Storvik high conductivity anode yoke with copper core

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Abstract

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Copper is already used in aluminium electrolysis cells as inserts in steel cathode collector bars with the aim of lowering cathode voltage drop. With the same idea in mind, Storvik has designed and manufactured cast steel-copper core anode yokes. Storvik together with partners has developed a method of combining copper and steel through casting. This method is quite different to the conventional methods used in the aluminium industry today (gun drilling and heating) which is not possible for anode yokes. In this paper, the results of mathematical modelling and laboratory experiment, using cast steel-copper core anode yokes are presented. The modelling showed 43 % voltage drop reduction in the copper core yoke in comparison with standard steel yoke. Laboratory tests shows 29 % voltage drop reduction even though the specimen had casting defects. The casting method achieved 100 % molecular bonding of metals with iron particles penetrating several mm into the copper and copper particles penetrating 20 µm into the iron at the interface between the two metals. Storvik is now preparing a full scale industrial trial in a smelter. Economical analysis of the gains by using copper core yokes will also be presented in the paper.

Keywords: Copper core anode yoke; copper-steel casting bond; anode yoke voltage drop; voltage drop; high conductivity.

1. Introduction

The aluminium industry has a need for good heat and electrical conductors that are resistant towards corrosive environments. Metals such as copper (Cu) and aluminium (Al) are preferred conductors were copper shows the best properties. Cu is more expensive than aluminium and the Cu density is higher than that of Al. Al is frequently used rather than copper because it is lighter for the similar electrical conductance. Steel is used in areas which are exposed to high temperatures. Steel also has very good mechanical properties, however the electrical conductivity is relatively poor compared with Cu and Al. Table 1 gives the resistivity and density of aluminium, copper and iron.

Table 1. Resistivity of aluminium, copper and steel at 150 °C.

Material	Resistivity (µΩm)	Density (kg/m^3)
Aluminium busbars	0.04314	2 700
Copper	0.02647	8 960
Iron	0.231	7 874

In aluminium industry, the focus is particularly aiming at anodes and cathodes. Those are used in an environment where steel and cast iron are common but very poor conductors in comparison to aluminium and copper. However, they are the best materials due to their resistance to high temperature and mechanical strength. To decrease electrical resistance, copper and aluminium are used in combination with steel and cast iron. Aluminium and is used for anode rods, which are the least exposed to high temperature. Copper is sometimes mechanically inserted in steel cathode

collector bars. There are many published articles about new cathode technology referring to usage of copper and steel as combined conductors, this technology increases the pot efficiency and the refractory lining lifetime considerably, due to the fact that the current distribution is more even with copper inserts [1]. This is mentioned as a reference to our invention as the theoretical analysis shows that the current distribution is more equally distributed through the cell with copper core in the steel. Copper can also be done in anode yoke as described in this paper. Basically, Storvik's main target with the new Storvik High Conductivity Anode Yoke is reduced voltage drop in the anode yoke.

2. About Storvik AS

Storvik roots goes back to 1913 and started by the local black smith Nils Storvik. Figure 1 shows the old smithy at Viklandet, Sunndalsoera. The company Storvik as an industrial company was founded in 1952 upon the construction of the Hydro Aluminium smelter in Sunndalsoera (then belonging to Årdal og Sunndal verk). First metal (aluminium) was poured in 1954. Storvik is now a company with the head quarter located in Sunndalsoera, close to Hydro Aluminium Sunndal. In addition to the main office, we have branch offices in the Czech Republic, Iceland, Russia and Kristiansund, Norway. Storvik employs a total of 85 persons. Storvik provides multidisciplinary services, products and projects to Norwegian and international primary and secondary aluminium industry, which is the main market. Storvik, also delivers projects and products to oil and gas industry and hydro power stations.

Figure 1. The old Storvik smithy at Viklandet, Sunndalsoera.

3. The pilot project - "Storvik High Conductivity Anode Yoke"

During 2014 and 2015, Storvik has performed a pilot project of the Storvik High Conductivity Anode Yoke. The pilot project has been funded by Innovasjon Norge. This paper will basically describe the pilot project including findings and possible next steps for the invention.

The basis for this study has been to verify the following parameters:

1. New design anode yoke for pilot project,

Table 3. Estimated savings due to reduced voltage drop in anode yoke with copper core, US $.

Parameter	Unit	Value
Smelter capacity	kt/year	300
Number of pots		362
Number of anodes per pot		30
Amperage	kA	300
Current per anode	kA	10
Anode yoke voltage drop without Cu	mV	29
Anode yoke voltage drop with Cu core	mV	16.4
Voltage reduction	mV	12.6
Energy saving per potline per year	MWh/year	11920.6
Price of energy	$/MWh	40
Operating cost saving per potline	$/year	476824

10. Patent

Storvik applied for a patent on 31 December 2014. The application "20141570" is pending at Patentstyret in Norway.

11. Acknowledgement

Storvik received funding from Innovasjon Norge for the pilot project.

12. References

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