AL06 - Production of Premium Grade P0404 Metal at Mahan Aluminium

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Abstract

Customers consistently demand high purity metal and Mahan Aluminium (MH), a unit of Hindalco Industries Limited and a part of Aditya Birla Group (ABG), took this as a challenge to produce high purity metal beyond the regular grades & established itself as a quality conscious unit. Mahan metal is categorized as equivalent to "Good Western Metal" by some of our major customers. For production of high purity metal to meet customer's demand, the chemical composition is the major attribute that controls the product quality and adds extra value to the aluminium production. Raw materials, cell process and regular operational works play important role in the production of high metal grade. To compete in the global market as a preferred supplier of metal, good product quality, consistent metal purity, new product development, good packaging, and timely delivery were essential perquisites. To achieve this high metal grade production, a cross functional team was formed and they worked in coordination with various departments. Mahan products have reformed the views of Global customers for Indian Aluminium by continuous quality improvements in all products. Our new initiative "Make in India" for manufacturing of Aerospace and Defense products encouraged us to foray into this premium segment. These segments are currently dominated by West & Middle East smelters. With continuous product quality upgrades, we have an opportunity to enter this segment and be a partner in nation building.

Mahan team took this challenge as an opportunity in the form of new product development & production of P0404 grade sows and ingots. The methodology adopted for achieving this goal consists on understanding of customer requirements, analysis of factors affecting hot metal purity, brainstorming, raw material selection & blending to produce high purity anodes. Dedicated pots to produce P0404 grade metal, shuttle planning, process improvements, monitoring and feedback enabled us to consistently produce P0404 as well as and even a higher purity grade, namely, P0303. This new product has enhanced our product portfolio and meet our clients' expectations while showing the world that Mahan has the capability to produce high premium grade metal on a consistent basis.

Keywords: Metal Purity, Premium Grade Metal, P0404, Mahan Aluminium, Hot Metal Purity.

1. Introduction

Mahan Aluminium is an integrated aluminium smelting complex which uses globally proven smelter technology AP36 from Pechiney, France, while its integrated carbon plant uses technology from Solios and the captive power plant uses BHEL technology for each of its 6*150MW units. Both smelter and CPP commenced operation in April 2013 and reached full

capacity in Aug-2015. The Plant was commissioned in a record time of 27 months, a benchmark time for Greenfield project execution in India. Mahan Aluminium is an ISO 9001, 14001, 45001 & 50001 certified unit & its primary products are LME registered. Within a short time, Mahan has established itself as the preferred choice of the world's leading customers of primary aluminium. Over 40 per cent of total production is exported to various countries such as USA, Japan, Korea, Mexico, Israel and others.

Delivering high quality grade metal has been the primary goal of Mahan Aluminium smelter, which has a direct impact on the customers and at large the face value of the organization. The P0404 metal grade comprises elemental impurities such as silica < 400 ppm and iron < 400 ppm. The source of Si and Fe in metal is primarily from raw materials like alumina, anode, cover mix, AlF_3, etc.

Figure 1 shows that while Mahan was continuously producing high purity metal, it kept on adding new grade products in its portfolio.

