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Original Research Article

300,000 TPY Aluminium Smelter Upgrading Project at PT. Indonesia Asahan Aluminium (Persero) in North Sumatera

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Abstract

Growing demand of aluminium in domestic and international markets, forcing aluminium producers to modify their smelter to increase the production as well as to reduce the electricity consumption, though to build a new aluminium smelter plant is one of solution to meet this demand. This article is described modification one of the aluminium smelter plant in North Sumatera Province, Indonesia as a parts of aluminium smelter upgrading project to reach production up to 300,000 TPY.

Keywords: Aluminium, Smelter, Production, Modification, Pots.

BACKGROUND

PT Indonesia Asahan Aluminium (Persero) (*PT. Inalum*) owns an aluminium smelter which has 510 pots. (3 potlines x 170 pots) located at at Kuala Tanjung Kecamatan Sei Suka, Kabupaten Batu Bara, North Sumatra Province. They have plans to increase the potline current gradually from the present current to a reasonable target to increase production capacity and to lower energy consumption. This planning is referring to the high demand of aluminium consumption in domestic and international markets.

In the beginning stage, they intend to upgrade 8 reduction cells first as a trial test, with the objective of testing higher amperage and lower electrical power consumption. The main electrical power source for this smelter is coming from their hydroelectric power plant at Sigura-gura (PLTA Sigura-gura). Nowadays, this hydroelectric power plant experienced a reduction in the supply of electricity power due to a decrease in the water level of Lake Toba and the Asahan River as the main source of this power plant. Power consumption cost will be increasing significantly if electrical power for their smelter is supplied from steam power plant for instance or supplied by other independent power producer, which make aluminium price un-competitive. Therefor it required modification or upgrade the pot production capacity and energy consumption.

METHODS AND SOLUTIONS

In order to achieve this target, PT. Inalum engaged 2 (two) worldwide technology provider for aluminium smelter from China and Switzerland. Both company possesses the technologies and know-how for upgrading pot performance and engaged by PT. Inalum to conduct test of upgrading 8 pots (The Test Pots) in initial stage as a pilot project. Under the contract, they shall provide engineering, procurement of certain equipment and materials, construction and commissioning of the Test Pots. To carry out the construction works, the technology provider from China engaged the author's organization as their sub-contractor.

To increase production capacity and to lower energy consumption of Aluminium Smelter Plant the methodology prepared is as follows:

1. Modification of busbar.
2. Modification of pot shell.
3. Modification of super structure.
4. Modification of pot lining.

As a construction company the author's organization prepare procedure for these modifications. These procedures are considered based on actual conditions on existing production smelter in PT. Inalum and basically refer to construction methodology to carry out the modification works.

Detail of the methodology and procedure of modification is as follows;

1. Modification of Busbar

a. Dismantle of original busbar
   1) Cutting of original busbar on the pot room and transport main busbar to maintenance workshop.
   2) Cutting, cleaning original flexible strip and machining the old flexible strip and the main busbar as per dimension required for reused.
   3) Transport the reused busbar to workshop to start modifications.

b. Assembly welding busbar on the manufacturing site.

1) Assembly busbar
   - Prepare assembly mould for table of busbar assembly and fabricate support and levelling of mould table assembly busbar.
   - Assembly of busbar modification as per drawing.
   - Check levelling, positioning and measuring all assembly busbar as per drawing and design.
   - Check welding machine and all accessories before start of welding busbar.
   - Inspect of quality aluminium welding and cleaning of welding point.

2) Welding busbar
   - The assembled spot welding, inspection and approval shall be carried out before welding.
   - The longer weld shall be welded in sections, and each section shall be 200-250mm.
   - Layer welding must be tightened by hammer and then welded another layer and finally weld the heads at both ends.
   - The welding line may be connected into a reverse polarity electrode (ie. the workpiece is negative) or positive connection electrode (the workpiece is positive), depending on the method used.
   - When the length of weld is less or equal to 50mm, the arc board shall be adopted.
   - Make sure for welding point with some inspect of quality.
   - The weld must be full welded, melted and weld surface must be full and even.
   - The overlap depth of weld shall be ≯0.5mm, and the length shall be not more than 10% of total length.

