Engineering challenges encountered during the shipping of two converters to Madagascar for the Ambatovy Project

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Abstract

Bateman's portion of the Ambatovy Nickel Project consisted of the design and supply of two 2,750 t/d sulphuric acid plants each including a very large converter. The two Noram (from Vancouver, Canada) designed converters, each 24m x Ø14.5m with a mass of 395t was to be manufactured at Metso ND's fabrication yard at Bayhead in Durban, South Africa.

Bateman followed a piece large shipping strategy whereby all major pieces of equipment were to be delivered to site complete and placed directly onto the foundations. This philosophy allowed for the minimum of site fabrication on site allowing for reduced exposure to safety incidents, faster mechanical erection and lower costs. Shipping of all items was to be done by the Client's main EPCM contractor, SNC Lavalin from Toronto, Canada.

However, the shipping of the two Converters was removed from the Client's scope and it was requested of Bateman to take over responsibility for transporting each converter in the upright position from Durban in South Africa to Tamatave in Madagascar.

Introduction

Bateman's acid plant experience spans ~30 years (all plants utilising 3rd party technology):

- Rössing 1977 Rössing , Namibia
- Fedmis 1979 Phalaborwa, RSA
- Buffelsfontein 1980 Potchefstroom, RSA
- Ambatovy 2008 Tamatave, Madagascar

Bateman has a long term technology marketing agreement with Noram Engineers and Constructors of Vancouver, Canada. Utilising this agreement, Bateman was awarded the Engineering and Procurement (EP) contract for the Ambatovy Nickel Project Sulphuric Acid Facilities in 2007, incorporating a Noram technology design and supply of proprietary equipment package.

This 5,500 t/d sulphuric acid plant is the first sulphuric acid plant Bateman has designed and supplied in 30 years.

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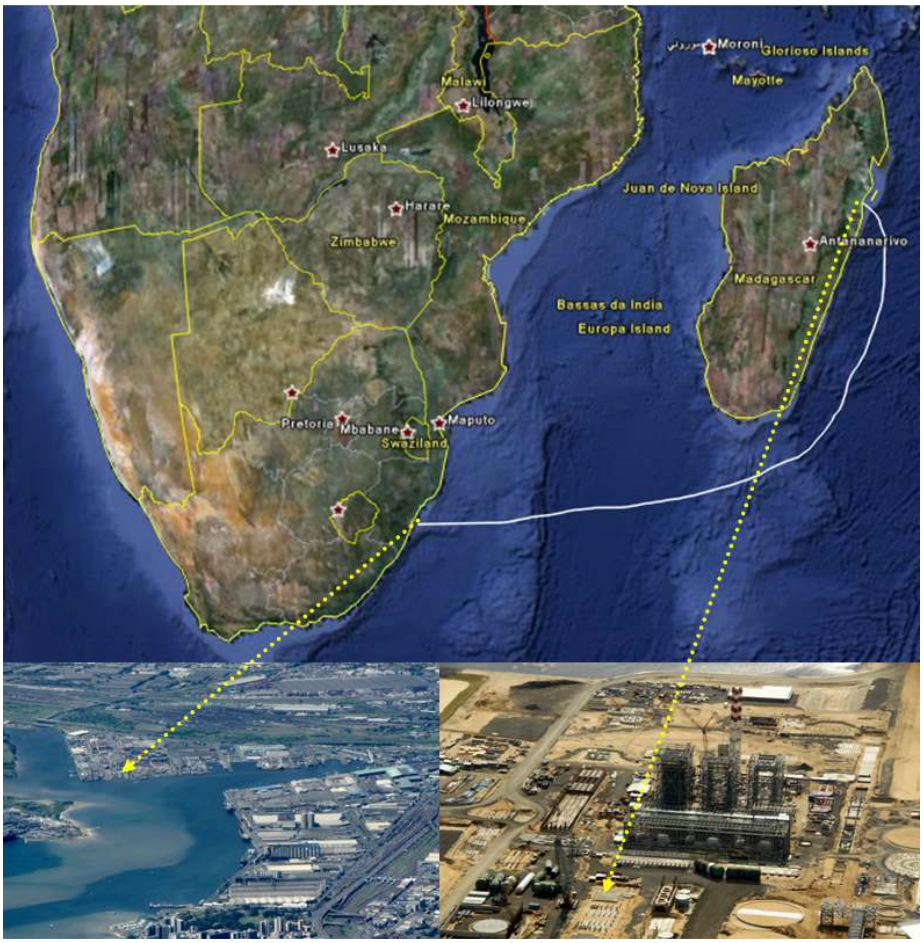
However, the shipping of the two Converters were removed from the Client's scope and it was Bateman's responsibility to transport each converter (height and weight of a 395t, equivalent of an eight storey building) vertically from Durban in South Africa to Tamatave in Madagascar.