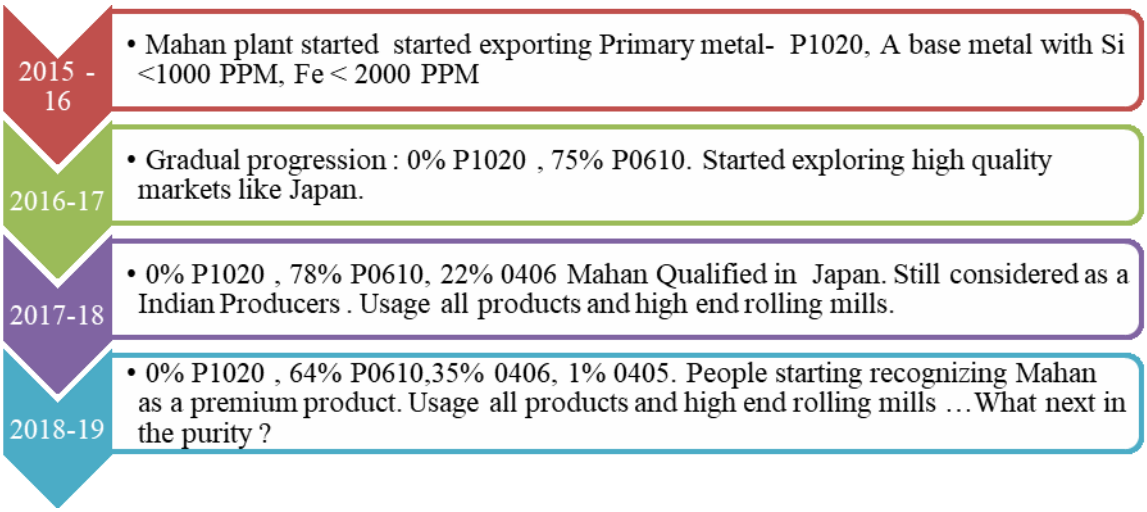

Figure 1. Evolution of metal purity at Mahan Aluminium.

Demands from customers were coming through marketing on capability to produce P0404. Since this metal grade is used in aerospace & defense equipment, this gave us an opportunity to enter into premium market and take Hindalco Mahan into new horizons as no other plant in India was producing P0404 premium grade metal and so Mahan took up this challenge to enter into league of premium metal producers.

Table 1. Chemical composition of different metal grades.

Nomenclature	
P0404	Al- above 99.85 %, Si- 0.04 % max and Fe 0.04 % max
P0405	Al- above 99.85 %, Si- 0.04 % max and Fe 0.05 % max
P0406	Al- above 99.85 %, Si- 0.05 % max and Fe 0.06 % max
P0610	Al- above 99.85 %, Si- 0.06 % max and Fe 0.10 % max
P1020	Al- above 99.70 %, Si- 0.10 % max and Fe 0.20 % max

2. Challenges

The following challenges were faced while improving metal purity:

- Alumina received from two different suppliers, namely, Utkal and Muri:

    - Two different supplier means different chemical composition of alumina and managing these two different chemical compositions posed a major challenge;
- Multiple grades of coke:
    - Mahan is getting two types of coke, namely, high sulfur (high vanadium) & low sulfur (low vanadium) from different suppliers in an 80:20 ratio;
- Pot relining:
    - Relining of second-generation pots began in April 2017, which also impacts metal purity of pot line. As newly started pots were having very high silica which needs to be diluted by blending with other high purity metal;
- Dilution of high Fe metal:
    - High Fe metal needs to be diluted by high purity metal to meet the required metal purity standards;
- Equipment availability:
    - Breakdowns in potroom, cast house cranes or sow casting line affects P0404 metal production.

3. Execution Methodology

Mahan realized that a proper methodology must be adopted for production of P0404 on a consistent basis, which is briefly described below:

- Understanding customer & their requirements:
    - P0404 grade is mainly used in Aerospace & Defense applications, where minor elements like Na, V etc. impacts the process;
- Gap analysis and scope of improvement with respect to customer's requirements;
- Analysis of factors affecting hot metal purity, raw material quality assessment of coke, alumina and hot metal;
- Raw material selection & blending to produce high purity anodes;
- Brainstorming;
- Dedicated pots to produce P0404 grade metal;
- Shuttle planning;
- Strategy development and process improvements at anode, hot metal and casting stages;
- Process capability, process improvements, monitoring and feedback;
- Qualification and sustenance.

4. Actions Initiated at Various Levels

The following sections briefly describe the different initiatives undertaken on different fronts in order to improve metal purity.

