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SWOT PERSPECTIVES OF MIDAGE PREBAKED ALUMINIUM SMELTER

(Case studies of State run Smelter of National Aluminium Company Limited, Orissa, India)

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Abstract

Aluminium smelters in nineties witnessed radical changes in technology of electrolysis, carbon manufacturing and casting. The pace of transformation in aluminium industries posed different challenges specifically to the mid-age smelters operating with relatively lower amperage. Enduring needs to match the demands of evolving technology, socio-cultural and environment issues forced mid-age Smelters to adopt appropriate strategies as long-term business imperatives. With structured approach, the threat perception could be turned into vast opportunities of innovation and improvements. Energy conservation, waste management, recycling, emissions control and customer orientation remained specific focus areas to enhance productivity and retain profitability in the backdrop of global economic recession. Process optimization and system upgradation through customised solutions, motivating and retaining high employee morale became the order of the day. The paper is a case study on the sustainable achievements of the state owned Indian aluminium major, NALCO, through well-coined strategies and pragmatic investment.

Introduction

The innovation in bauxite refining by "atmospheric digestion" revolutionized the era of alumina extraction from lateritic bauxite. India constituting 7.5 % of global bauxite deposit has most of its reserve in "Eastern Ghat" region. The government of India fully aware of the market potential formed "National Aluminium Company" with an initial thrust on mineral exploration and self-sufficiency of aluminium in the subcontinent. The company, which was formed in 1981 with adaptation of contemporary "state of art AP-18 technology", surged to production in 1987.

The Company within a short spell had the enviable track record of exporting its product worldwide and has the distinction of being among the cheapest producers in the world. Company's core strength lay in its technological superiority, green field project from mining to power generation & smelting, and the elite work force in the average age group of 25-30 in the beginning years.

NALCO Smelter plant located at around 150 km away from Bhubaneswar, capital city of Orissa started production in 1987 with two pot lines of 240 pots each operated at approximately 180 kA for production of around 220, 000 MT of aluminium per year.

In 2003, a third pot line was added with 240 pots of AP 18 technology. Production capacity enhanced to 345,000 MT of aluminium per year after commissioning of the third pot line operating at 183 kA. Additional capacity was built in anode paste plant and cast house for supporting another pot line of 240 pots.

In 2009, a fourth pot line was added with 240 pots of AP 18 technology. Production capacity increased to 460,000 MT of aluminium per year after commissioning of the fourth pot line operating at 184 kA. Figure-1 shows the gradual increase in production capacity achieved during last decade.

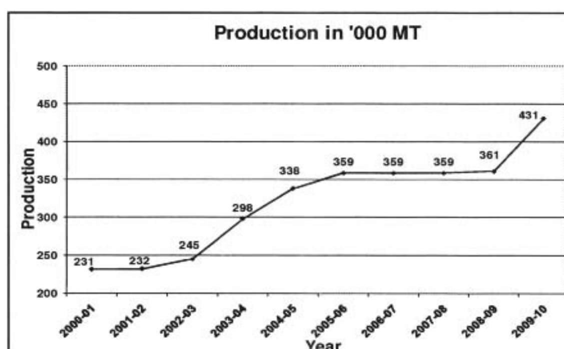

Figure 1

Every smelter is unique in its characteristics considering technology deployed, operating environment, processes adopted and number of years in operation. The NALCO smelter plant on its 25+ years of operation is in the middle of the life cycle.

The strength, weakness, opportunity and threat of a mid age smelter is a complex business model with its diversified dimensions of risk and opportunity. While the organization has the advantages of knowledge and experience as its capital, the challenges of technological obsolescence, radical changes in the market, and reforms in the statutory & regulatory requirements are major bottlenecks in maintaining the pace of growth of the smelter. Therefore, the constraints posed by mid-age smelter offer tremendous opportunities as well as introspection to improve processes and bottom-line of the company.

Smelters experience a series of challenges as they mature through the learning curve. The degree of such challenges led series of improvements, changes, innovations in every facet of smelting operation in NALCO. The distinctive changes in potlines that include operating at higher anode changing shift cycle, alumina feeding to pots, improvement in pot-lining, thermal equilibrium of pots, treatment of gases based on fluorine emission models, migration to higher kA and improved pot regulation made enormous impact to the smelter's operational efficiency. The improvements achieved in the aluminum fluoride consumption, reduction in net carbon consumption, significant improvement in pot life bears the testimony of the success through better process management.