The converters were shipped individually - approximately 10days apart – utilising a special type of cargo vessel - one that had the capability to enter a medium depth port facility, lift using it's own cranes and ship such a large but delicate piece of equipment across the Mozambique channel to Madagascar.

This paper gives the reader an overview of engineering challenges that had to be overcome during the shipping of the two converters (designed by Noram, fabricated by Metso ND, and logistics co-ordinated by Bateman) from Durban, South Africa, to Tamatave, Madagascar.

Figure 1 : Route of the converter transport



Design and fabrication

The decision was made upfront to ship the converters in a vertical position as shipping them horizontally would have resulted in a threefold increase in weight as well as subsequent costs due to the increased strength that would have been required for the units to support themselves in the horizontal position. In addition, at the outset of the whole project, the Client had to upgrade the road between the site and port in Tamatave and it was noted that there was not sufficient road surface to transport the convertors to the site.

Bateman Engineering was allowed to specify the transport envelope required, (exact dimensions) and the road was built/upgraded to accommodate the shipping of the converters as single units according to this requirement by the Client.

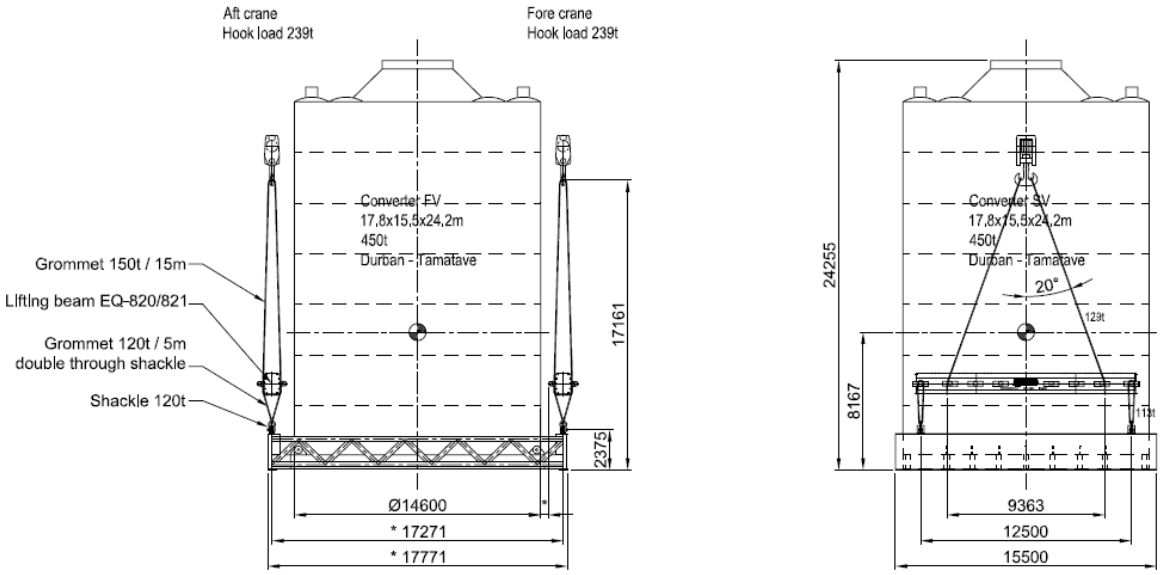
Metso ND was chosen for the fabrication because of their track record of producing quality large scale Stainless Steel units and because they had the Bayhead fabrication facility adjacent to a private berth at South Africa's busy Durban harbour. Metso ND commenced fabrication of the two converters in early 2008 and completed them by December 2008, a task which occupied all of the available manpower at it's Bayhead facility.