5. Alumina Handling System and Bath Recycling System

- Silo categorization to produce metal based on Utkal and Muri alumina:
    - A silo categorization of two different type of alumina received was implemented. Both Utkal and Muri alumina specifications were studied and dedicated groups of pots were defined based on age and other parameters for focused quality metal production;
- Increased focus during unloading of raw materials & proper housekeeping of area to avoid floor contamination and control on Si:
    - Proper housekeeping and 5S implemented in alumina handling shops and increased focus of unloading of raw materials to avoid any contamination and to

control silica levels. Methodology for pre-sampling and then blending of bath from various sources were implemented (refer Figures 2 and 3).

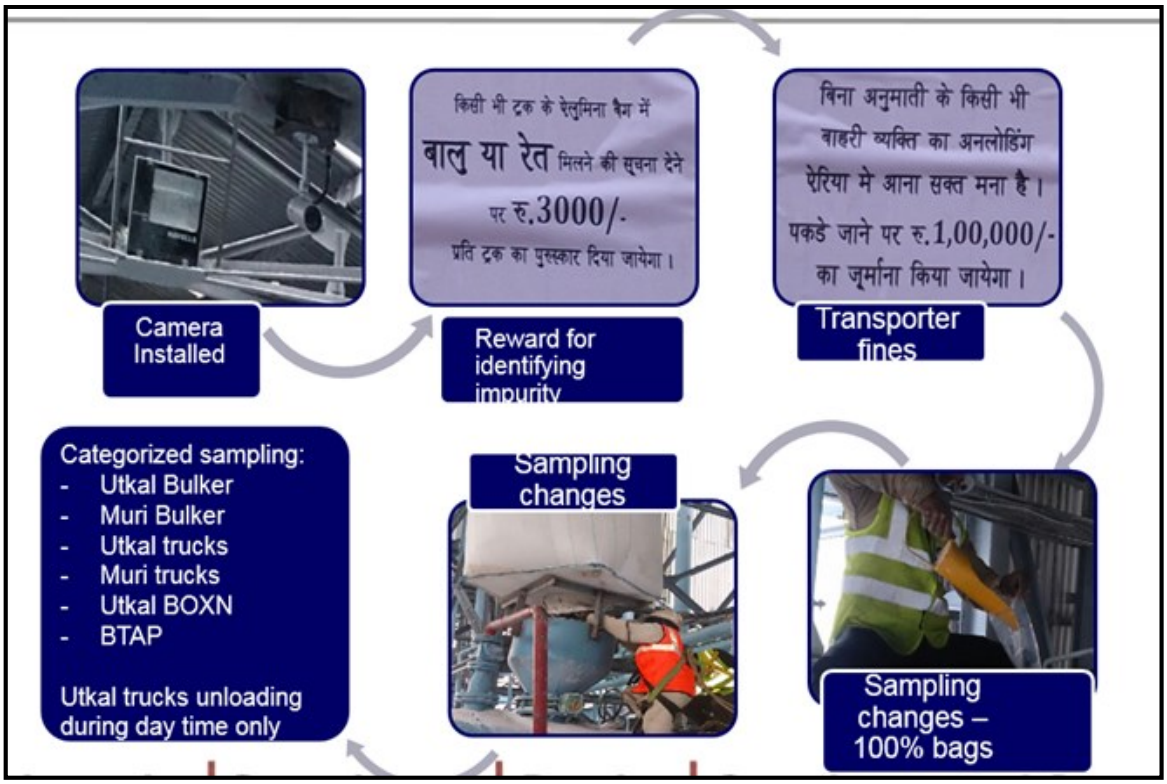

Figure 2. Sampling methodology of incoming materials.

Figure 3. Sampling methodology of in-process materials.