2. Modification of Pot Shell

a. Transport pot shell to manufacture site and check for rework to original design before handing over to start of modifications.
b. Check all dimension of pot shell and fit-up of modifications fins at pot shell.
c. Welding of modifications fins at Pot shell.
d. Check all dimensions of pot shell after modifications.

3. Modification of Super Structure

a. Manufacture the installation platform, adjust the levelness and place the superstructure on the installation platform
b. Switch on the power source of anode jack, install the support pillar of anode busbar, lifted down the anode busbar and demolish the anode jack.
c. Take off the bolts of hopper, hoist the hopper and place on the supporting frame manufactured on the construction site.
d. Hoist the whole anode busbar by crane and put it on the supporting frame manufactured on the construction site and grind and smooth the place where anode busbar and anode rod are in contact.
e. Cut off feeding device and flue duct underneath the hopper.
f. Setting out and cutting holes on the side wall (web plate) of hopper in strict accordance with design dimension and position. Install diaphragm plate at web plate and welding.
g. Weld with steel plate underneath the sealed hopper in line with requirements of design drawings, and then check the photo permeability of welding joint and leakage of kerosene, to prevent materials from leakage
h. Setting out on the web plate of superstructure in strict accordance with design
i. Position, cutting holes; weld diaphragm that is connected with the web plate for levelling after cutting holes on the web plate.
j. Install the supporting frame of cylinder and sleeve.
k. Reinstall the modified hopper on the superstructure, and fasten bolts.
l. Install the support pillar of anode busbar, hoist the anode busbar again on the temporary support.
m. Reinstall the anode jacking device, turning gear to fixed position and then locking; install the anode busbar to anode jacking device.
n. Install and fix the mould and clamping fixture of anode busbar, weld the anode balance busbar.
o. Install and fix the mould and clamping fixture of riser, install the inclined riser, weld anode flexible, recheck the dimension deviation of anode busbar

4. Modification of Pot Lining

a. Check quality fabricate and installation then clean up pot shell before construction lining start.
b. Check and measure according to the drawing of the pot lining.
c. Start lining work.

5. **Brick Masonry Support Busbar and Concrete Masonry**
   a. Checking & marking support position, make from brick masonry.
   b. Built 2 Support busbar brick masonry.
   c. Levelling and alignment of centre before start of civil works.

6. **Installation Busbar**
   a. Check of centre line pot shell and move point of centre to bottom of pot shell for reference point of busbar support frame then continue to positioning and installation of busbar support frame.
   b. Erection of busbar to position pot room as per drawing and design.
   c. The transformed cathode busbar shall be welded and arranged orderly before the pot shell is installed.
   d. Assembled with bolts, nuts and steel plates.
   e. In the case of installation, attention shall be paid to the electrical insulation of the busbar contact area, as well as the accessible parts between the busbar and other metal objects in the pot room.
   f. The argon arc welding is applied to the connection points of anode busbar after the positioning of busbar.

7. **Erection and Alignment Pot Shell on Pot Room**
   a. Check centre line of pot shell place at pot room area.
   b. Mark and install the reference centre line at the operating floor.
   c. Transport pot shell after modification to pot room.
   d. Clean up the top of cell basement, use the level gauge to measure the elevation to make sure the top elevation of cell basement remains at H + 0 mm
   e. Place the insulator plate, use the level gauge to measure the elevation to make sure the top elevation of insulator plate remains at H + 0 mm
   f. Put the shell on the shell pads temporarily and by using jacks to bring the centre of shell into the pot centre in the operation floor.
   g. Lift up the shell 20 mm by the jacks. Take out the shell pads and take down the shell on the insulators.
   h. Check centre line and levelling of pot shell.

8. **Pot Lining Erection**
   a. Laying of ceramic fibre board.
   b. Laying of xonotlite compound insulation brick
   c. Laying of insulation brick (dry laying).
   d. Laying of dry barrier mix (DBM).