Diversification, capacity augmentation and quality improvements in raw materials for carbon plant, standardization of sources, upgradation in mixer, screens, vibro-compaction in green anode manufacturing, changes of heating & regulation in anode baking, de-bottlenecking in rodding shop contributed significantly to the consistency in quality of anodes for potlines. The structured approach adopted for improvement in the green and baked anode quality through selection of sources, changes in the granulometry, improvement in kneading & vibro-compaction led to appreciable reduction in net carbon consumption.

A commendable alignment with customer focus through innovative casting and downstream facilities, mechanization and technological improvements adapted in furnaces, wire rod mills, ingot casting, and addition of new product portfolios created competitive advantages in terms of cost and product quality. The capacity addition in strip casting, air slip billets, rolled product added company's new market segment in the areas of down streams.

Critical strategies in the areas of energy conservation through implementation of Clean Development Mechanism (CDM project), selection of energy efficient drives, improving current efficiency in potlines, lowering specific consumption, waste management, emissions control, and water resource management provided the much needed impetus to statutory and regulatory requirements. Creative & innovative pursuits like quality circles, small group activities, quality improvement projects, extensive in-house training addressed the core issues of retaining a high employee's motivation and morale.

NALCO has always been a trend setter for Indian Aluminium industry in caring for the community. Much before the word CSR was coined, NALCO has adopted many community projects like building roads and schools, providing drinking water and medical facilities in the surrounding villages matching the highest standards of corporate citizenship. Specific focus on CSR through peripheral developments brought in confidence of the society that helped the organization to excel.

NALCO smelter invested substantially to protect the environment by continuously upgrading the bag houses, dry scrubbing units, floor cleaning units and fume treatment centers. Like any other mid age smelter, NALCO had to address the gargantuan issue of disposal of SPL (Spent potlining) material. The solution adopted was engineered landfill and exploring the possibility of using the carbon portion with high calorific value as fuel and the refractory material as a raw material for cement industry. However, disposal of SPL still remains a challenge for NALCO as much for other smelters.

Strategy followed by NALCO smelter during last decade was not only to sustain the production capacity but also to gradually increase it. This could be accomplished by converting the threat perception during global recession to challenges and resultant opportunities for growth. Increase in production capacity was achieved through continuous process evaluation, control of process inputs, and up-grading of processes and equipment etc. At present amperage increase programme has been initiated in existing smelter to migrate from 185kA to 220kA or more. Complete migration will take around 6 to 7 years and addition of 110,000 MT/Year of aluminium production capacity shall be achieved through a seamless migration.

1. Carbon Plant

Right from the inception, anode quality was a major constraint in pot line operation. Variation in anode density was the major issue along with high rate of rejection after baking. Physical & Chemical properties of anode were also not consistent resulting in high consumption of net carbon. Variation of anode density was addressed by improving the quality of coke and pitch used for anode. Use of liquid coal tar pitch, introduction of mesophase parameters and improvement of the process at the source by the Smelter quality group improved significantly the quality of Liquid pitch. Similarly, through the bench scale and plant scale trial, source of the coke as well as the granulometry was established to meet the requirements of desired physical and chemical properties. The experimentation on raw materials blending and segregation of sources of supply established the consistency in quality parameters.

Green anode plant equipment of coke fractionating circuit were upgraded to maintain consistency of coke fractions. All mechanical screens were replaced with electro-mechanical screen to have control over the screening efficiency and output. Speed variation in proportioning circuit equipments was controlled by installing variable voltage variable frequency drives to minimize the effect of grid frequency variations. Controllers of the proportioning circuit were replaced to improve regulation of the proportioning system. For accurate fines regulation in the dry mix, a weigh hopper was installed replacing the twin hoppers. A mass flow meter was installed replacing twin weigh balloons to improve accuracy of pitch regulation. Control and automation equipment of the green anode plant was replaced with new generation automation equipment with advanced user interface. Mixing tools of the paste mixer were regularly replaced to maintain mixing quality. Mechanical suspensions of old vibro compactor were replaced by pneumatic suspensions for smooth compaction. Spray nozzles were replaced in anode cooling tunnel to increase water flow and a water filter was installed to improve recycling efficiency and reduce nozzle choking.

Heat regulating system of baking furnace was replaced to up grade the system for better control of the anode baking process. After installation of the new system level of baking could be effectively monitored and consistency in baked anode quality could be ensured. Twelve more sections were added to increase the number of sections from 72 to 84 in old baking furnace. Time Lag created between two consecutive fires in four fire configuration was effectively utilised for cooling of anodes and better refractory maintenance of the furnace considering higher ambient temperature. With all these modifications substantial improvement in anode quality were achieved that led to reduction in net carbon consumption (see figure-2). At the Rodding shop, large scale modifications in the stacking crane, chain conveyor, casting zone, anode extractor, hooking & unhooking were carried out to improve the reliability of the plant. Apart from this, the bimetallic clad was replaced with trimetallic titanium clad to reduce the voltage drop.