5.1. Potroom

- Changes were made in user interface of ALPSYS pot controller to display and monitor key elements such as Ti, V, Ga & track metal grades on a pot-by-pot basis:

  - Changes were made in that to display and monitor key elements such as Ti, V, and Ga and to track pot wise metal grades;
- Detailed process mapping of each output parameter was formulated:
  - A team of process control engineers along with few technicians were designated to monitor and control raw material quality. Amidst many power troubles and few power outages, said process control team maintained pot thermal balance and improved the pot process to sustain and continuously improve the quality of metal produced.
- Focused covering quality & bath height:
  - Changes were made in the bath tapping logic of ALPSYS to control proper bath heights and increased its follow up after bath tapping. Implemented auditing systems for checking anode covering quality and reporting of abnormalities as soon as possible. In depth checks were performed for those pots to reduce the quality of metal and identified issues were rectified as soon as possible;
- Raw material quality control:
  - A methodology was developed to monitor all incoming raw materials and in-process checks for pot line such as alumina, cover mix and tap hole closing material on a daily basis.
- Dedicated pots for P0404 metal production:
  - 21 pots dedicated for P0404 production. Consistent metal purity (low Fe, Si, V & Na) for continuous production of P0404;
  - Bath height optimization. Bath tapping logic & bath height set point revised. Bath height measurement done every 16 h as opposed to the regular 32 h schedule to minimize any adverse impact of bath heights on metal quality. Note that metal quality checks, on the other hand, were done on regular 32 h cycle.

5.2. Carbon

- Multiple checks were imposed on incoming raw material and in process materials to avoid any adulteration;
- Modifications in operational procedures were made in the carbon plant, such as various check points that were imposed on incoming raw material to avoid any kind of contamination. Periodic scheduled inspections were made to ensure the availability of magnetic separators. Changes in process systems for handling and monitoring the quality of raw materials like coke, butt and green scrap were made. Changes in design and structures were made for improved quality of butt cleaning to reduce iron, silica and sodium in anodes. Furthermore, silo categorization for low and high sulfur calcined petroleum coke to reduce vanadium in baked anode and finally in cold metal via blending.
- Recipe change for anode production:
  - Selection & blending of raw materials (low sulfur coke) for production of high purity anodes. Usage of low sulfur coke to reduce Fe, V in anode. Recipe as shown in below Table 2.

Table 2. Recipe blending table for prediction of elemental impurities in Baked Anodes.

Prediction of Fe, Si, Na & V in metal with respect to different calcined petroleum coke & anode butt recipes	Normal (20.5%) anode butt				With 10% anode butt				Remarks
	Fe	Si	Na	V	Fe	Si	Na	V	
20% low sulfur calcined petroleum coke* blending	549	317	261	233	510	325	238	257	Fe & V not qualified for P0404
100% Brahmaputra high sulfur calcined petroleum coke**	546	312	258	104	507	319	235	101	Fe & V not qualified for P0404
50% Numaligarh low sulfur calcined petroleum coke* + 50% Brahmaputra high sulfur calcined petroleum coke**	527	256	252	91	485	253	228	86	Fe & V not qualified for P0404
100% Numaligarh low sulfur calcined petroleum coke*	509	199	246	84	464	187	220	78	Fe & V qualified for P0404 & lowest impurities in anode to produce premium metal grade

**Low sulfur coke: 90 ppm vanadium & 1% sulfur.*
***High sulfur coke: 350 ppm vanadium & 2-3% sulfur.*

As per predicted scenarios (based on previous data), with 100% Numaligarh calcined petroleum coke & 10% anode butt suited for the production of high-quality anodes. These anodes contain lower Fe (approx. 100 ppm), Si (approx. 120 ppm) & V (almost 130 ppm) which helps to produce P0404 quality metal.

5.3. Cast House

- Focused metal planning & furnace categorization;
- Cast house team diligently studied the quality of metal produced in ingot and sow and designed a blending strategy to achieve the desired quality of metal. Furthermore, an appropriate metal tapping plan was devised, as per in Figure 4.