9. **Manufacturing of Cathode Assembly**
   a. Graphitized cathode blocks are used, and the cast iron is used for connecting the cathode collector bars and cathode block.
   b. After cast iron and cathode carbon block cooled, remove the aluminium silicate round braided rope. Cathode bar sealing mortar is rammed to fill the 200 mm length space in the end of the cathode block.
   c. The rebars need to be weld and the castable need to be constructed. The castable shall be allowed to dry over 48 hours. The first 120mm range of the collect bar which exposed the cathode block is brushed by the mixture of the refractory mortars and the sodium silicate up to 3mm.
   d. The special cathode block clamp should be used to hang or move the cathode blocks and the collector bars in the whole assembly process to avoid damaging the cathode block group.

10. **Quality Requirements of Cathode Block Assembly**
    a. The appearance of the cathode block assembly shall be regular after casting. There are no casting cracks in the cathode block. No deformation on the cathode collector bars. The central carbon paste is compact well, and no loose, no uneven.
    b. The deviation of total length of the cathode carbon block (including the length of collector bar) is less than ±5mm.
    c. The centre distance error of the end part of the carbon block is not more than ±1mm.
    d. The total height deviation of the cathode carbon block after casting is less than ±2mm.

11. **Installation of Cathode Carbon Blocks Assembly**
    a. The qualified cathode carbon block assembly with the greater voltage drop shall be put in the centre of groove, those with little voltage drop shall be put on the two sides of groove according to the voltage drop data and the pre-designated operation baseline.
    b. Only the carbon blocks of the same batch from the same manufacturers shall be put into each pot.
    c. The baffle plate of collector bar at both ends of the carbon block assembly shall be placed on both sides of the cathode collector bar in advance.
    d. The carbon blocks, collector bars and baffle plates shall not be damaged. The installation work shall be carried out in order. The uneven part shall be levelled up by powder materials.
    e. The special carbon block clamps shall be used to handle the carbon blocks, to prevent against damage.

f. The collector bar should be placed in the centre of the window. The parallel misalignment of centrelines between the cathode collector bar and the cradle shell window is ± 3 mm. The baffle plate of cathode collector bar is placed closely against the shell steel plate, and the sodium silicate asbestos filler is used to plug the collector bar window outside of the shell. If there are seams between the baffle plate of collector bar and the inner wall of shell, then the sodium silicate asbestos filler shall also be used to plug these seams.

g. Cathode assembly upper surface shall be even levelled and the standard level of finished upper surface shall be maintained at 552±3mm below the top face of pot shell.

12. Masonry around Cathode Block and Castable Built

a. On top of DBM and near the collector bar windows, three layers of insulation bricks (longitude brick between bars) and castable shall be laid.

b. Insulation bricks shall be laid tightly with joint mortar (all: side, top, bottom joint). Each joint shall be less than 2mm.Bricks could be cut by cutting machine to adopt the space.

c. Adding water mixing and stirring test shall be done before building. The quality of the water required for building castable is particularly the key to the quality and performance of the material. Drinking water must be used, and the water temperature should be maintained at 4-27°C , and the amount of water must be controlled less than 10% strictly. In order to achieve the proper consistency, the amount of water added should be measured strictly and carefully as required. Too much water will reduce the strength of the castable. Less water will increase the difficulty of the construction, and lead the delamination phenomenon.

d. The mixing time of the castable is 1.5 to 2.5 minutes normally, but no more than 5 minutes.

e. After the end of the mixing, the castable should be built immediately. Different castable type has different interval time from adding water to building castable.

f. The castable shall be dumped into the mold slowly, make sure the remote and narrow area such as corner, bottom and the side of the mold is all filled with castable. At the same time, the mixing and vibration must be start rapidly to remove the bubbles in the castable and achieve the best density.

g. The plastic films are used to cover the castable, and the castable shall be allowed to dry no less than 48 hours.

h. The horizontal tilt of the upper surface of the castable is no more than 5 mm, and the smoothness of the upper surface is no more than 2mm.

i. Upper surface shall be even levelled and the standard level of finished upper surface shall be maintained at 697±2mm below the top face of pot shell.

13. Side Composite Block Masonry

a. The side composite block is consists of SiC wall block and profiled carbon block,

b. Before building, clean the filth on the pot shell and slurry on the surface of surrounding bricks, pre-polish both sides of SiC wall blocks and profiled carbon blocks prepared for building.

c. Wet masonry shall be adopted for side composite block, and the joint mortar shall be provided together with the side composite blocks.

d. Building shall be carried out from corner, and the vertical joint shall be less than 1.5 mm, longitude joint shall be less than 2 mm.

e. The adjustable carbon block is used to adjust the building.

f. Masonry and adjusting blocks shall be knocked by wooden hammer, and the metal hammer is not allowed to use to avoid damage of side composite blocks.