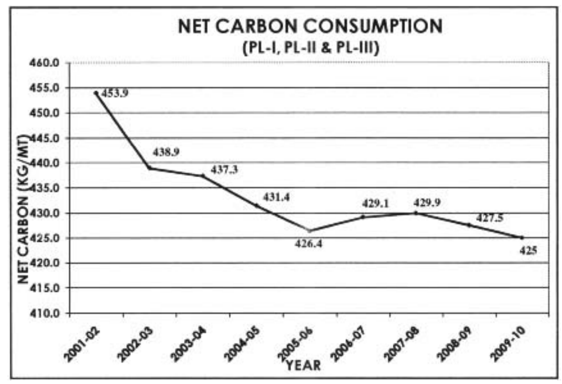

Figure 2

2. Reduction Area

To reduce the cell voltage drop, the first generation alteration was introduced with replacement of anthracite cathode blocks to semi graphite cathode blocks. NALCO smelter replaced all the cells having anthracite blocks to semi graphite blocks by the year 2002. Thus NALCO was able to reduce its energy consumption by reducing the cell voltage.

Further to reduce the cell voltage and to obtain better process parameters NALCO smelter has upgraded its first generation pot regulation system from pot microcomputer to advanced HMI pot regulating and feeding system. The advanced regulation system helped the operating personnel to ensure effective decision making and better work organization. The distinctive feature of the new regulation system [2] encompassing "thermal balance control", "alumina feed rate", "measurement of pot resistance & rate of change of resistance" led to reduction in energy consumption and significantly improved the process and health of the pots.

Based on the knowledge based information and trouble shooting guide, standard work practices

(SOP) were dynamically changed to suit the operational needs. Large scale revamping was carried out in critical pot equipment like PTMs to enhance the overall equipment effectiveness and reliability. The major modifications included replacement of the vane compressor, introduction of VFD in LT & hoist drives, metal siphoning system, and alumina feeding system. To improve the competence of the working personnel, regular interaction classes at the shop floor were organized and mentoring was initiated to guide newly recruited. This resulted in better understanding of the pot parameters by the operating personnel and they could assess the consequential impact on processes and metal quality. The consolidated approaches led to substantial reduction [1] in number of A.E./day/pot (See figure-3), decrease in average noise level/day which leads to reduction in average cell voltage and better C.E (*Current Efficiency)* (See figure-4). All the above improvement contributed substantially to abatement of GHG emissions.

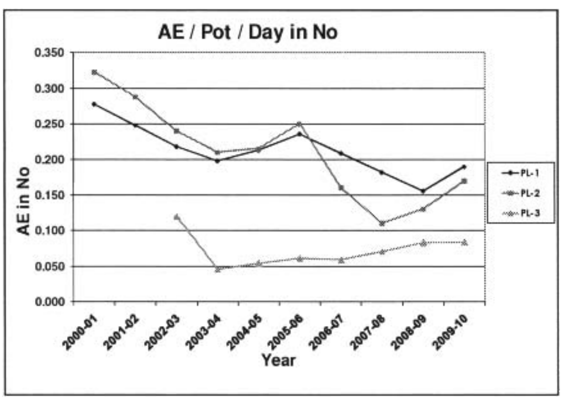

Figure 3

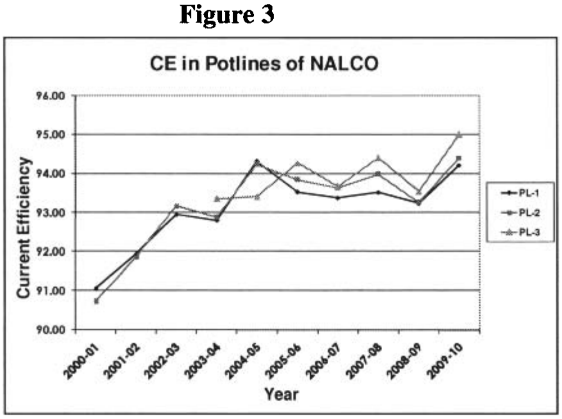

Figure 4

To maintain the thermal balance of the pot, the following activities were carried out:

- The bath composition was monitored closely, mainly the percentage of excess AlF_3 in the pot.
- The regular cleaning of the cathode clad was introduced in the SOP as a lot of crushed bath and alumina covers the cathode clad and the pot shell which obstructs the heat flow from the pot shell/clad to the ambient atmosphere resulting in thermal imbalance.
- The pot ventilation grills were regularly cleaned to facilitate heat dissipation.