Figure 2 : Fabrication of Converters in June 2008

Figure 3 : Completed converters in December 2008

The two converters took Metso ND a total of 65 000 man-hours to complete - all of which were successfully completed injury free. By December 2008 both converters - each weighing 395t, with individual shipping envelopes of 17.8 m by 15.5 m by 24.6 m in height- was ready for shipment.

Figure 4 : Extraction of part of the shipping preparation study



During the finalisation of the shipping study, it was found that extensive preparations had to be made before the MV Fairlane (the vessel chosen for the transport operated by Jumbo Shipping) could dock at the private Bayhead wharf in Durban, South Africa.

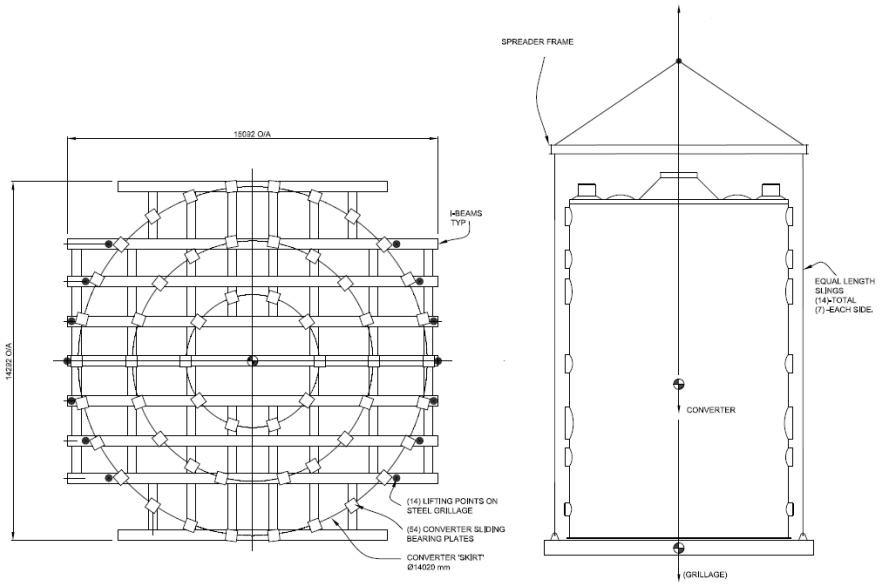
Figure 5 : MV Fairlane in the process of docking at the Bayhead wharf in Durban

The preparations specifically required included the complete redesign and supply of the lifting arrangement of the converter, an area adjacent to the wharf had to be dredged to achieve 7.5m depth and the completed converters had to be moved closer to the edge AND had to be rotated by 90° for the ships cranes to reach the lifting arrangement. Much of this study work and preparation theory was concluded in conjunction with Jumbo Shipping's professional team of engineers.

Lifting Frames:

It was originally planned to lift the entire grillage beam assembly complete with the completed converter as a unit, using 14 lifting points radially arranged on the grillage beams.

Figure 6 : Original radial lifting arrangement



In practise, however, this turned out to be an impractical solution, so Bateman Engineering designed a new lifting arrangement for each converter, which could now be fully utilised in Durban South Africa, at the Madagascan port of Tamatave and on site.

Figure 7 : The grillage modifications required shown in Orange

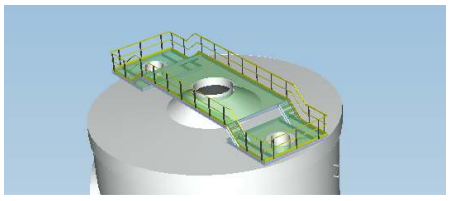


Figure 8 : The fabricated lifting beams and girders

The special lifting beams, designed by Bateman's professional structural engineering team and fabricated by Moco Steel, consisted of two plate girders, each 2.1 m high, 17 m long and weighing 18 t, two stiffening beams and four new lifting points. The additional lifting gear was also fabricated by Moco Steel. A key critical point of design criteria was the very tight deflection criteria imposed to ensure that the converter welding would not crack due to possible unnecessarily induced stress brought on by distortion under lifting conditions if the deflection was not accounted for in the lifting beam design.

