Construction and Commissioning of ERAMET SiMn + EMM Plant in Gabon

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ABSTRACT

In 2009, ERAMET-COMILOG – the world leader producer of refined Manganese alloys and one of major player in Mn Ore, SiMn & Mn-alloys production – decided the construction of metallurgical smelter called CMM (Complexe Métallurgique de Moanda) in Gabon in order to produce Manganese Metal and Silico-Manganese to positively answer wishes from Gabonese authorities to create value locally, to develop local industry and to promote downstream activities from the 3,5 Million ton/year Mn ore mine from Moanda.

This project is in line with the strategy of ERAMET-COMILOG to develop the portfolio of Mn-products produced by our company in including Mn Metal, market mostly dominated by China (95%), where we have not been represented so far. The project benefits from a competitive hydro-power price from the newly constructed Poubara dam (160MW - 300M€) started in 2014 and high Mn content ore from the neighbor COMILOG Mine. Construction of the project started in 2011, including hydro-metallurgical Mn Metal shop (20 ktpy), pyro-metallurgical SiMn shop (65 ktpy) and was completed in 2014. The first furnace was launched in August 2014 followed by the second furnace in January 2015 and Mn Metal in March 2015.

INTRODUCTION

The CMM project has been managed with a stage-gate process including the classical PFS (Pre-Feasibility), DFS (Detailed Feasibility Study) leading to CEA (Capex Application) approved in March 2009 by ERAMET-COMILOG and followed by the equipment procurement, construction and commissioning. Here, we offer a description of the key points of this project including the design choices, technical solution and construction program until the point when the first metal was tapped in August 2014.

1. Plant Design

1.1 Key project principles

Products: SiMn & EMM

The choice to produce SiMn and EMM (Electrolytic Manganese Metal) has been motived by several factors:

- These products were not represented or had a low production share in the ERAMET portfolio
- Production processes of these products are simple and well-known so adapted to a remote place like Moanda (600 km inland from Libreville).
- They have local competitive advantages (competitive power price and close Mn ore) as they are the most electro-intensive (4200 kWh/t of SiMn and 9000 kWh/t for Mn metal), they allow utilization of low grade Mn ore (high P) not commercialized currently which permits an extension of mine life-time.
- Production processes are well known in ERAMET as they already exist in other plants (Comilog-Dunkirk, Eramet-Norway) for SiMn and they are close to EMD production in Erachem.

Chinese equipment & engineering

Within CMM project, we decided to buy Chinese equipment which corresponds well to our need and optimize CAPEX:

- Standardized and simple equipment with an average level of automation corresponding to chosen process and local environment.
- Well know equipment with a good technical feed-back following the boom of SiMn production in China for 10 last years at least.
- Cheap investment cost for equipment as well as their operation costs
- Possible important synergies with ERAMET Guilin plant for SiMn (identical furnaces)
- Know-how about Mn metal is focused today in China (96% of world production capacity) with recent experience from ERAMET in similar hydro-metallurgy process with Chongzuo plant.

Choice to build a combined plant

Our choice to build a combined EMM/SiMn instead of purely SiMn plant or purely EMM plant for the following reasons:

- Better distribution of commercial risks
- Several synergies for raw material (for example, coke: lumpy fraction for SiMn, fines fraction for Mn metal
- Well-balanced relationship with Gabonese government: Mn metal workshop creates more jobs than SiMn workshop, SiMn part will consume 50% power more than Mn metal (SiMn 65 KT : 270 GWh and Mn Metal 20 KT : 180 GWh)

1.2 Key project parameters

Products: SiMn & EMM

Manganese Metal HP >99,7% - production 20 kt/year, SiMn: Mn ≥65%, P≤ 0.3% - production 65 kt/year

Mn Ore & other raw materials (cf figure 1)

- 165 000 tons Comilog Mn Ore
- Coke : already utilized in the neighbor sinter plant
- Sulfur: for production of sulphuric acid for EMM workshop

