Upgrade and Innovation of a Multivariate Process Parameters Intelligent Control (MPPIC) Technology for Aluminum Reduction Cells

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Abstract

An advanced Multivariate Process Parameters Intelligent Control (MPPIC) technology was developed by CHALIECO GAMI several years ago and has been used in many large domestic and foreign Greenfield or modernized brownfield smelters. In this paper, the new up-grading and innovation research resulting from MPPIC technology developed by CHALIECO GAMI in recent years will be described and the successful application of this latest technology, especially with the "Remote Data-Diagnosis Technology Service" (RDTS), will be introduced, too. The new upgraded MPPIC results in significantly higher current efficiency and reduced energy consumption for some smelters and is superior to the original MPPIC technology which it can replace.

Keywords: Multivariate Process Parameters Intelligence Control (MPPIC), cell control model, cell computer network control platform, Remote Data-Diagnosis Technology Service (RDTS).

1. Introduction

Over the past decade, the original MPPIC technology and device [1] with independent intellectual property rights developed by CHALIECO GAMI has reached the international level and achieved great reputation in China and abroad with excellent product quality and technical service. However, with the rapid development of world primary aluminum industry, especially the Chinese primary aluminum industry during this decade, it also faces more and more intensive competition. Therefore, how to further reduce the production cost becomes one of the key tasks for each aluminum smelter. According to the report [2], the average power cost of Chinese primary aluminum industry amounts to more than 44 % of total production cost and is about 16 % higher than the average in the rest of the world. So, how to reduce the specific energy consumption per kg of aluminium is by all means the priority for the aluminum smelters in China.

Based on several cell control technologies research and application achievements in recent years, especially on original MPPIC technology developed by CHALIECO GAMI, this latest technology is more efficient, energy-saving and emission-reducing control technology system for aluminum reduction cells. It takes advantage of theoretical research and successful practical implementation of the cell intelligent control systems in China and abroad and uses the in-depth research of cell control technology software and hardware at its core. To further achieve the obvious economic and social benefits based on the existing conditions for Chinese primary aluminum industry, the MPPIC technology has been first implemented on the large pilot Centre Worked Prebake (CWPB) anode cells and are now used in several large CWPB cell lines.

The latest generation of MPPIC technology is developed from the original generation. It could enable each large Point Fed Prebake (PFPB) reduction cell to achieve the best technical and economic key performance indicators with high current efficiency and low energy consumption under stable production conditions of minimum operator interference. This is not only the development direction of intelligent pot control systems for primary aluminum industry, but also the new innovative development model for continuous increase of the performance of the aluminum reduction cells.

2. The Concept of the Latest MPPIC Technology

Everybody knows that the aluminum reduction process has strong interaction multivariate characteristics with limited observable process and responses which are non-linear and vary over a wide range of time scales. Figure 1 shows a diagram of main interactions between mass and energy balance.



Figure 1. Overall interactions between mass and energy balance [3]. H_{bath}, H_{metal} are bath and metal height, Q_{sidwall} is sidewall heat loss.

The first main successful step of the original MPPIC technology was that both mass balance and energy balance control of single reduction cell were included, which means that AlF_3 could be automatically fed and excess AlF_3 in the cells could be controlled more accurately [1].

Generally speaking, pilot cells should be built and tested before they would be put into construction and production for each kind of new larger PFPB cell lines. But in fact this cannot be done for most kinds of new cells, especially in China.

Nevertheless, the final performance of the cells depends on every step of its Engineering, Procurement, Construction, and Management (EPCM) procedure. The latest MPPIC technology just takes better account of the above EPCM interaction factors, which is suitable for all kinds of the PFPB cells; it can give the cell not only more accurate control, but also find some problems especially for energy balance and solve these problems better quickly.

