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# PERFORMANCE ANALYSIS OF ACSS CONDUCTOR WITH CONVENTIONAL ACSR CONDUCTOR FOR INCREASINFG THE THERMAL LOADING OF TRANSMISSION LINE-CASE STUDY

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***Abstract***
***In India, ACSR and AAAC conductors are ordinarily used for transmission of electricity. As the consumption of electricity jump up across the country in order to speedy expansion in industrial, agriculture and commercial section. In outcome, amount of power transfer capacity has to be raised on overhead transmission lines, diminution of losses and optimization of Right of Way are the big matter we are facing presently. To overcome these affairs, new generation high performance conductors are appropriated which would support in rise the power transmission capacity and meet today's demand under normal as well as in emergency situation. So HTLS ( High Temperature Low Sag) conductors is the one of the progressive way to expand the transmission line capacity and settling the matter like growing congestion in existing network. It is wise option to change the ACSR conductor with the HTLS conductor which can be treated as the re-conductoring of the transmission network. Choose of HTLS conductor is also a vital parameter for re-conductoring of any transmission line.This paper examine the problem of overloading of transmission line and mitigation by re-conductoring through HTLS conductors. A case study is described by re-conductoring of ACSS type conductor and optimum solution is recommended for bypass burden of transmission line.***

***Key words- ACSR conductor, ACSS conductor, Re-conductoring, Ampacity, Thermal Loading Limit.***

## I. INTRODUCTION

The requirement of electric power is hike at a faster growth while new transmission line facilities are being erected at a moderate rate. This leads to overburden of transmission line. The Loading limit of line is thermal loading limit. Thermal loading limit of line is also an essential parameter of transmission line. The overloading of line causes heating of the conductor and it can degrade the conductor. Overloading of the transmission line and Right of Way issues are the extensive challenges for any Utility [1].
In India, widely transmission lines are composed using ACSR conductors. However, ACSR conductors can't worked at grater temperatures and their losses are more at higher power transmission. Thus, it becomes very momentous to up-rate the transmission line or build up new line. The construction of new transmission lines required grater expenditure. ROW is also a extensive challenge in construction of new line. There are multiple options possible for up-rating of overhead lines like Up-gradation of transmission lines i.e. modification in the existing transmission line to grant it to operate at a higher voltage and Up-rating of transmission lines i.e. revolution in the existing transmission line to enable increased current flow [2].The many capacity enhancement approach are summarized in Figure 1.

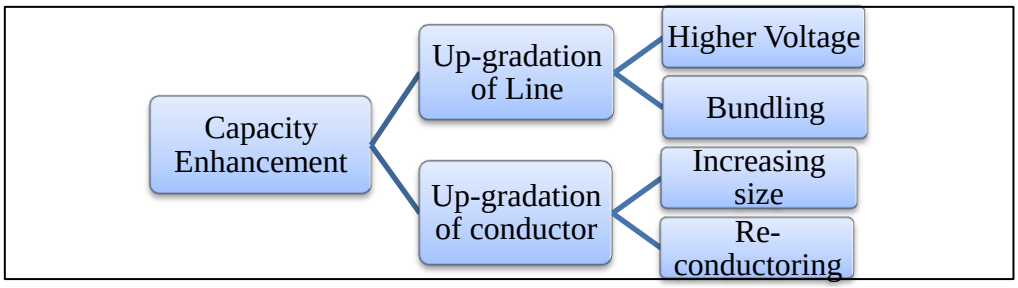


*Figure 1 capacity enhancement methods [2]*

The boost of voltage level requires the re-insulation of the line to the new voltage level which increases phase to phase distances and ground clearances.
One of the methods to accomplish the above is by re-conductoring the transmission line**.** This can be achieved using conductors bigger than the existing ones or using conductors with the same diameter having higher temperature capacity. Increasing the thermal loading of an existing line by replacing the conductor larger than the original will expand both tension and wind loads on current structures [3].

The tremendous features of HTLS conductor is that double the power can be transferred in with the ACSR conductor of same size. Re-conductoring with HTLS conductors is best satisfactory option in order to higher temperature capacity and low Sag conductor .