Moving and Rotation:

Having finalised the lifting beam design, it then became apparent that the converters being fabricated, were in such a location that the ship's lifting gear could not reach the lifting points as they were outside of its lifting range, which resulted in the COMPLETED converters needing to be rotated and moved closed to the wharf's edge. The first converter had to move a mere 5m Eastwards along the wharf and the second Converter 20m Eastward, both had to be rotated by 90° to accommodate the Jumbo Ship's crane configuration. A specialist company, Machine Moving Equipment, was contracted for this scope of work which involved hydraulically jacking each converter to its required position and then lowering the converter onto a specially prepared surface prior to be rotated, using hydraulic jacks.

Dredging:

A bathymetry study had revealed the exact section of the harbour adjacent to Metso ND's facility that was too shallow for the estimated 7.5m draught of the loaded vessel. As a result, Subtech was contracted to mechanically dredge that part of the sea bed ensuring enough depth for the loaded vessel.

Figure 9 : Mechanical dredging of the harbour in progress by Subtech

However, this also produced some problems for the engineering team. A part of the retaining wall of the wharf was in danger of collapse should the dredging proceed. This now further required special engineering audits into the structural integrity of the wall in addition to specific instructions as to the re-instatement of the dredged area to prevent the collapse. It also emerged that for dredging to be done, a full Environmental Impact Assessment would have to be done which would push the schedule (already exceptionally tight) out by at least 6 months. At the last minute after extensive discussions with the authorities, this requirement was waived as the dredging was classified as “reinstatement of the embankment only” and the work could proceed.

Shipping:

Before the converters could be lifted onto the MV Fairlane, the ship had to be stabilised in position, using two spacer barges between the ship and wharf as well as by means of its own its own outrigger system. Once the ship was stable, the converters were lifted onto the ship using the two mammoth 400 t capacity cranes on the ship.

This whole process preparing for the lift took about 12 hours. Once everything was in place, the actual lifting of the converters onto the ship took only one hour. The design specification allowed for a 5 mm deflection of the main lifting beams, however, it was successfully lifted onto the ship with negligible deflection:

Figure 10 : Lifting of converter onto vessel in Durban, South Africa

At 7am on the 21st December 2008, the MV Fairlane set sail on it's voyage to the Madagascan port of Tamatave, taking 5 days to reach its destination. Once off loaded, the ship would return to Durban, South Africa to repeat the process with the second converter. On the 1st January 2009, the Ambatovy team in Tamatave worked relentlessly to lift the first converter. The converter was lifted directly from the ship onto an ALE Heavy Lift self propelled motorised trailer - known as an SPMT – for the commencement of the second part of its journey to the site which was located east of the Port city of Tamatave on the east coast of Madagascar.

Given the dimensions of the converter, individual SPMTs has to be locked together to form one transport vehicle to provide a platform 8.5 m wide and 16 m long. But even then particular attention was required in terms of the overhang of the converter as its base measured 15.5 m by 17.5 m. Once again, the converters were transported in a vertical position adding to the challenge of this task.

Figure 11 : Tight clearances

Figure 12 : Moving the converter across the newly constructed bridge

The SPMTs, which are remote controlled by a highly skilled operator, were free issued to Bateman Engineering by the Client. Remarkably this massive vehicle was ideal for this application as it's load bed remained level with the wheel heights varying to accommodate any undulations in the road surface, thus keeping the load stable at all times.

Figure 13 : SMPT wheel articulation

Figure 14 : Removal of obstacles

The journey from the port to the site was a slow 12 km. With the operator accompanying the SPMT at a walking pace of between 3 and 4 km per hour, the rather strange procession naturally attracted huge public interest as it passed through the small villages. Minor obstacles were encountered as well as uneven road surfaces but with the amazing use of the SPMT, and crossing bridges specifically constructed by the Client, the converters arrived safely at their destination.

On arrival at the Ambatovy Nickel project site, a specialised 800t crawler crane provided and operated by Sarens and free issued to Bateman Engineering by the Client, lifted the converters directly from the SPMT into position onto the foundations that were already prepared.

Figure 15 : Lifting of the converters onto foundations

Figure 16 : Perfect alignment

Conclusion

Despite significant engineering challenges, the shipment of the two converters for the Ambatovy Nickel Project's Sulphuric Acid Facilities was accomplished without mishap or incidence.