A new electrorefining system for aluminium

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Super pure aluminium is at present produced on commercial scale by three layer electrorefining process which has several draw backs. A new nonalloying refining system was hence developed and tried in laboratory scale cells. The performance of the new system and the results obtained therein are discussed in this paper.

Key words: Aluminium electrorefining, nonalloying refining, super purity aluminium

INTRODUCTION

The primary aluminium produced commercially is of purity 99.5–99.8%; a higher purity is needed for certain alloys in aeronautical and battery industries and for making capacitors and contacts in electronic industry. Super pure aluminium is at present produced on commercial scale by the three layer electrorefining process.

Three layer process

The three layer process [1] suffers from several drawbacks. The introduction of alloying gives room for contamination in the refining metal. To avoid this as well as any physical disturbances, a large interelectrode gap is maintained, leading to a large energy consumption of 20-22 kWh/kg of Al. The introduction of feed metal into the bottom layer requires special complicated arrangement. Graphite consumption due to erosion of current leads to the top metal layer is also considerable.

Alternative to the three layer process

What is essential for electrorefining is the separation of anodic and cathodic metal layers. In the three layer process, this is obtained by increasing the density of anode metal layer through alloying. The same separation could, however, be obtained without the necessity of alloying in a modified U-tube type of arrangement, where both the anodic and cathodic metal layers are separated by a thin refractory partition and float over the molten electrolyte.

For such a system, the IR drop is affected by (i) thickness of partition (ii) depth of electrolyte from bottom of the metal layer to the tip of partition (iii) width of metal layer compartment. Of course, the current distribution will not be uniform—the current density being maximum near the partition and minimum at the farthest. By judicious optimisation of these three parameters and employing a plurality of adjacent cells, it will be possible to conduct refining at lower cell voltages compared to the three layer cell.

EXPERIMENTAL

Based on the above considerations, a few small scale refining cells were designed and constructed. Some preliminary experiments were carried out to establish the feasibility and advantages of electrorefining in a nonalloying system described as above. Because of the small capacities of these cells, the D.C. power impressed was not sufficient to keep the electrolyte and metal layers molten. As these cells were all refractory lined, external heating also was not possible. Hence the additional heat required was supplied through auxiliary A.C. (low voltage, high amperage) source with the electrolyte itself acting as the resistor. These heat reservoirs were accommodated at the two ends of the cell. (This auxiliary heating could be dispensed with in larger capacity cells). Refractory partitions were employed to keep apart the heating chamber and the electrolyser. The electrolyte for this refining system was similar to the one employed for the commercial three layer process (AlF_3—23%, NaF—17%, $BaCl_2$—60% by weight) [2]. The cells were operated at temperatures around 1023K. Commercial aluminium was used as the starting anode and feed material.

RESULTS AND DISCUSSION

Table I gives the operating characteristics of some of the cell runs and the results obtained therein.

From Table I, the following conclusions can be drawn: (i) the cell voltage as measured was in agreement with the value employed for determining the capacity of these small scale electrorefining cells. By employing thinner partitions, it is still possible to further reduce the cell voltage to about 4.0V in higher capacity cells (ii) specific energy consumption was appreciably less than that reported for the commercial three layer electrorefining cells (iii) current efficiencies realised are of the order as obtained in industrial scale cells.

TABLE–I: Operating characteristics of the cell for electrorefining of aluminium

Sl. No.	Current (A)	Cell voltage (V)	Hrs. of electrolysis	Current efficiency (%)	Energy consumed (kWh/kg)
1.	100	6.0	72	87	20.57
2.	100	5.0	96	90	16.84
3.	200	4.8	124	90	15.98

Table II shows the typical data of extent of refining for various elements [3] and the refined metal obtained conforms to the requirement of superpure aluminium.

CONCLUSION

It can be concluded that a nonalloying type of refining cell as described above can be advantageously utilised for producing superpurity aluminium with reduced energy consumption, better purity because of absence of alloying and easier cell operations. The cells could be easily scaled up to industrial scales by having a plurality of metal compartments.

REFERENCES

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TABLE–II: Typical data for refining of various elements [3]

Element	Feed material %	Refined aluminium %
Copper	0.05	0.001
Iron	0.50	0.002
Silicon	0.18	0.005
Manganese	0.40	N.D.
Magnesium	0.20	0.001
Zinc	0.005	0.001
Aluminium by difference	99.665	99.990

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