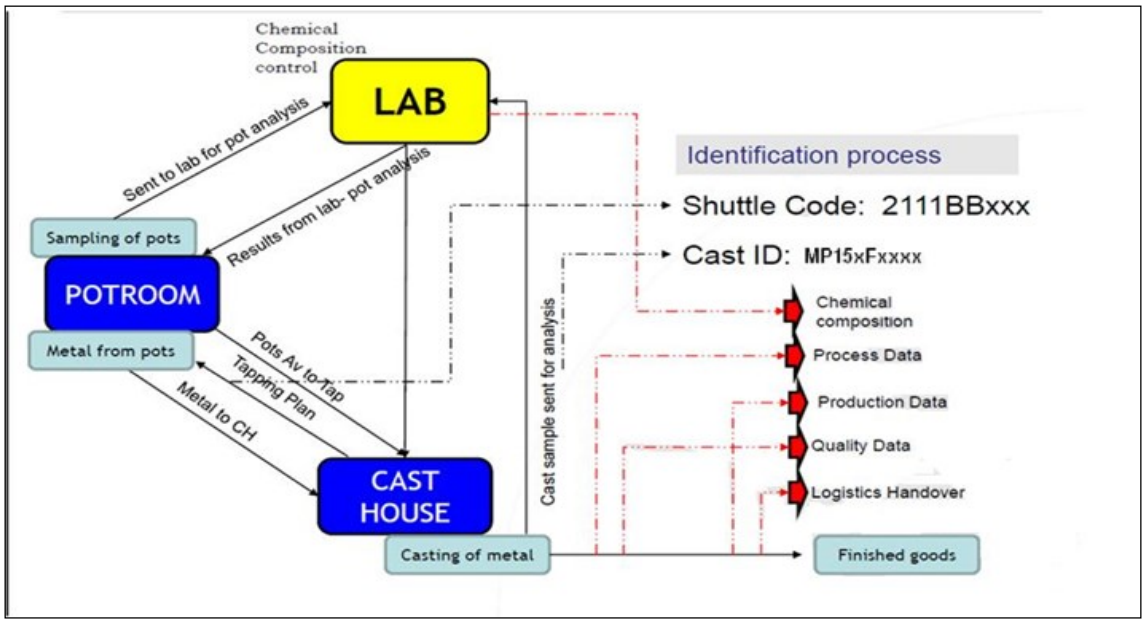

Figure 4. Process flow diagram for metal tracking and reporting system.

- Shuttle Planning:
  - Planning and making of shuttles with Fe (370 ppm), Si (380 ppm and below) for P0404 production;
- Use of statistical tools, Critical to Quality and Critical to Process were identified:
  - Quality control team at cast house identified Critical to Quality and Critical to Process with use of statistical tools. Cast house team blended raw materials and liquid metal to get the correct mix of cost and quality.

5.4. Process Improvements

- Critical parameters identified for P0404 production in carbon, potroom & cast house. Process modified to accommodate dedicated pots in Potroom B, special anode production in carbon and shuttle planning, metal allocation & equipment allocation in cast house.

5.5. Monitoring and Feedback

- Analysis of P0404 pots and failed P0404 casts. Monthly meeting with pot room team on metal quality and delivery. Improvement project started by the carbon plant for special anode for P0404 production – refer to Figures 5 and 6.