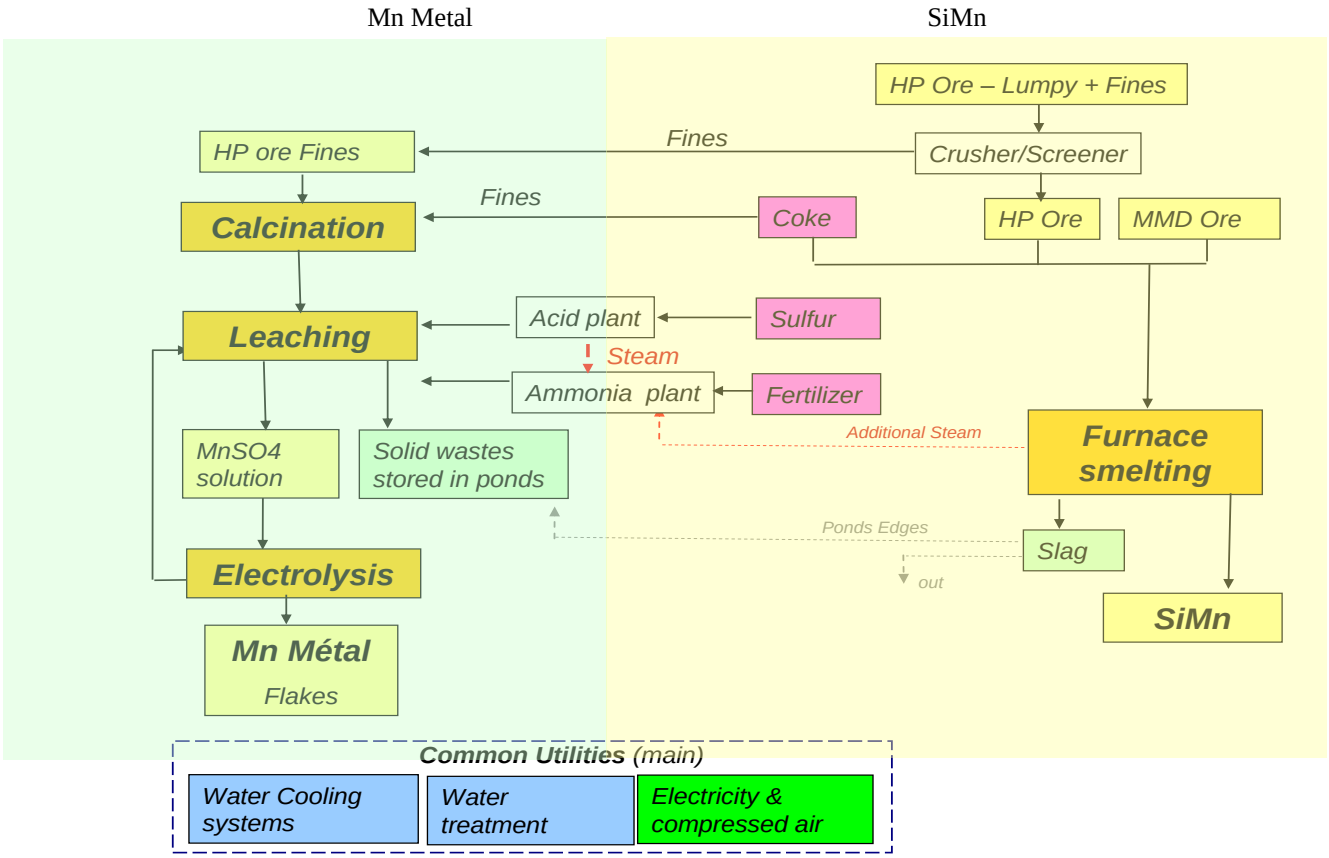

Figure 1: Overall process description with material input/output

Electric power

Electrical power: 69 MW (Mn metal 27MW- SiMn 42 MW). Alimentation with 63 kV from a transformer 220KV/63 KV built by the Gabonese government close to the plant.

Workforce

Workforce: 400 people (300 people for Mn metal, 100 for SiMn part)

Figure 2: design plant lay-out

1.3 Manganese Metal plant

General process description of Manganese metal

- Product: Manganese Metal High Purity > 99.7 % – flakes
- Capacity: 20 kt/year – possible expansion to 40 kt/year
- Process: 3-stages hydro-metallurgical process:

Stage 1: Crushing & reduction of MnO_2 ore in MnO with calcination furnace
Stage 2: Leaching & purification: production of purified solution of manganese sulfate after dissolution of MnO in sulfuric acid and removing of Fe/heavy metals by precipitation and filtration (gangues); solution is neutralized with ammoniac.
Stage 3 : Electrolysis and Mn settlings at cathode level; Mn deposit is collected regularly (cycles of 36 h) as 'flakes'.
NB. Typical composition of the EMM flakes:
Mn≥99.7%, Fe≤0.005%, Si≤0.008%, S≤0.04%, Se≤0.0002%

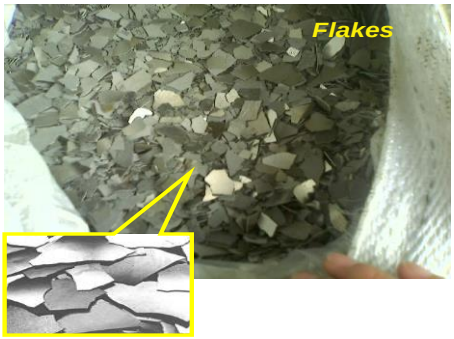

Figure 3 : EMM flakes

Required utilities & productivity
Electrical supply: 27 MW for 20 kt/year production capacity with a specific consumption of 9000 KWh/t EMM
Production unit of sulfuric acid and ammoniac
Estimated productivity in China: 50 tons EMM / person / year
Estimated productivity in CMM: 66 tons EMM / person / year
Figure 4 shows overall scheme of the process.

