THE PRODUCTION OF REFINED FERROMANGANESE AT CATO RIDGE ALLOYS

R. Burger[1] and M. Masukawa[2]

[1]ASSMANG Cato Ridge Works, Eddie Hagan Drive Cato Ridge, RSA. E-mail: robertb@feralloys.co.za
[2]Mizushima Ferroalloy Co. LTD, 1-1 Chome, Kawasakidori Mizushima, Kurashiki-Shi, Okayama-Ken, Japan.
E-mail: masanobu-masukawa@mizukin.co.jp

ABSTRACT

Cato Ridge Alloys (CRA) is a joint venture company between Assmang of South Africa, Mizushima Ferro Alloy Company (MZK) and Sumitomo Corporation from Japan. Negotiations for the formation of the company started in 1992 with the joint venture agreement signed on the 19th September 1996. MZK was to supply the technical know how for the production of Medium and Low Carbon FeMn while Assmang was to manage the day to day activities of the company. Sumitomo Corporation was to act as facilitator between Assmang and MZK and, together with Ore and Metal are responsible for the marketing of the refined products.

The conceptual design of the plant started in December 1996 and the first charge of molten high carbon ferromanganese metal was charged on the 19th January 1998.

Problems experienced during the initial startup period were addressed resulting in substantial operational improvements. A build-up in the stock of fine metal was addressed through the development of a process to remelt the fine metal, the development of a market for fine metal and the upgrading of the crushing and screening plant to reduce the generation of fine metal.

The mass yield from High Carbon Ferromanganese to Refined Ferromanganese was increased through the implementation of statistical process control, changes to the blowing patterns and the development of a sampling device for taking samples during the process.

Converter refractory consumption was reduced. This was achieved on the converter by improving the cooling of the converters with the installation of cooling fans and cooling fins. The heating schedule of the converters was changed for improved refractory life. Production schedules were modified to allow cooling of the refractory between low carbon ferromanganese charges.

Additional changes made to improve operations were:

- *Changing from mehanite casting trays to metal fines beds.*
- *Installation of sonic horns in the baghouse to prevent the bridging of dust.*
- *Improved welding on the lance tips.*

1. INTRODUCTION

Cato Ridge Alloys (CRA) is a joint venture company between Assmang of South Africa, Mizushima Ferro Alloy Company (MZK) and Sumitomo Corporation from Japan. Negotiations for the formation of the company started in 1992 with the joint venture agreement signed on the 19th September 1996. MZK was to supply the technical know how for the production of medium and low carbon ferromanganese while Assmang was to manage the day to day activities of the company. Sumitomo Corporation was to act as facilitator between Assmang and MZK and, together are with Ore and Metal responsible for the marketing of the product.

Proceedings: Tenth International Ferroalloys Congress; 1 – 4 February 2004
INFACON X: '*Transformation through Technology*' Cape Town, South Africa
ISBN: 0-9584663-5-1 Produced by: Document Transformation Technologies

The conceptual design of the plant started in December 1996 and the first charge of molten high carbon ferromanganese metal was charged on the 19th January 1998.

2. PRODUCTION PROCESS

Molten high carbon ferromanganese is supplied from Assmang's submerged arc furnaces.

The process is a decarburisation-based method developed by MZK. This features top blown oxygen injection via a water-cooled lance.

The refined metal is tapped into ladles and cast into fine metal casting trays. After removal the metal is allowed to cool to ambient temperature before being crushed and screened to customer specification.

The dust generated is collected and sold to the ceramic industry and the slag and excess dust to Assmang for use as ore supplement.

3. PROBLEMS DURING STARTUP

Various problems were experienced during the startup phase that had to be addressed. Examples are:

- High converter refractory consumption.
- Premature failure of the water-cooled lance tips.
- Low manganese yield.
- Higher than anticipated generation of fine metal with a lower than anticipated consumption of fine metal as coolant.
- Higher than anticipated sculling up of the ladles.
- Unacceptable material losses due to the burn through of the mehanite casting trays.
- Unpredictable failure of ladle refractory.
- Bridging of dust in the baghouse hoppers.

