Copper or Aluminium cable conductors, broadly compared in a life cycle perspective

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ABSTRACT

In this paper, the results of three studies are presented. The first studyconcerns technical information on copper versus aluminium followed by a decision model how the selection process of the conductor material happens in practice. The second studyis about the environmental performance of both conductor materials in a Life Cycle Assessment. The analysis finds that copper cables have lower net environmental impacts than their aluminium counter parts. Finally the third study deals with a complete Life Cycle Cost Analysis, resulting in the conclusion that both materials, although significantly different in raw material pricecan be considered to give equivalentsolutions from a life cycle costing perspective.

KEYWORDS

Copper, Aluminium, Conductor, Cable, Material Properties, Modelling, Life Cycle Assessment, Life Cycle Cost Analysis, Asset Management, End of Life

INTRODUCTION

A cable conductor usually consists of copper or aluminium.Originally copper was the only conductor material used, later aluminium was introduced as a new conductor material. Copper and aluminium differ in properties and in raw material price. In particular the significantly lowerraw material price presentlyplays animportant role in the purchasing strategy of utilities.On the other hand it is well known that the initial costs have to be projected overa long term perspective in order to reliably show the ultimate price quality ratio.

In this paper, attention is first paid to the decision model of utilities when selecting the conductor material for their cables. What material properties are important? Is there a compensation to be expected for the initial higher raw material cost? Then a proper Life Cycle Assessment(LCA) will be applied, aggregating the environmental impacts associated with the manufacturing, recycling effort and credits through replacement of primary material replaced by recycled material on the market. Finallya Life Cycle Cost Analysis (LCCA) will be added. All costs over the entire lifetime of a cable will be considered, including initial CAPEX costs, O&M costs, cost of electric losses and residual value after decommissioning.

The three studies presented in this paper contribute thus to the complete picture of efficient conductor material use in power cables, leading to a conclusion thatinvestment decisionsshould consider all relevant costs over the entire life cycle, and not focus on initial costs only.

TYPICAL PROPERTIES OF COPPER AND ALUMINIUM

Copper and aluminium differ in properties. The main differences are in specific conductivity and in specific weight. As the density of aluminium is about one third of that of copper, for equal conductance the weight of the aluminium conductor material is almost halved, however the cross-sectional are has to be increased by a factor of 1.6. For a quick overview the differences between copper and aluminium are presented in Table 1 on a relativescale, based on the specific values for copper=100:

Table 1: Material properties

Material Properties	Comparative Values	
	Copper	Aluminum
Electrical resistivity	100	164
Density	100	30
Weight/unit resistance	100	53
Diameter/unit resistance	100	129
Elastic modulus	100	55
Hardness	100	44
Ultimate tensile stress	100	35
Melting point	100	61
Stress fatigue endurance limit	100	62
Thermal resistivity	100	158
Corrosiveness	1)	2)
Specific Heat	100	230
Thermal expansion	100	135

1) Copper is resistant to most organic chemicals

2) Aluminium may corrode quickly

When paying attention to the failure mechanisms [1] the major difference between copper and aluminium is that contrary to copper aluminium reacts with water and oxygen rather quickly [3][4][5]. The insulating layer of aluminium oxide is an advantage for reducing the skin effect for a stranded conductor, but is a clear disadvantage with connectors in joints.

DECISION MODEL

Utilities were asked in aninternationalquestionnaire about their motives to make a choice between copper and aluminium as cable conductor materials. Therefore in Table 2 the following list of criteria was presented with the request to give a scorebetween (1 to 5):