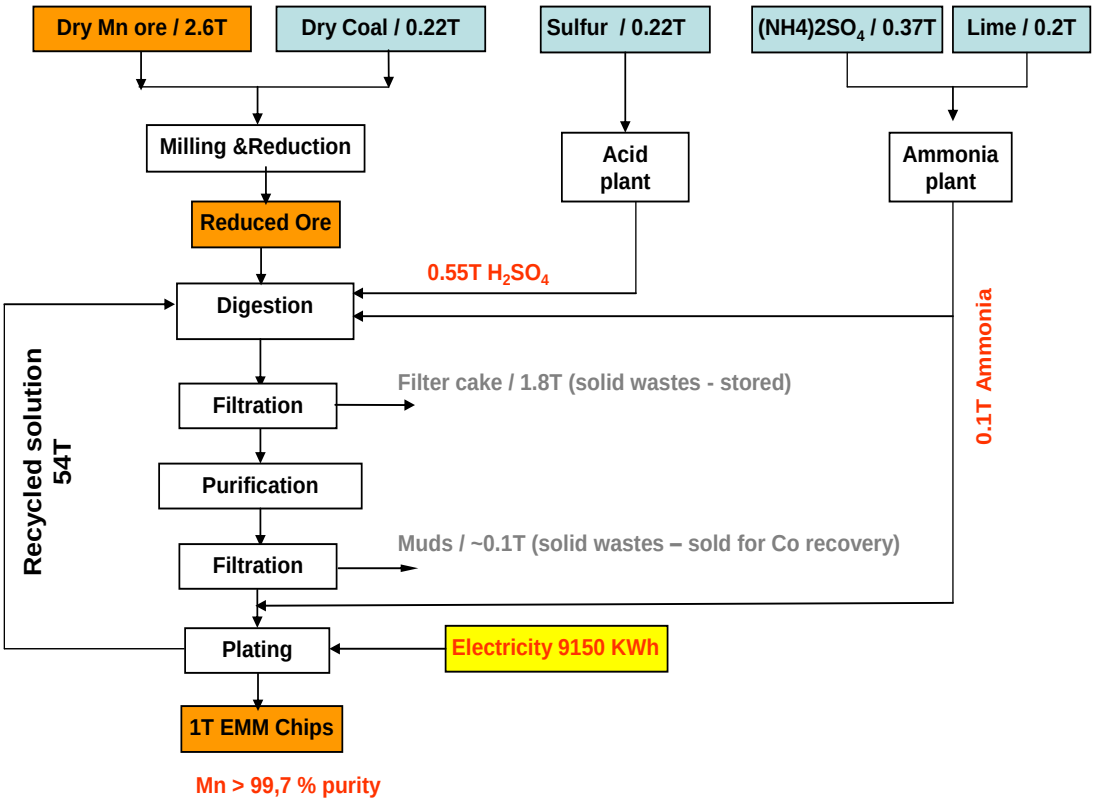

Figure 4: EMM general production process

Required raw material for Mn metal production:

- Mn ore: high flexibility concerning ore input: fines from Mn ore utilized for SiMn. Minimum Mn content: approx. 44%, ore consumption is estimated at 2,6 tons dry Mn ore per ton of EMM.
- Sulfuric acid: estimated consumption at 0.55 ton per ton of EMM. Sulfuric acid is produced on-site.
- Ammoniac: estimated consumption: 0.09 ton per ton of EMM or 1800 tons NH3/year. Production on-site from fertilizer + lime. In the future, the idea is to produce lime locally.
- Coal for the reduction: Coal characteristic: Carbon content > 80% with low sulfur. We are planning to use the fine fraction from Coke utilized in the sinter plant located next door.