## II. HTLS (HIGH TEMPERATURE LOW SAG) CONDUCTORS

HTLS stands for "High Temperature Low Sag" conductors. They can be operated at high temperature beyond 100° C for longer span without dropping their strength and have less sag [4].
HTLS conductors are made from thermal resistant aluminium alloy layers stranded over a core of material with a small coefficient of thermal expansion because of low coefficient of thermal expansion of the core, above a certain temperature, called knee point, the mechanical stress of the external aluminium layers is transferred to the core. From this knee point to the grater temperature, the HTLS conductor has the same mechanical behaviour of the core which results in a low increase in sag [4]. The several types of HTLS conductors are given below:

**(1) ACSS - Aluminium Conductor Steel Supported**
**(2) TACSR – Thermal Alloy Conductor Steel Reinforced**
**(3) STACIR–Super Thermal Aluminium Alloy Conductor INVAR Steel Reinforced**
**(4) ACCR – Aluminium Conductor Composite Reinforced**
**(5) ACCC – Aluminium Conductor Composite Core**

### *2.2.1 ACSS - Aluminium Conductor Steel Supported*

ACSS conductors are shaped from Annealed Aluminium 1350 wires and an inner large tensile strength core of Galfan covered steel wires or Aluminium Clad steel [4].

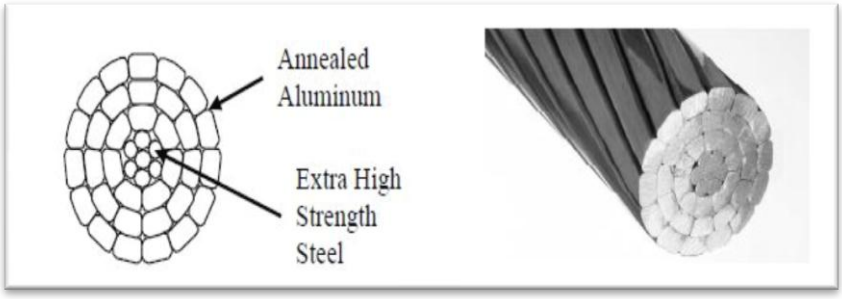


*Figure 2: Aluminium Conductor Steel Supported [4]*

***Features:***

- Current taking quantity upgraded.
- It can work up-to 250°C without failure of strength.[4]

### *2.2.2 TACSR – Thermal alloy Aluminium Conductor Steel Reinforced :*

TACSR have a unique construction featuring a small gap between the steel core and (super) thermal-resistant aluminium alloy layer. TACSR Conductors are high ampacity conductors, wherein the internal core is made of Galvanized Steel and surrounded by heat-resistant aluminium twist-paired with thermal resistant aluminium alloy stranded conductors. Continuous operating temperature of conductor is 150°C.

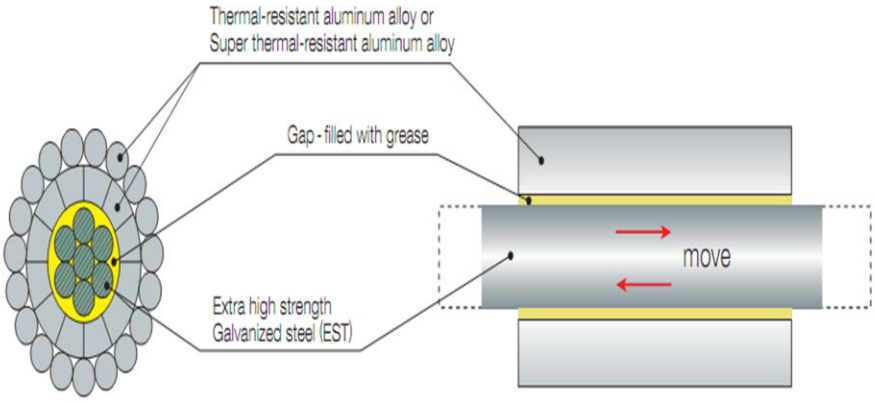


*Figure 3: Thermal alloy Aluminium Conductor Steel Reinforced [5]*

***Features:***

- Low thermal knee-point.
- Extra and Ultra High Strength steel core with adequately tested galvanization.
- resistant to temperatures up to 300°C.

***2.2.3 STACIR – Super thermal resistant Aluminium Conductor Invar steel Reinforced***

Super Thermal Resistant Aluminium Alloy conductor, INVAR reinforced conductor is manufactured from Super Thermal Aluminium (STAL) alloy wires and the inner core is composed of aluminium clad INVAR (Metal alloy with 36% Ni Steel) wires.

