

DEVELOPMENT OF TIN METALLURGY IN RWANDA

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<https://doi.org/10.37904/metal.2022.4439>

Abstract

This article presents the history of tin metallurgy in Rwanda, its current state, and future development prospects on the example of the Luna Smelter production plant, located in Kigali. The authors of the article pay special attention to the issues of successful restoration of production, which was stopped in 1994, shortly before the Tutsi Genocide, the impact on the labor market in Kigali, the creation of new commercial and economic ties, as well as the improvement of production lines and the optimization of technological parameters of smelting and refining.

Keywords: Rwanda, tin, metallurgy, smelter

1. LUNA SMELTER LTD. INTRODUCTION

Luna Smelter is a leading tin metal producer located in East Africa, Kigali, the capital city of Rwanda.

Luna is a part of Luma Holding Ltd, a private European Industrial Group focused on the metallurgical, mining, and automotive industries. Rwandan partner and shareholder in the project is Ngali Holding – a state-owned investment Group. The LuNa Smelter's mission is to act as an industry change agent and a diversity trend-setter through ESG-driven investments with a strong focus on traceability, gender equality, and unserved communities' development. Own cassiterite exploration assets, with a fully certified laboratory as well as a modern smelting facility, make LuNa a scalable project with a vertically integrated organization.

Luna Smelter's key product is tin metal. The tin market is set to boom due to strong fundamentals and "tin's bright electric future" – a technology revolution encompassing electrical vehicles, robotics, and the Internet of Things. In addition to a favorable market environment, LuNa has a strong value upside related to the potential coltan business and the sale of tin drosses and other subproducts achieved during the production process. The additional revenue stream is based on the services – laboratory services. The company's focus on quality translates into continuous investment in laboratory equipment, which is then reflected in the steady growth of testing capabilities. Luna Smelter has established a new fully capable laboratory unit, located at the Kigali-based Smelter, to support the production process. The laboratory has been certified with ISO 17025 accreditation and has received accreditation from the Rwanda Mining Board.

The Company is the only tin smelter in Africa conformant with the Responsible Minerals Assurance Process (RMAP) under OECD guidance.

2. THE SMELTER – HISTORICAL OVERVIEW

Previously known as the *Karuruma Tin Smelter*, the smelter was built at the beginning of 1982 within the "Société des Mines du Rwanda" ("SOMIRWA") project. SOMIRWA was consolidating critical Rwandan tin assets, including Rutongo mines, located 30km from the Smelter. The Smelter was operative, with short shutdown periods, almost until April 1994, when the Genocide against the Tutsi started.

The Genocide and wars run in the region in the 90ties have impacted Rwanda, Great Lakes Region, and the Smelter - equipment has been destroyed and Smelter was completely unoperational. The privatization program implemented in 2002 was aiming at finding investors for the mining and metallurgy sector in Rwanda. The Smelter was acquired by NMC Metallurgie, and later change the name to Phoenix Metal. Some renovation and equipment installation was implemented, but due to unstable energy supply, and problems with raw materials sources, the production was run continuously.

In 2006, the company tested a new process based on an exothermic process. Although the tests were successful, the second increase in the price of electricity in December 2005 and the lack of raw materials have caused the stop of smelting activities. In 2017, the company entered receivership and was bought by the Rwandan government for 1.2 billion RWF [1].

3. PRESENT LUNA SMELTER

In the first half of 2018, after having won the tender organized by the I&M Bank, Luma Holding and Ngali Holdings took over the Smelter in the first half of the year. Investors had a chance to conduct detailed a due diligence process on the facility and prepare an investment program, based on the full production at one electric arc furnace (EAF). The companies have registered a JV company in Kigali, Rwanda – Luna Smelter Ltd – established to develop the plant and its operations – **Figure 1** [2].



Figure 1 Luna Smelter Ltd, Karuruma, Kigali

Since the acquisition of the Smelter, a lot of investment in machinery, process improvements, renovations, acquisition of highly skilled consultants, various technical training of Luna staff, and certifications, to name a few, have earned Luna Smelter a high standard reputation on an international level.