1.4 Silico-Manganese plant

General process description

- Product: SilicoManganese with P< 0,3%, Mn 70%, Si17%, C < 2%
- Fraction: 3-10mm, 10-25mm , 25-50mm, 50-75mm
- Capacity : 65 kt/year (with possible expansion to 130 kt/year). With 2 furnaces of 30 MVA
- Process: pyro-metallurgy

SiMn is produced from a mix of Mn ore, coke, quartz and dolomite after reduction in SAF (Submerged Arc Furnace). Different raw materials are taken from storage yard and sent to daily bins. They are extracted, scaled and mixed before sending to bins on top of the furnace roof. Raw material is then introduced inside the furnace through charging tubes and ore is pre-reduced with CO gas then fully reduced by carbon from the coke in the melting area. SiMn is tapped at same time with slag, firstly in a ladle then in sand casting bay. Therefore, after cooling, SiMn is sent to crushing to get the proper fraction.

- Furnace characteristics : SAF Soederberg type Furnace 30 MVA. Furnace diameter: 11 m, Electrodes of 1500 mm diameter, 2 tapping holes at 180° with tapping in ladles.
- Power Consumption at 4200 kWh/t SiMn or 270 000 MWh per year. Total power: 42 MW
- Number of people: 100 persons

Figure 5 shows general SiMn production process

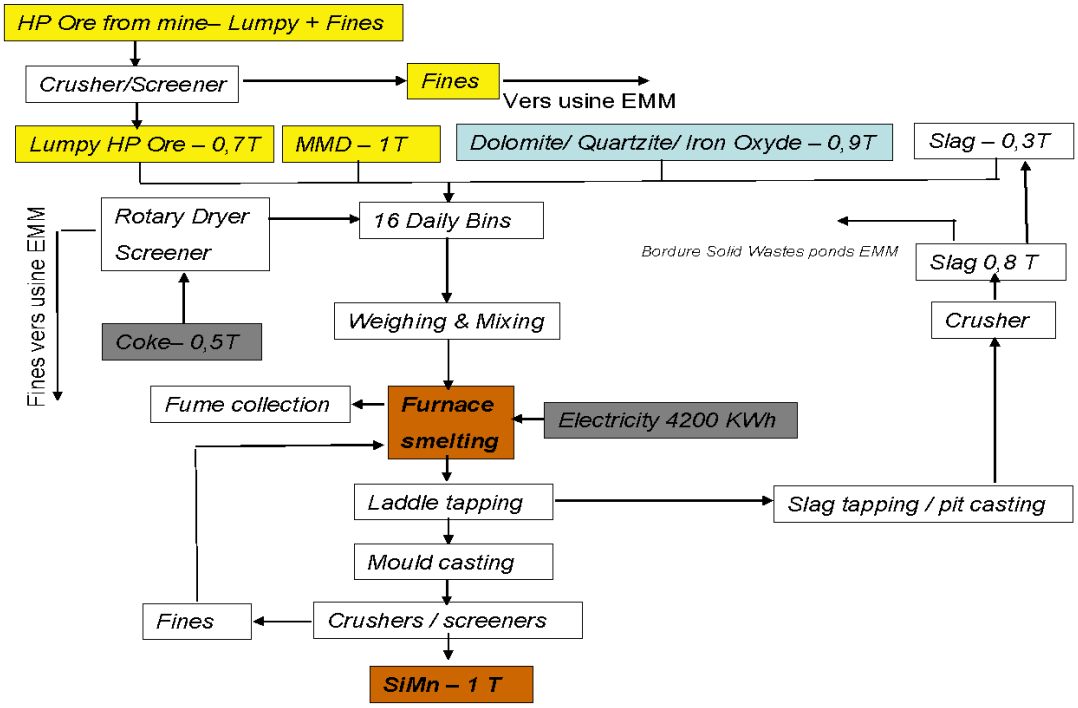

Figure 5: SiMn production process

Raw Material

- Mn ore: approx 110 kt per year of COMILOG ore MMD
- Other raw material from local open-pit started in 2014 in the Franceville region including:
  - ➢ Dolomie: 16 kt/year -Lastourville ~150 Km from the plant (transport by truck)
  - ➢ Quartz: 30kt/year - Mvengué ~40 Km (transport by truck)

Imported raw material

- ➢ Coke: 35 kt/year (from South/North America)
- ➢ Electrode Paste: 3,4 kt/year. Import from Europe by containers

2. Plant Construction

2.1. Planning & schedule

The initial construction planning (as shown on Figure 6) was based on a 36 month Procurement & Construction schedule with target to launch first SiMn furnace End of 2013 and pot rooms beginning of 2014. During the peak of construction, we had 1000 people working at the construction of the plant with EPC contract signed with a leading Chinese Engineering company.