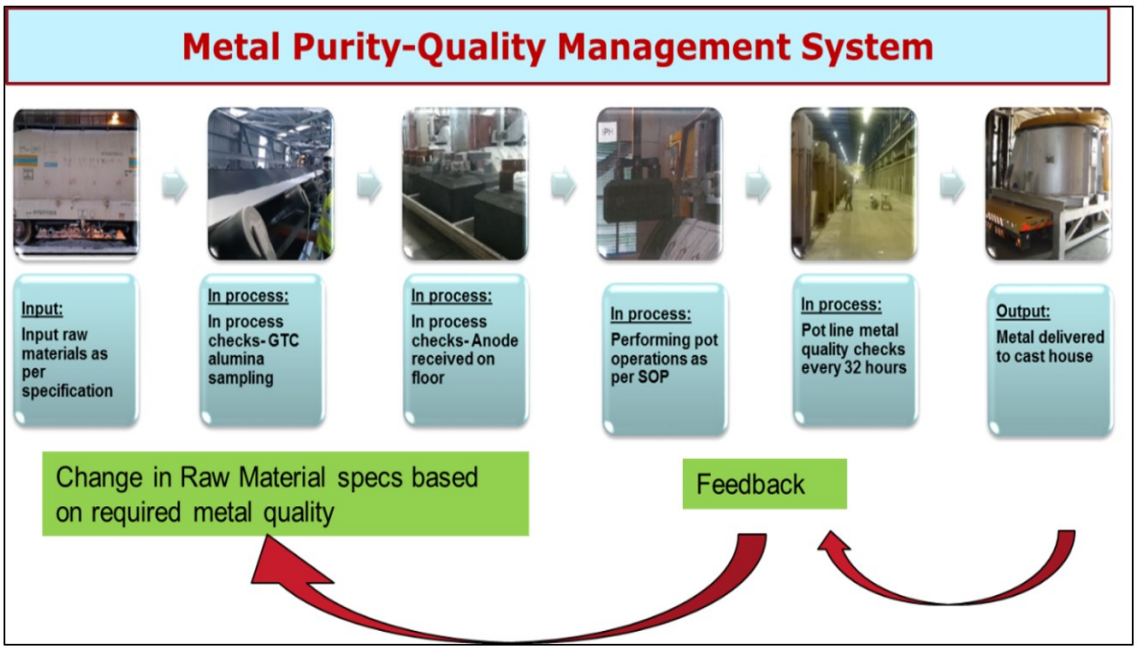

Figure 5. Quality management system.

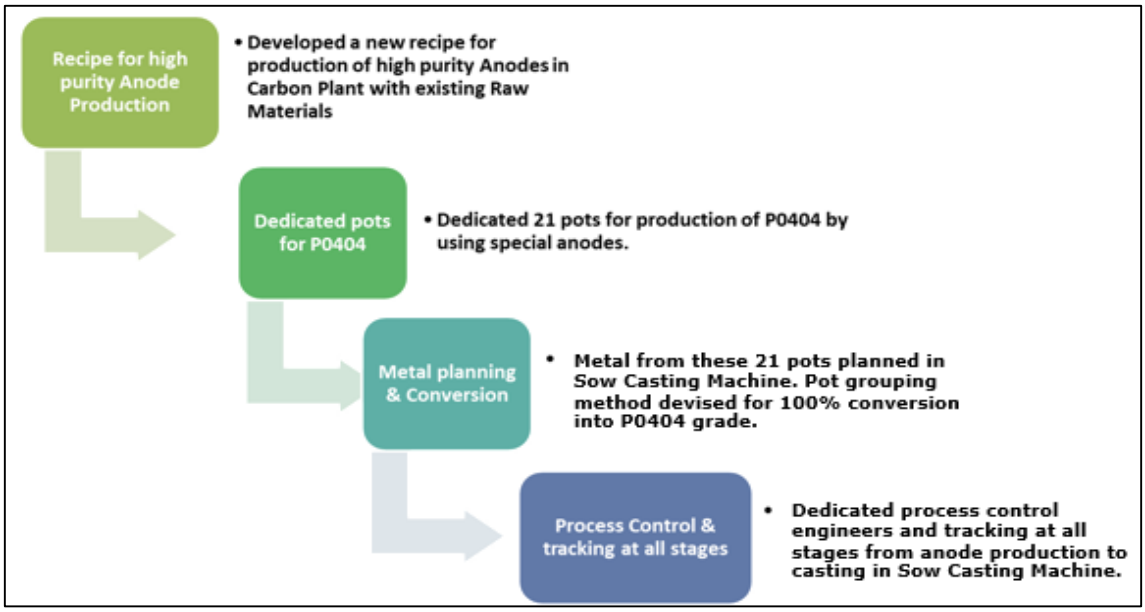

Figure 6. Approach used.