Luna Smelter has identified the key environmental aspects associated with its production processes. The specific nature of tin production is associated with an impact on the environment related to the generation of waste, noise emission, dust emission, gas emissions into the atmosphere as well as water pollution. To mitigate the said impacts Luna has already put in place measures for each identified aspect. The goals toward environmental protection are also elaborated in both Environmental policy as well as Integrated management policy. These mentioned policies are communicated to all workers for their engagement. Most importantly Luna smelter is certified ISO14001:2015: Environment management system (EMS). The maintenance of the EMS

helps Luna Smelter to keep track of the best practices as far as environmental protection is concerned and efficient usage of natural resources

The CO₂ emissions calculated generally come from the charcoal used in the smelting process as a reducing agent. Other additives like marble chips, limestone, and lime powder are considered in calculations. However, they make up a small percentage compared to the contribution of charcoal. Charcoal is considered a renewable emission source, hence net greenhouse gases based on charcoal are considered zero emission

Every year, Luna Smelter conducts the Industrial air emission test. In both reports of the year 2019 and 2020, they concluded that all the tested pollutants, on the test list of the standard EAS 751:2010 have a concentration less than the standard limit. Resulting in the usage of the best available techniques. The SO₂ reported was mainly from forklifts, and traffic as the smelter is located near the main road. To reduce the SO₂ and fugitive emissions, the two new forklifts were bought recently

The dust emission is monitored, and the level of the particulate matter reported in 2019 and 2020 is due to activities in the smelter and the forklift exhaust. Water spray is used during sampling to avoid this.

A strong focus has been put on energy consumption. The advanced control system was introduced which was followed by digitalization. The smelting capacity was improved from six tons of cassiterite concentrate per day (6t/day) in 2019, to thirteen tons of cassiterite per day (13t/day) in 2021. This resulted in improved energy consumption. Also, the smelter was classified by Rwanda Utilities Regulatory Authority (RURA) as a large industry from being a medium industry. The power factor is monitored and is always greater than 0.9 resulting in the most efficient loading of the supply, no power loss in the system- quality and stability of the system.

It needs to be underlined that Luna Smelter is the only tin smelter in Africa conformant with the Responsible Minerals Assurance Process (RMAP) under OECD guidance, the flagship program of the Responsible Minerals Initiative (RMI). Recognizing the need for the implementation of the new technologies and possibilities offered by blockchain solutions Luna Smelter shareholders have been actively seeking the right partner for the new supply chain due to diligence tool implementation. After careful analysis of the MineSpider pilot project in Peru, the company was chosen as a partner for blockchain solution implementation in the Great Lakes Region. In mid-2020 MineSpider AG has been invited by LuNa Smelter to implement offered OreSource tool, jointly with LuNa Smelter and Luma Holding Group in Rwanda. Luna Smelter production has been presented on the blockchain platform since November 2020.

A key element that has contributed to Luna Smelter's success is also Luna's employees. Currently, Luna Smelter employs 157 employees, of which 153 are Rwandan citizens. Due to all improvements planned in the nearest future, the number of employees will significantly increase. Luna Smelter aims at creating the best working environment where each employee feels valued. The Company culture is based on mutual trust and true professionalism, respect, and support within the team.

Luna Smelter Management's priority was always to integrate gender equality into the natural resource management system, starting from the supervisory board level, through the management board, senior managers, and through all the employment structures. Over 15 % of Luna's employees are women, they work at all levels starting from mining operations to the management of the Company.

The Company is an active participant in the International Women in Mining initiatives and supports the organization's global activities related to gender equality. Luna sponsors the participation of its female employees in the global mentoring program run by the IWIM organization.