14. Tamping Carbon Paste

a. Tamping vertical seam

1) The production date of the paste shall be checked before tamping, to ensure that the paste in the warranty period.

2) The cathode blocks seam shall be cleaned by compressed air before tamping.

3) Tamping paste temperature is maintained at 15 to 45℃.The lining temperature before tamping is controlled at 15 to 45℃.

4) No spraying bitumen of coal tar when tamping.

5) Feed the paste by amount, and scrapped by the sample plate, and then carry out the tamping work not less than two circles, the vertical seam shall be finished for 8 times, the air pressure of operating point shall not less than 0.65 MPa.

b. Tamping surrounding seam

1) Claw hammer should be used when tamping surrounding seam. Then the flat hammer should be used in the final treatment to smooth the paste.

2) The surrounding seam shall be finished for 7 times. The first five layers are tamped horizontally, and the fifth and sixth layer are tamped in a slope way.

3) The air pressure of working point shall not lower than 0.65 MPa, and the compressed ratio shall not less than 1.60:1.

4) The surface shall be smooth and even, without pitting.

c. Tamping material under deck plate

After the surrounding paste finished, according to the lining drawing, the material under deck plate which thickness is 30 mm shall be tamped between the upper surface of the side block and the deck plate

15. Erection and Alignment Superstructure

a. Check all modification of super structure before transport to pot room area.
b. Check and measure data of modifications then transport Superstructure to pot room area.
c. Lifting super structure at pot room by crane and put at correct position with connection leg Superstructure with rail point at pot shell area.
d. Fit position of the sockets of anode flexible bus bar and rising bus bar while adjusting of the legs of superstructure and guide pins.
e. Pull out the guide pins, and insert the insulator and set bolts by slightly tightening.
f. Adjust and put the bolts to the holes with the sockets of the anode flexible bus bar and rising bus bar together and then tighten them slightly with impact wrench. Take out the lifting device and the original anode flexible supporting frame.
g. Align and lock superstructure on correct positions.
h. Install equipment at superstructure on pot room and constant volume feeder.
i. Check the agility Installation of crust breaking cylinder and hammer then continue installation of compressed air piping for pots.

16. Installation of Grating

a. After superstructure finish, reinstall grating around pot
b. Modify grating 2 points hole with size (300 mm x 300 mm) for point of new flexible strip busbar, two points each pot.

17. Installation Fume Duct at Superstructure

a. Install fume duct to complete at super structure works by lifting to the position and joint connection fume duct by bolt.
b. Tighten bolt connection fume duct, to anticipate leakages.

18. Air Pipelines Installations

a. Connection air pipeline from existing compress air to pipeline inside the superstructure.
b. Install pipeline and connection to solenoid box to pipeline cylinder.
c. Connection main pipeline to cylinder by high pressure hose.
d. Check every joint and valve before install cover of superstructure.

Construction schedule for implementing upgrading 3 (three) pot shell work can be completed within 124 days from mobilization and preparation up to completion and running tests. Modification and installation of busbar was taken 94 days, modification and installation of superstructure was taken 57 days, modification and installation of pot shell was taken 16 days, modifications and installation of pot lining was taken 49 days, while finishing and test running / commissioning was taken 8 days.

CONCLUSION

During commissioning and trial period after modification construction works is completed, it brings result that electrical power consumption is lower and production is higher than before modifications. Breakdowns are as follows;

	Description per pot	before modification	After Modification	% Increase
1.	Incoming current	193 kA	235 kA	21.7%
2.	Productivity (*)	850 – 950 kg	1.3 – 1.4 ton	14.7 – 15.3%

Note (*): Productivity every 2 x 24 hours smelting aluminium.

From the result of the reduction cells upgrading pilot project, PT. Inalum will continue to modify all remaining cells pots. PT. Inalum in Kuala Tanjung has 510 pots (3 potlines x 170 pots). With this all modifications of pots, they expect to reach annual production of aluminium with total 300,000 ton per year with lower electrical power consumption.

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