In-house design modification carried out in stem brushing machine at Rodding shop improved the stem surface cleaning of any types of stems therefore ensuring better contact and reduction in cell voltage drop. Proper cleaning of stem surface reduced the contact voltage drop. To decrease the contact drop further between anode and pot beam, older clamps were replaced with better clamps which helped in reducing the contact drop. It also helped to decrease the noise level of the pots as well as helped in reducing the number of clad fails in pot line. Regular greasing of the clamps was introduced in the SOP which led to fewer numbers of clad fails, which ultimately resulted in reduction of average cell voltage. (See figure-5)

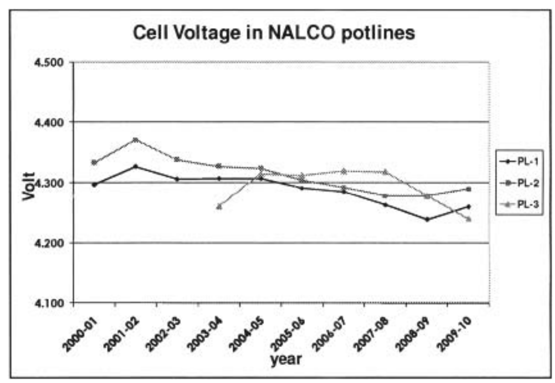

Figure 5

To avoid inadvertent tapping of metal during bath correction, a transfer launder was introduced to recharge the metal in to pots. This also helped in improving the current efficiency. Apart from the continual improvement programme, further improvement in the areas of stub length & diameter increase, graphitisation of cathode blocks, introduction of anode slotting machines are being pursued to improve the energy efficiency of the system.

3. Power Crisis

Aluminium smelter being power intensive, the requirement of large sustainable power source is primary requisite for its survival. Despite the availability of a captive power supply system, the smelter in the recent times has been facing the problems of power interruptions. The power plant is dependent on coal supply which is controlled by the Government owned mines. To cope up with fluctuation of power, operating the pots in lower amperage as well as switching in to higher amperage as and when power is available has become part of the improvised process.

For a smelter to increase its production capacity the most critical issue is availability of required input power. Enhancement of power generation capacity becomes imperative for smelters having own captive power plant. NALCO smelter expansion was carried out in stages matching with enhancement of power generation capacity. However, with increase in generation capacity coal supply became unstable. Hence the power generation could not be ensured to maintain a consistent level of power supply to smelter. The trade off was between reducing number of pots by shutting down running pots or sustaining operating pots at lower amperage. Both the options were tough considering the requirement of meeting annual production target, maintaining pot parameters, minimizing effect on pot life, etc. NALCO Smelter preferred the second option to retain all the pots and reduce pot amperage. The experienced pot line operation group worked hard to set parameters for operating pots at amperage less than 175 kA and even to sustain the pots for a considerable long period of time at the lowered amperage of 160 KA. Problems related to power outage and amperage reduction like increase in instability of pots, disturbed bath chemistry, disturbed thermal regulation, fluctuating bath temperature, dusting of carbon, increased cathode voltage drop, increase in set point resistance were successfully addressed. Consistent operation of pot lines yielded optimum production quantity and smelter could add number of pots matching to increase in power generation capacity.

4. Limitation of infrastructure

Ageing infrastructure like rectifier groups of substation, alumina transportation / unloading and storage facility, coke / pitch handling and storage facility, HFO unloading & storage facility, coal handling and transportation system of captive power plant, ash disposal system were the areas of concern to sustain the smelter operation.

NALCO installed an additional rectifier group to strengthen the substation and planned overhaul of all the transformers to extend the reliability of the existing facility. Overhauling of twelve transformers completed in the year 2009-10 without affecting the potline operation although the substation witnessed failure of one half of a rectifier group during the year. With the experience of installing one swing rectifier group the substation engineers are planning for installation of additional two rectifier groups within the same substation area for supporting 220 KA up gradation program,

Alumina is transported by railway network to NALCO smelter located at around 700 km away from the alumina refinery. Railway rakes are unloaded at smelter end by using air slides to belt conveyors and the alumina silos are fed trough the belt conveyors. To establish reliability of alumina supply to the pot line alumina unloading and transport system are being augmented by installation of another unloading and transportation system.