6. Current Status and Deliverables

The above improvements resulted into a consistent production of P0404 while also enabling us to produce the P0303 premium grade, as shown in Figure 7.

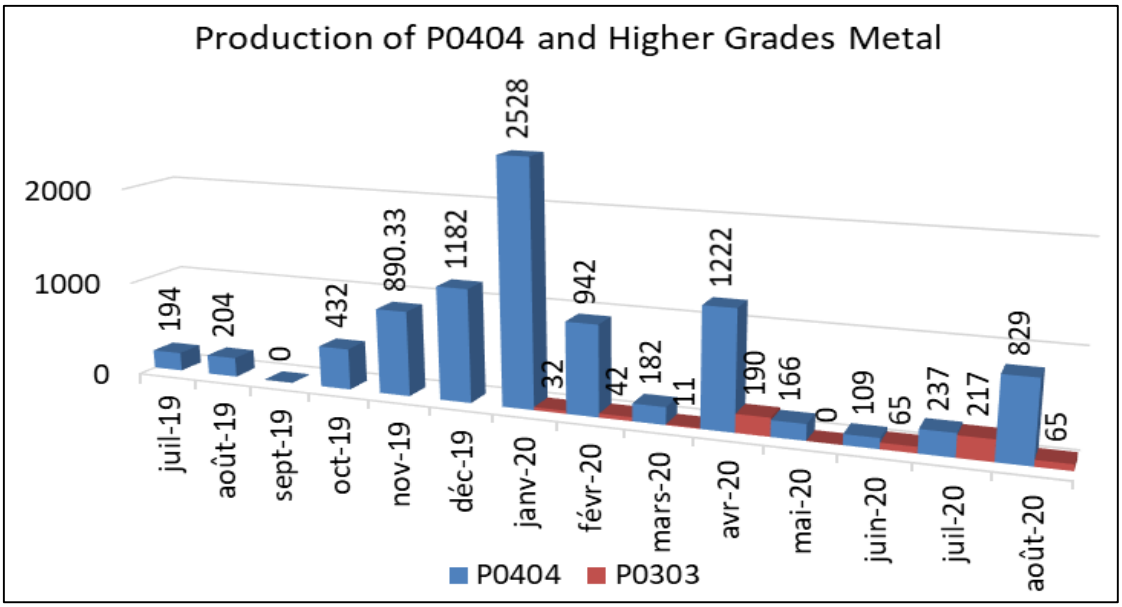

Figure 7. P0404 & P0303 monthly production (tonne).

7. Financial Benefits

The financial benefits of continuing P0404 metal production are shown in Table 3 below.

Table 3. Financial benefits.

From April-2018 to March 2019		
P0404 Production (tonne)	Premium Obtained ($)	Actual Gain ($)
5980.45	70	418,632
Investment or Cost Incurred	NIL	

7.1. Non-Financial Benefits

- Customer satisfaction;
- Product portfolio enhancement;
- Deeper penetration of Hindalco brand in exports market;
- Mahan has entered in the league of premium metal producers in the world;
- Developed first time in India as an import substitute;
- Capability to produce high premium grade metal on a consistent basis;
- Supporting "***Make in India***" initiative by enabling Aerospace and Defense manufacturing.

8. Acknowledgements

We would like to extend our sincere gratitude to the following leaders of Mahan Aluminium: Mr. Ratan Somani (Unit-Head), Mr. Senthil Nath (Head Smelter), and Mr. K. K. Pandey (Head Reduction) who were spearheading this project and made it successful.