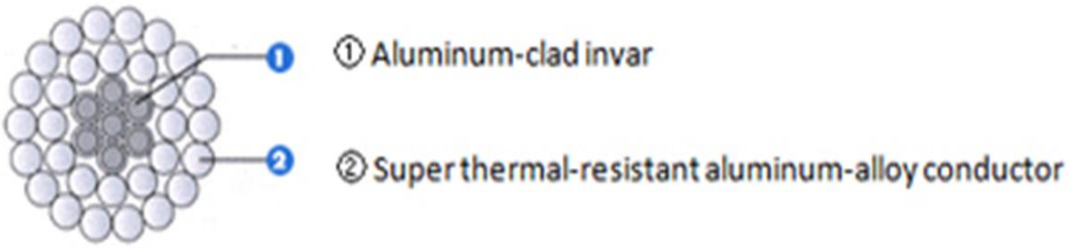


*Figure 4: Super thermal resistant Aluminium Conductor Invar steel Reinforced [5]*

**Features:**

- Low thermal expansion coefficient
- Easy installation and improved resistance to corrosion
- 14 % extra conductivity than ACSR conductor.

***2.2.3 ACCR – Aluminium Conductor Composite core Reinforced***

ACCR is built with outer layers of heat-resistant aluminum-zirconium (Al-Zr) wires and a fiber reinforced aluminum matrix composite core. The composite core has a lower thermal elongation.

*Figure 5: Aluminium Conductor Composite core Reinforced [4]*

**Features:**

- Greater resistance to corrosion
- lesser creep
- Mitigate Thermal Sag

***2.2.5 ACCC – Aluminium Conductor Composite Core***

Aluminium conductor composite core consists of hybrid carbon and glass fibre core. The high strength structural core take maximum conductor's mechanical loads, while the fully annealed aluminium strands carries all of the conductor's electrical current. ACCC conductor composite core is enough lighter and powerful than traditional or high strength steel core.

ACCC conductor have greater conductivity, greater ampacity, cut down line losses and fewer temperature, without any bust in the conductor's overall diameter or weight.

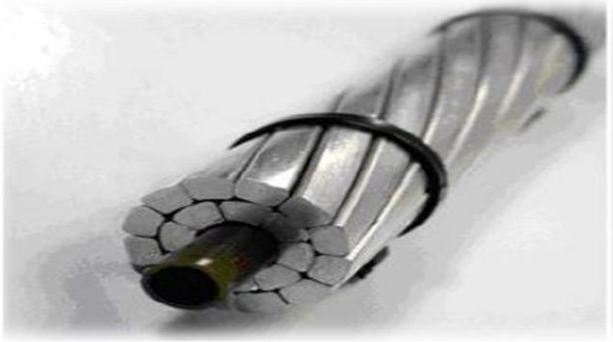

*Figure 6: ACCC – Aluminium Conductor Composite Core [4]*

**Features:**

- Mitigate Thermal Sag.
- Reduce Line Losses
- Strength is grater and less weight

## III. CASE STUDY

The investigation of re-conductoring is attained using ACSS conductor on 220 kV D/C transmission lines. The line is constructed using zebra conductor. The line can transfer up to 213.38 MVA per circuit at ambient temperature of 45°c and topmost operating temperature of 75°c. For the analysis, the network is created using mi-power software.

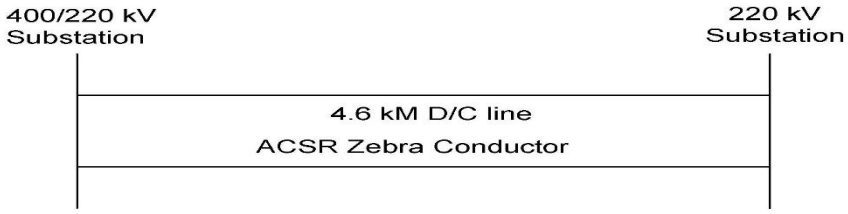


*Figure 7: 220 kV D/C line from 400 kV Substation to 220 kV Substation*

It is monitored that in the peak load period, loading of each line is almost 87.3% of loading limit. We have accomplished N-1 contingency survey of one of the circuit of 220 kV D/C Transmission line. At N-1 condition, it is found that another line will be loaded as 164% of loading limit. Focusing to the N-1 contingency outcomes, it is observed that it is needed to up-rate the 220 kV D/C Transmission lines from 400 kV Substation to 220 kV Substation.
The ampacity of various conductor with conductor size at ambient Temperature at 45°C is listed as per Table 1.