Luna Smelter is focused on vertical integration and has been granted mining and exploration licenses in the Eastern Province, in Gatsibo and Kayonza districts. These concessions are known to be endowed with Sn-Ta deposits, tin dominating over tantalum. Moreover, Luna sources cassiterite concentrate from licensed Rwandan cassiterite mining and trading companies – the company cooperates with almost 100 Rwandan suppliers with full traceability credentials. Luna Smelter also sources cassiterite from South Kivu, the

Democratic Republic of Congo, and the Northeastern part of Tanzania. Luna plans to expand the cassiterite sourcing from traceable sources in the other parts of the Democratic Republic of Congo (Tanganyika, North Kivu, Maniema, and Haut-Uele provinces) and other countries. [3].

4. METALLURGICAL R&D

Luna Smelter's production is based on the modernized and customized submerged arc furnace. The furnace has three graphite electrodes of 300 mm each, carbon lining, and it works with a programmable logic controller operating system. The scheme of tin production is shown in **Figure 2**.

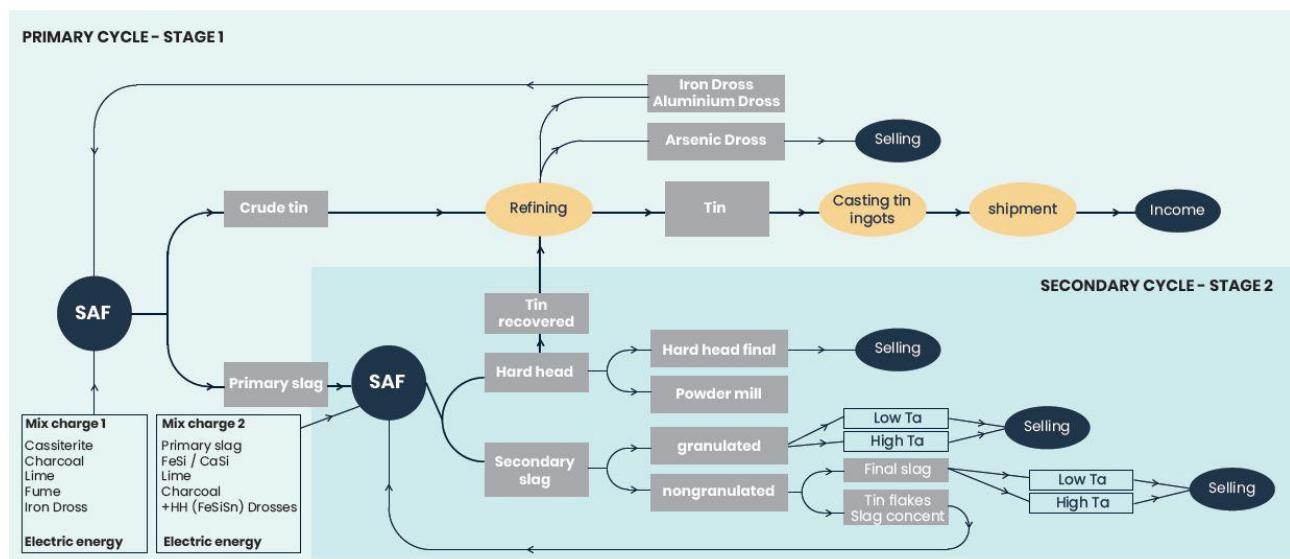


Figure 2 Luna Smelter production process

Due to the basic production type, the current capacity of the furnace is up to 320 tons of cassiterite concentrate per month. The cassiterite which is being purchased has between 55% to 78% Sn content.