Coke storage facility was enhanced by addition of one coke silo of 6,000MT capacity. Coke handling facility was retrofitted to facilitate feeding to the new silo and extraction from the new silo. However, the coke unloading and feeding system needs to be mechanized to enhance efficiency of the system. With expansion of the plant, liquid pitch storage facility was augmented by two new storage tanks of 300 MT capacity each. However, consistent pitch supply could not be maintained due to distant location of the liquid pitch suppliers. To ensure reliability of liquid pitch supply to the green anode plants two additional pitch tanks of 300 MT capacity each were constructed with in house engineering. The new unloading and storage facility is designed with complete automation for quick unloading of road tankers and ensure interconnectivity with all the existing pitch storage tanks to facilitate reliable supply of liquid pitch to both the green anode plants. NALCO uses heavy furnace oil (HFO) for its melting & holding furnaces and baking furnaces. Smelter is planning to augment its HFO handling facility to accommodate larger railway tankers for unloading and storage.

Matching with the expansion of smelter the generation capacity of the captive power plant was enhanced. Coal supply became a constraint as NALCO was receiving major portion of coal from state owned mines. The coal supply was augmented by introducing washed coal and imported coal. However, to find a long term solution NALCO ventured into coal mining activity. One coal block is under development to start coal mining in full swing.

Ash disposal is another area of concern for most of the thermal power plants. NALCO is the pioneer in implementing zero discharge technology for ash disposal among the power plants in India. Ash disposal system shall further be augmented by establishing lean slurry disposal system to fill up coal mine empty pits.

5. Addressing Meltdown in LME Price:

Metal price was never considered as a threat for operation of NALCO smelter as the company has been extremely doing well in its financial performance from the first year of operation. From inception, NALCO maintained a robust financial performance due to its core strength of integrated operation from bauxite mining to export of aluminum metal through its captive sea port. The company ensured a dividend payment of more than 40% for all the years since 2000-01 and the dividend payment was as high as 75% in the year 2006-07. Financial performance in terms of net profit as % of sales turnover of the company is presented below for reference. (See figure-6)

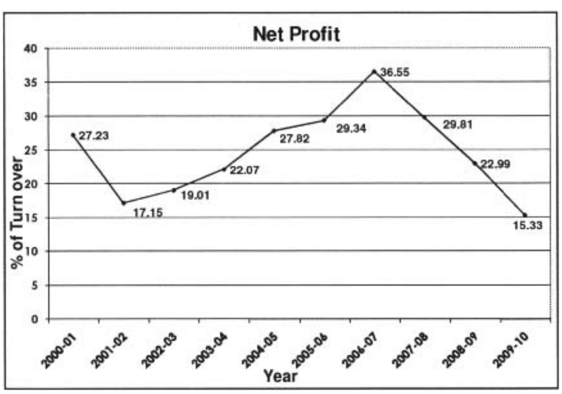

Figure 6

NALCO started experiencing the effect of economic recession in third quarter of 2008-09. Smelter operation was caught between falling market price and increasing production cost. The temptation to limit number of pots in operation was also very high looking at the fluctuation in power generation capacity. It was a Catch 22 situation whether to close down some of the operating pots to reduce projected losses considering falling LME price or to avail the opportunity of adding 120 new pots under expansion for future output growth. When few of the Smelters worldwide were closing down entire potlines even Smelting operation, NALCO decided to commission the new pots and increase the production capacity to 460,000 MT, spurred by relatively low cost of production. Rigorous cost reduction measures in the areas of specific consumption of input materials including power and fuel, optimization of furnace operation, operating at higher anode changing shift cycles, recycling of waste, management of scrap generation and disposal paid off the company's risk of operating higher numbers of pots.

Thrust areas were identified considering all controllable factors contributing to cost of production. Action plans were prepared and implemented in each identified area. As a result, the year 2009-10 witnessed the lowest specific consumption of major raw materials including specific power consumption. NALCO could maintain profitability due to increase in production volume although margin of profit reduced due to fall in market price.

Conclusion

Aluminium industry in India is entering into a volatile phase with most of the producers adding new smelters to buildup production capacity. Although falling aluminum price in the year 2009-10 affected the in swing projects, the new smelters will start production within a couple of years. To remain competitive and retain its market share, NALCO is pursuing both brown field and green field expansion plans. The company is also aiming to be an independent power producer by 2015. This would definitely provide competitive advantage for the smelting operation.

The mid age Smelter poses diversified challenges and constraints that open up new horizon of opportunities to excel. A holistic and structured approach in every facet of business dimension is needed to overcome the challenges and threat and bring in parity with new smelters equipped with high end technology & resources. The AP-18 smelter in Nalco is a paragon of case study describing the gradual journey of transformation accomplished over a period of one and half decades.

References

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