**Table I: Thermal Loading Limits For ACSR (Zebra) Equivalent Conductors [6]**

| ZEBRA EQUIVALENT | MINIMUM OPERATING TEMPERATURE IN DEGREE | AMPACITY(A) | MAXIMUM MOPERATING TEMPERATURE IN DEGREE | AMPACITY(A) |
|---|---|---|---|---|
| **ACSR** | 75 | 560 | 85 | 703 |
| **ACSS** | 85 | 625 | 200 | 1260 |

## IV. RESULT AND DISCUSSION

### 4.1 RESULTS

In Case study simulation, two cases have been performed: (1) Conductors Ampacity of maximum operating temperature (2) N-1 Contingency analysis of one circuit of D/c line with Conductors Ampacity of maximum operating temperature. The case wise outcomes are discussed as below:

**CASE 1: Conductors Ampacity of maximum operating temperature**

**Table II: Comparison of ACSS conductor with ACSR Conductor at Maximum operating temperature**

| Parameter | ACSR | ACSS |
|---|---|---|
| **Operating Temperature ˚C** | 75 | 200 |
| **Voltage Level** | 220 | 220 |
| **Ac Resistance** | 0.08479 | 0.1455 |
| **Ampacity In Amp** | 560 | 1260 |
| **Power Flow In MW** | 189.66 | 189.68 |
| **Loss In MW** | 0.2517 | 0.4890 |
| **Percentage Loading** | 87.2 | 38.7 |

**CASE 2: N-1 Contingency analysis of one circuit of D/c line with Conductors Ampacity of maximum operating temperature**

**Table III: Comparison ACSS conductor with ACSR Conductor a Maximum operating temperature in N-1 Contingency Analysis**

| Parameter | ACSR | ACSS |
|---|---|---|
| **Operating Temperature ˚C** | 75 | 175 |
| **Voltage Level** | 220 | 200 |
| **Ac Resistance** | 0.08479 | 0.1455 |
| **Ampacity In Amp** | 560 | 1260 |
| **Power Flow In MW** | 356.351 | 356.14 |
| **Loss In MW** | 1.0085 | 1.7214 |
| **Percentage Loading** | 164 | 72.7 |

The (N-1) contingency analysis of carried out by ACSS and ACSR conductors are carried out by and The results are compared in Table 3.

**4.2 DISCUSSION**

The simulation examine for re-conductoring of 220 kV D/c line with ACSS is done with various conditions. The comparison of ACSS conductor with ACSR Zebra equivalent in terms of percentage loading and percentage losses is shown in Figure 8,9,10,11.

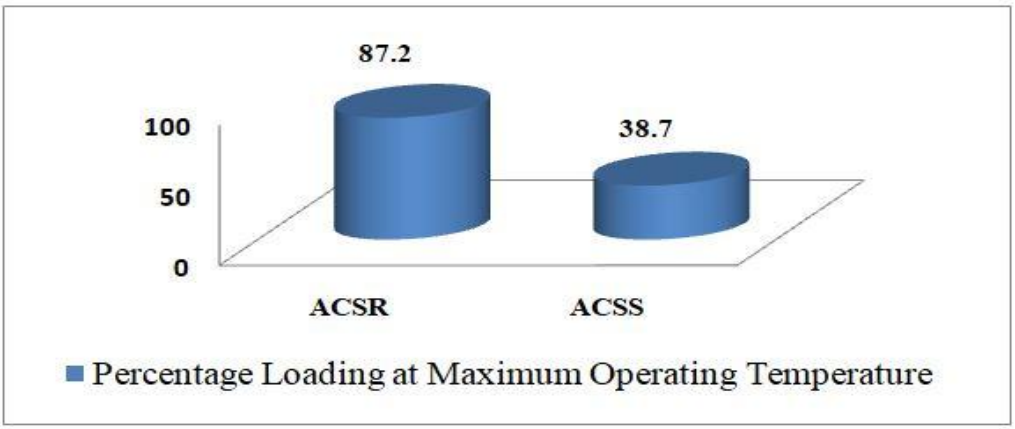


*Figure 8: % Line loading in ACSR and* ACSS *Conductors at maximum operating Temperature*

