig. 7 and Fig. 8

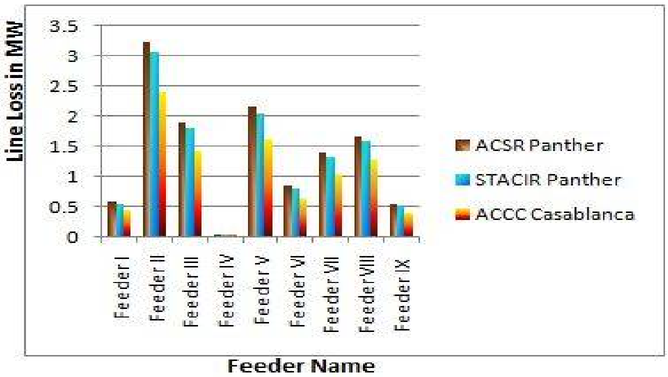

Fig.6 Feeder wise Line Loss in MW(Base Year)

Fig.7 Bus Wise Voltages in kV(Base Year)

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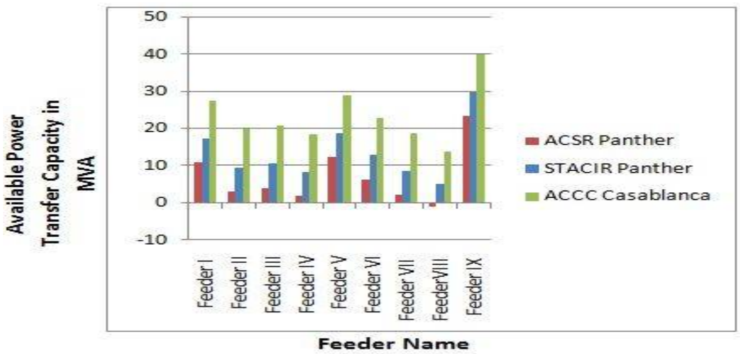

Fig.8 Feeder wise available power transfer capacity in MVA(Base Year)

The results of the three cases at base year are shown in the Fig.6, Fig.7 and Fig.8 give the graphical comparison of the performance of the network subjected to the three types of conductors. The graphs show the comparison of Line loss in MW, Bus Voltage in kV and Available Power Transfer Capacity of Lines at base year i.e without 9 hours day time agriculture supply. From the fig.8 it can be observed that in case of Feeder (VIII) with ACSR Panther, the available power transfer capacity is negative, which indicates slight overloading (but within limits of less than 10%), no further available power transfer capacity in that line.

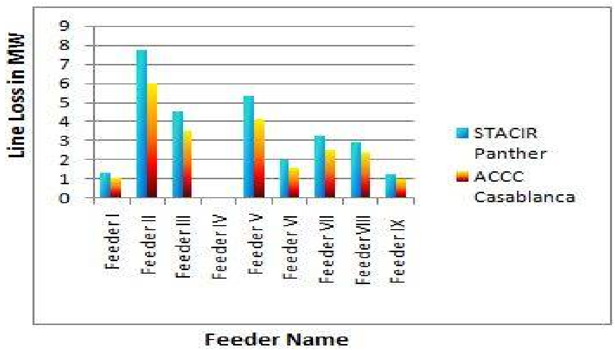

Fig.9 Feeder wise Line Loss in MW(Horizon Year)

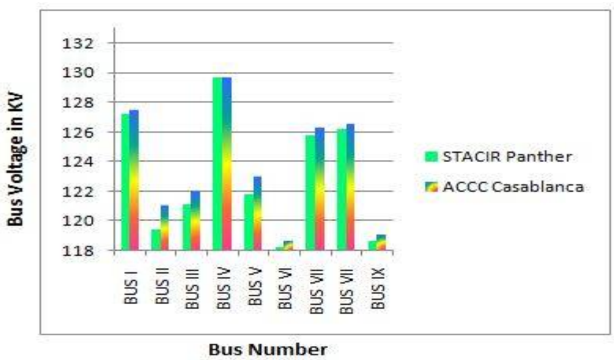

Fig.10 Bus Wise Voltages in kV(Horizon Year)

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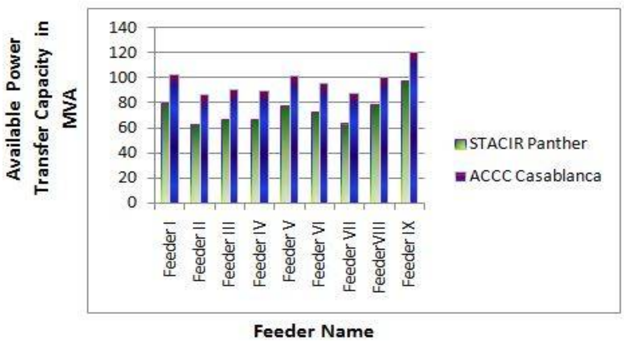

Fig.11 Feeder wise available power transfer capacity in MVA (Horizon Year)

Similarly, the results of the case(iv) and case(v) for horizon year are depicted in the Fig.9, Fig.10 and Fig.11 give the graphical comparison of the performance of the network subjected to the two types of conductors. The graphs show the comparison of Line loss in MW, Bus Voltage in kV and Available Power Transfer Capacity of Lines at horizon year i.e with 9 hours day time agriculture supply.

VIII.CONCLUSION

The figures (6) to (8) shows line losses, the bus voltage and available power transfer capacity of lines for base year. The figures (9) to (11) shows line losses, the bus voltage and available power transfer capacity of lines for horizon year. From the results we observe that ACCC Casablanca shows better performance over the ACSR Panther and STACIR Panther equivalent.

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