Table 1 Comparison of LME tin requirements [4] and typical production of Luna Smelter

Composition (wt%)		
Element	Requirement Tin LME	Production Luna Smelter
Sn	99.85 min	99.94
Al	0.0010 max	0.0005
As	0.030 max	0.013
Bi	0.030 max	0.014
Cd	0.0010 max	<0.00003
Cu	0.050 max	0.0022
Fe	0.010 max	0.0043
Pb	0.050 max	0.015
Sb	0.050 max	0.0081
Zn	0.0010 max	<0.00003
Total of all impurities	0.150 max	0.06

Basic production is divided into two stages. The first stage of the smelt is designed to yield a tin metal product with as low an iron content as possible and a primary slag (which, in the process, is granulated with water) containing most of the iron present in the original charge mixture and a significant level of tin. The second stage smelt (often referred to as the slag smelt) on the molten high tin content slag is conducted under more strongly reducing conditions to yield a slag with a minimum quantity of tin (to maximize tin recovery) and as high an iron content as possible and a metal alloy of tin and iron. This metal alloy from the second or slag smelt stage is referred to as "hardhead". To remove impurities from crude tin, the plant has three refining kettles. After the refining process, produced tin metal ingots meet the requirements of the London Metal Exchange (LME) for tin metal, as shown in **Table 1**.

Between 2019 and 2021, 1700 tones of concentrate have been processed and converted to more than 1000 tons of a tin of purity above 99.96% tin content

Tin concentrates have different impurities and every single one of them is removed differently. It can then be said that refining capacity is one of the very important aspects which defines the capacity of smelters.

In 2021 LuNa Smelter purchased and implemented technology, which is based on the crystallization of preliminary refined tin to remove lead and bismuth and achieve High Purity tin- 99.99 % Sn- Spiral Crystallizer shown in **Figure 3**. The molten tin flows to the crystallizer by gravity, with its flow rate regulated by a manual handle-regulated valve. The crystallizer has a tilting angle of 8 degrees.

The crystallizer has a temperature drop from the higher end to the lower end. The feeding point is located in the lower end of the crystallizer, between 3 & 4 blades. The lead-tin alloy keeps as a liquid at the lower end and the purified tin gets into the crystal, taken by the spiral upward to be discharged at the higher end G1->G2->G3->G4. The solder-tin slag will gather at the lower end and then be discharged at the drain hole once the plug is released from the outer side.

The crystallizer has a manually heating zone operating system. The entire device includes 9 heating zones, 4 adjustable according to the needs of the process, and 5 permanent zones as shown in **Figure 3**.



Figure 3 Spiral crystallizer

After the process of refining, pure tin metal is transferred from the refining kettles to the casting kettles and then poured into molds through the casting procedure - **Figure 4**. Another two segregation furnaces are used

to recycle the dross from the refining process and recover tin from it. The plant is also equipped with magnetic separators and gravity shaking tables for the enrichment of cassiterite concentrate