The cell operation and performance depends on several parameters such as design current, anode current density, working voltage derived from voltage balance, etc., referred to as the "static balance" parameters of cells. The cell is impacted also by other factors like the materials selection and installation during the construction period, preheat and process control in early operation. This is particularly true for various complicated bath compositions of cells in Chinese aluminum smelters, where the best "static balance" of cells can only be realized by good control of the "dynamic balance" parameters, which includes the mass and energy balance parameters in the original MPPIC technology, such as alumina concentration, excess AlF₃ and voltage balance; in particular, high current efficiency requires an ideal cell-cavity shape, which is very important for ideal cell heat balance. Good "static balance" is the basis of ideal cavity shape and the condition

- Decrease of the potline average energy consumption by 0.15 to 0.50 kWh/kg Al,
- Increase of cell life and decrease of cell relining cost.

	Α	В	С	R	S	Т	U
1	Val Section 1st DIAGNOSE Date:2017-4-14						
2				Category	Phenomenon	Reason	Solution
3	No.	PotST	Age				
4	1101		C796	A			increase set Voltage 20mv
5	1102	Stop					
6	1103		D1175	В	High B/T	Low M/L	retain metal -500kg
7	1104		B1570	A			
8	1105		D1017	C	noisy,Low M/L	bad cavity	set ALF3 @ half =20kg
9	1106		C161	A			
10	1107		D1475	В	High B/T	Low M/L	retain metal -500kg
11	1108		B488	В	High B/T	Low M/L	retain metal -500kg
12	1109		D208	С	Low M/L,Low B/T	bad cavity	set ALF3 @ 0
13	1110		D1793	D			
14	1111		C605	A	Low B/T,noisy	High M/L	tap more metal +100kg
15	1112		B2125	В	High B/T	Low M/L	retain metal -500kg
16	1113		B1689	В	High B/T	Low M/L	retain meta -500kg
17	1114		B1734	С	Low B/T,High Ex.ALF3	Low M/L	set ALF3 @ half =20kg
18	1115		B1849	D	High B/T,Low Ex.ALF3	Low M/L	retain metal -800kg
19	1116		C1074	A	noisy	Low Voltage	increase set Voltage 20mv
20	1117		C762	A	High B/T	High Voltage	Voltage decreased,weigh ALF3 fedder
21	1118		B249	A			
22	1119		C960	A	High B/T,Low Ex.ALF3	Low ALF3 Feeding	increase set ALF3 =35kg
23	1120		B582	В	High B/T,Low Ex.ALF3	Low ALF3 Feeding	ALF3 feeding already increased
24	1121		C430	A	High B/T,Low Ex.ALF3	Low Voltage	increase set Voltage 20mv
25	1122		C1071	С	noisy	bad cavity	reduce set ALF3 =20kg
26	1123		C617	С	Low M/L,Low B/T		set ALF3 @ half =20kg
27	1124		C925	С	Low M/L,Low B/T		set ALF3 @ half =20kg
28	1125		D748	A	High B/T,Low Ex.ALF3	Low ALF3 Feeding	weigh ALF3 feeder
29	1126		C1775	D	noisy	Low M/L	increase set Voltage 20mv
30	1127		C147	A	Low B/T		set ALF3 @ 0
31	1128		D1082	В	High B/T	Low M/L	retain metal -500kg
32	1129		B172	A	noisy	High M/L	tap more metal +200kg
33	1130		C803	A	High ALF3 Feeding	High M/L	tap more metal +100kg
34	1131		B377	В	High B/T	Low M/L	retain metal -500kg
35	1132		C461	A	Low B/T, noisy	High M/L	tap more metal +100kg

Figure 9. Example presentation of analysis and diagnosis results in RDTS.

7. Conclusion

GAMI belongs to CHALIECO and CHINALCO, which have good record and reputation in the field of pot control technology not only in China but also in many other countries. An innovative model of the pot and its control technology has been developed by GAMI design and research team. This confirms that more and more intelligent technology will be applied in the cell operation resulting in higher current efficiency and lower energy consumption as well as less pollution in the aluminum electrolysis industry.

8. References

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