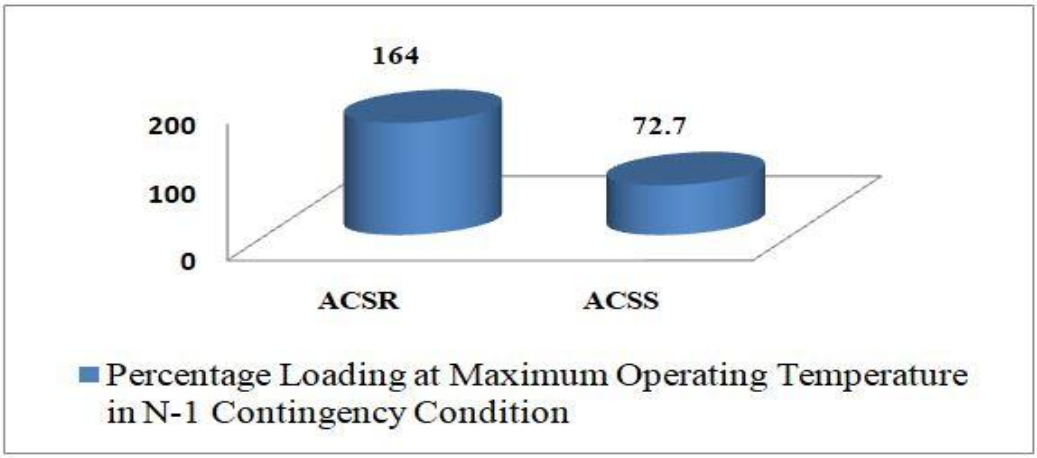


*Figure 9 : % Line loading in ACSR and* ACSS *Conductors at maximum operating temperature in N-1 contingency condition.*

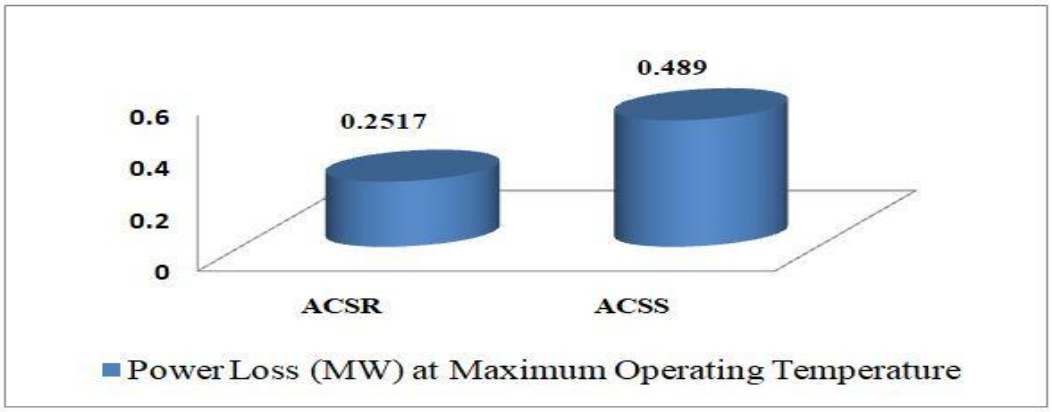


***Figure 10 : Power los in ACSR and* ACSS *Conductors at maximum operating Temperature***

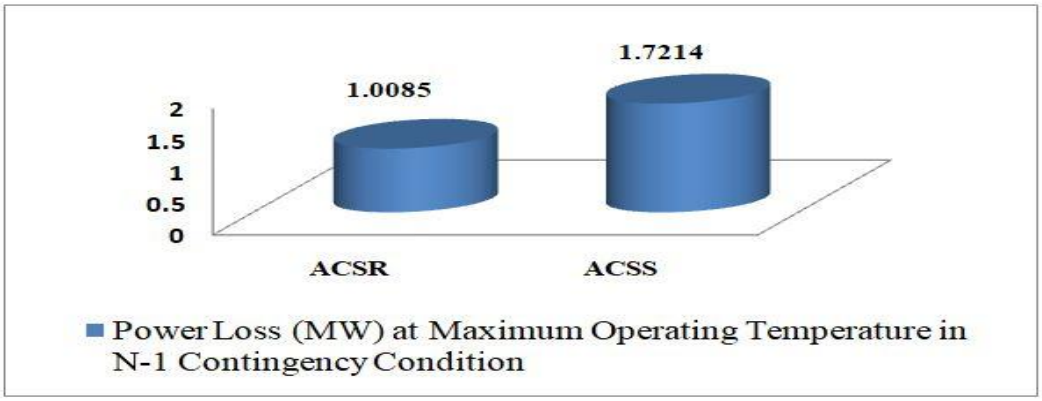


*Figure 11: power loss in ACSR and* ACSS *Conductors at maximum operating temperature in N-1 contingency condition.*

In different cases**,** ACSS conductor have less percentage of line loading and losses compared to ACSR Zebra conductor. In case of N-1 contingency analysis, the line will not be overloaded if re-conductoring of 220 kV D/c line is carried out with any of ACSS conductors.

## V. CONCLUSION

In this paper, various methods of up-rating a transmission network with various HTLS conductors are studied. As per the multiple tabular and graphical results; it is noticed that re-conductoring of existing transmission line with HTLS conductor would be the perfect option in compliance with system secure operation requirement. For the case study, it is concluded that re-conductoring with ACSS conductor will suitable option due to twice the power transfer as compared to ACSR and no overloading issue found during N-1 contingency analysis. The line losses are also reduced with the use of ACSS Conductor for re-conductoring of Transmission line.

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