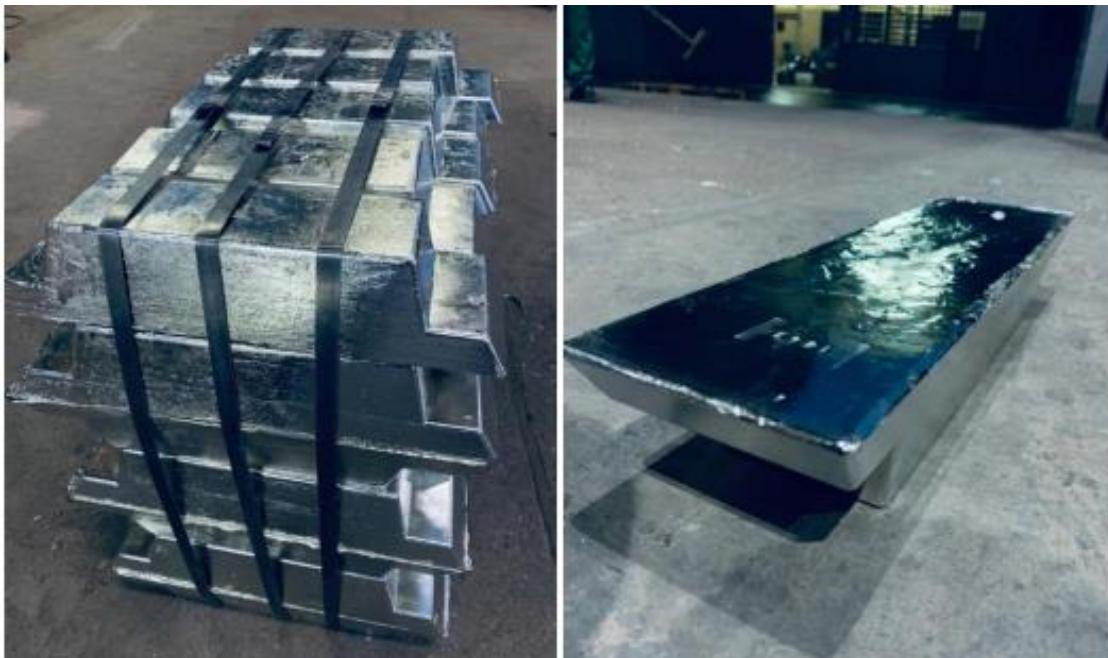


Figure 4 Tin ingots cast in Luna Smelter, with purity 99.965 wt% of Sn

Through a recent R&D project – Luna Smelter is implementing the highly efficient processing technique “single-stage smelt” which does not require recycling and the processing capacity increase to 360 tons per month. Luna plans to develop more such process which is more efficient, economic, and eco-friendly. The increase in processing capacity would also attract not only the local market but also the regional as well as international markets.

5. LUNA SMELTER'S FURTHER GROWTH

The ultimate goal of Luna Smelter Ltd. is to create a stable, African tin brand, which will not only answer the global tin supply needs but will also significantly impact the economic development and peace-building process while strengthening the responsible sourcing of the critical East African minerals, with special focus on the tin.

Currently, Luna Smelter Ltd. runs its smelting processes with one furnace. There is a second furnace that is being overhauled, which is projected to be put into operation once the processing demand exceeds 360 tons per month, doubling Luna's processing capacity to 720 tons per month. Moreover, Luna is projected to become a waste-free smelter by finding the use of by-products generated from the production cycle. Slag is the byproduct generated from the tin concentrates smelting cycle and Luna produces above 70 tons of such byproduct every quarter. Research and tests in both Rwanda and Poland are ongoing, on the usage of slag as a construction material, and results are so far optimistic. Road construction buildings, and bridges, are among the projected areas for the usage of slag, and Luna is committed to impacting the Rwandan construction sector with the slag.

Through Luna Smelter acting as a trigger of the change, upstream producers will have access to advanced solutions, stable offtake, and capacity-building tools, while downstream consumers will have direct access to stable and traceable tin metal sources. Further deploying the blockchain technology for the complete sourcing process will enable the direct information on the key components of the tin supply chain to be visible to all interested stakeholders.

6. CONCLUSIONS

Tin was known to mankind from the ancient ages, from the historical period characterized by the spread of bronze and its products. By the 19th century, Cornwall was the most important center for cassiterite mining and tin production. Currently, the largest cassiterite resources are in Bolivia, Congo, and Southeast Asia, where tin smelters are also headquartered. The development of tin metallurgy in Rwanda is also closely related to the presence of cassiterite deposits in the country. The tin production capacity of Luna Smelter was closely related to the availability of raw materials, the political situation, and the market situation. The 1994 genocide and the decline in demand for tin, related to its displacement from the food industry through the introduction of aluminum foil, the implementation of polymer coating for canned food, and from the mechanical engineering industry by replacing babbitt bearings with steel bearings, contributed to the reduction in production volume in particular. On the other hand, however, the demand for soldering materials and bronzes remains high, and in addition, from the beginning of the 21st century, new spheres of tin use appear, for example in the chemical industry for catalysis or in the electrotechnical industry for the creation of new generation batteries. The widespread use of electronics in various branches of the economy and the increase in industry innovation mean that the demand for tin and its alloys will increase, so the prospects for Luna Smelter's operations are optimistic, and the plant's development will have a positive impact on the development of Rwanda's economy and improving the living conditions of its citizens.

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