Large Aluminium Cable Systems

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ABSTRACT

The usage of aluminium in extra high voltage (E)HV cables is gaining importance and popularity. The leading arguments behind this development are environmental and economical. This paper will discuss the advantages of using such aluminium systems over copper ones, especially those where large cross sections are required to transport higher currents. Furthermore, a case study of a succesfuly type tested 4000 mm^2 400 kV cable system will be presented.

KEYWORDS

Cables, Extra High Voltage, 400 kV, 400 mm^2 Aluminium Milliken

INTRODUCTION

In certain markets, Aluminium has gained the upper hand as the metal of choice for the conductor of a high voltage cable [1]. Though the electrical resistance is inferior when compared to copper resulting in larger cross sections of conductor, the price advantage of the former metal has become a strong attribute in it's choice. The usage of aluminium in power cables is well established, but a trend in larger cross sections is being experienced. This is not only applicable to high voltage cables, but also to low and medium voltage classes. Furthermore, copper (Cu) and lead (Pb) are also being replaced as the choice of metal for the earthing screens, not only due to a price advantage, but also from an environmental point of view.

All these changes have an impact on the cable size and weight. The overall diameter of the cable increases but its weight decreases drastically This results, on one hand, in in shorter delivery lengths on the same size drum but on the other hand, the released carbon dioxide (CO_2) levels into the environment decreases due to lower transportation weights. These developments are found to be in line with the recccomendations of designing a sustainable product [2]

A case study is presented in this paper where the comparison of two cables will be discussed. Both cables will be applicable for 400 kV voltage levels but the metals used for the conductor and metallic sheath will be different. The traditional design will be built up with a copper conductor and copper wires plus lead metallic sheath, whereas the Eco friendly design will have an aluminium conductor with a welded alumium sheath. The comparison points discussed will include dimensional properties and CO_2 emission in the manufacturing process.

CABLE DESIGN

The following section describes the impact of replacing heavy metals with aluminium. These metals are found in two components of the power cable, the conductor and the metallic sheath [3].

Conductor

Multiple design options of conductors are available. The traditional designs consist of stranded copper conductor, either in a round stranded configuration or a Milliken sectoral layout. The choice is guided by defining the required ampacity and the manufacturing capabilities of the plant. This is translated into a geometrical size that corresponds to a predefined dc resistance in the norm IEC 60228. A commonly accepted alternative to opper is aluminium. Though inferior in electrical performance due to a higher resistivity, the mechanical and economical aspects are worth considering. The prices of each metal is predefined by the London Metal Exchange (LME) with a general ratio of 3:1 USD per kilogram for copper and aluminium respectively. Due to a higher resistivity, the equivalent size when switching from copper to aluminium requires a larger diameter for the conductor, resulting in a slightly thicker cable. Aluminium conductors can also be used as a solid rod. This design is not only water blocked, but also more compacted when compared to an quivalent cross section of stranded or Milliken design.

Metallic Screen

The metallic screen's primary function in a power cable is designed to carry the short circuit current (Isc) in case of a fault. The secondary function is to create a radial water barrier to protect the insulated core. The original designs were based on a lead sheath covering awhich fulifills both functions . In the course of the development of the electric grid, the short circuit requirements were increased and the lead layers had to be supported by additional copper wires, the so called composite design. Lead also has the disadvantage of being very dense, hence resulting in a heavy cable and cracking can be an issue when overbent or overexposed to environmental factors. The density makes this choice of metal relatively expensive. The addition of copper wires inmproves the electrical performance of the metallic sheath however the economic considerations are also considerable.

Exchanging the metals with Aluminium can be a reasonable compromise. Aluminium is the cheapest of the metals per kilogram and the resistivity of the matal is approximately one and half times higher than copper. Lead for comparison has a resistivity of approximately 13 times higher than copper. Aluminium welded sheaths can also act as a water barrier. Welding the tapes around the cable allows for a sturdy water barrier and mechanical protection of the cable. Additionally, corrosion of the welded