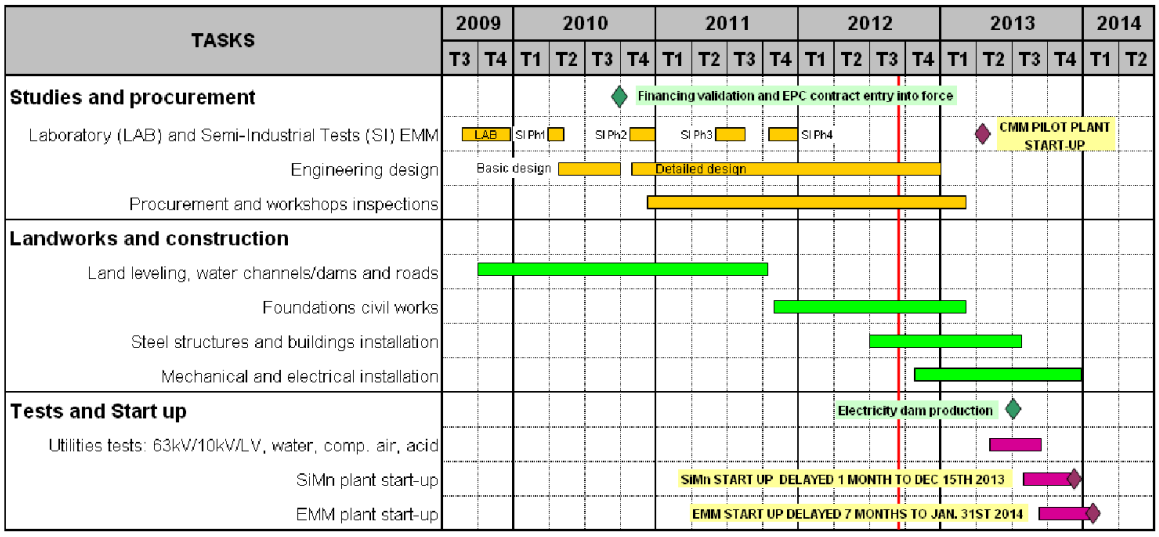

Figure 6: initial construction planning of CMM plant

2.2 Construction Photos Album

Figure 7: Start of leaching unit and SiMn Furnaces shops construction (2012)

Figure 8: Inside Electrolysis Hall and SIMn Furnaces shop (2014)

Figure 9: General plant view (2015)

3. Plant Commissioning

3.1 SiMn Furnace commissioning – August 2014

Training

A particular attention has been paid to training of approximately 30 engineers, 40 foremen, 90 technicians and more than 200 operators. Most of engineers have been recruited in 2010 and undergone an intensive training within the other plants from ERAMET, in particular Norway and France, at least 1 year before starting. Similarly, foremen and technicians received a 9-months training package with a period in France in our Dunkirk plant.

During the start-up of the plant, a dozen of Norwegian operators has been on-site for 3-4 months to help in the main & critical operations.

Furnace B startup

End of July 2014 (as scheduled + 6 months), furnace B was energized and startup procedure was carried out as described in the pictures below. The first tape and cast was implemented in August 2014 very successfully and the furnace was ramp up to 14 MW. Furnace A was started in January 2015 and is currently running. After 4 months, support team went back to Norway and plant operators were running the shop on their own.

Furnace preparation

Wooden charge between electrode

Firing wood to heat and soften electrode paste

Furnace energized

Furnace taping

Ladle casting in sand bay

Hot metal removal

Ready for crushing

Figure 10: Startup and first tap on Furnace B

3.2 EMM commissioning – February 2015

Training

Identically to SiMn, we paid special attention to training employees for the Manganese Metal part. As this process was new for us, a pilot plant has been built and launched in 2013 with a leaching unit and one cell tank producing approximately 900 kg/month of Mn flakes as shown in Fig. 11. This pilot allows us to train people and to set well our process parameters.

Figure 11: EMM Pilot plant – First production – July 2013

First industrial EMM Production

Cell-rooms have been started in February 2015 with 15 pots in production. Metal collection occurs every 32 hours. The production ramp up will continue with starting by package of 10 cells following process stability and product quality. Figure 12 shows production operations in the cell-rooms.

Figure 12: EMM Industrial – First production – Feb 2015

CONCLUSION

The CMM (Complexe Métallurgique de Moanda) has been successfully launched in 2014 after 3 years of the construction schedule and is on track now to ramp up to reach design capacity of 65 kt/year SiMn & 20 kt/year Mn Metal in the upcoming years. The project is successful as a green-field plant, first metallurgical plant in Gabon in order to process and create value from the local Mn ore from COMILOG thanks to the dedicated team who managed this 200 M€ project in respect of Safety, Environmental constraints and Local community.