4. PRODUCTION RESULTS AND IMPROVEMENTS

The following improvements were achieved:

4.1 Reduction in the fine metal

A build up of –6mm material was experienced during the first 2 years of operation to the extent that CRA had ±5 000 ton of –6mm material on stockpile. This was due to the higher than anticipated generation of fine metal, lower than planned consumption of the material as coolant and the excessive sculling of the ladles.

The levels of fine metal are indicated in figure 1 below:

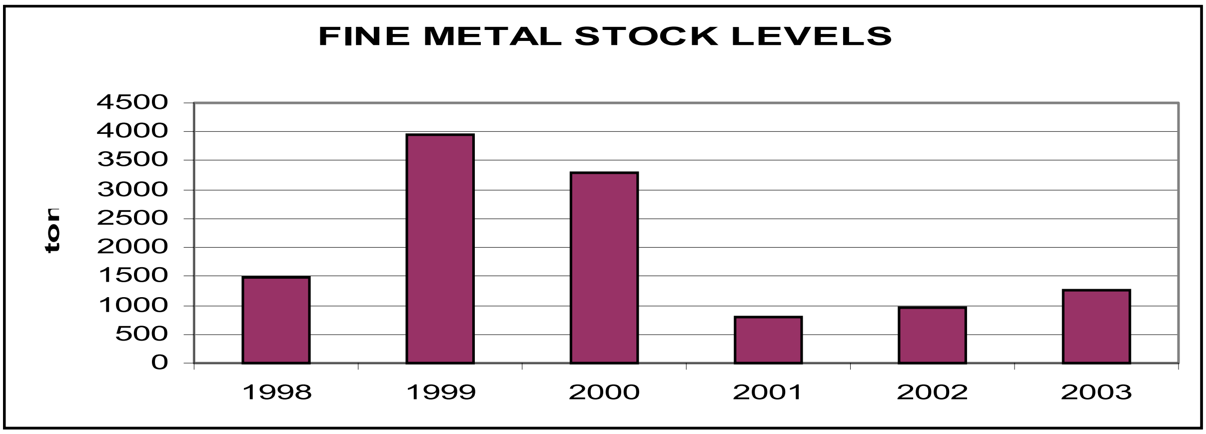

Figure 1. Fine metal stock levels.

The following steps were taken to reduce the stockpiled fine metal to a level of ±700 ton required for material in circulation:

4.1.1 Sale of fine metal
The first step taken was to develop a market for the fine metal to reduce the material on stockpile. Ore and Metal Company, the CRA sales agent was able to sell 7500 tons to customers who predominantly utilized the material for the manufacturing of nitrided FeMn.

4.1.2 Remelting of fine metal
Precharge
Fine metal was initially charged to the converter with the molten HCFeMn metal. The amount consumed was small.

4.1.3 Remelting with coke additions
A process was developed to remelt the fine metal by adding coke with the fine metal to act as a heat source. This enabled larger amounts of fine metal to be converted back to lumpy material. A total of 3800 ton of fine metal was remelted. The mass yield obtained on the fine metal remelted was 76% towards the end of the remelting campaign.

4.1.4 Increased consumption of fine metal
Metal was initially tapped via a runner into the ladles. This runner was removed and the metal tapped directly into the ladle. This prevented the generation of the runner sculls as well as reducing the ladle sculls. The tapping temperature could be reduced resulting in an increase in coolant consumption. It also enabled the feeding of fine metal to the ladle during the tapping process. Fine metal consumption as coolant was increased by 9.5%.

4.1.5 Improved crushing and screening plant operation
The crushing and screening plant was inefficient resulting in the generation of fine metal and the fines contaminating the larger size fractions going to the stockpiles. Material on stockpile had to be rescreened to meet the customer requirements. This resulted in the generation of additional fine metal. To improve the screening efficiency and reduce the generation of the fine metal the crushing and screening plant was upgraded by:

- Reducing the falling distances of the metal from the conveyor belts to the crushers.
- Installation of more efficient resonant screens.
- Installation of spiral chutes from the screens into the storage bins.
- Installation of luffing pans to allow the material to slide into the trailer from the product bin.
- Development of a plant model to predict the optimum crusher gaps.

The results achieved are indicated in Figure 2 below and show that the yield from metal cast to +12mm material improved on average by 7.0%.

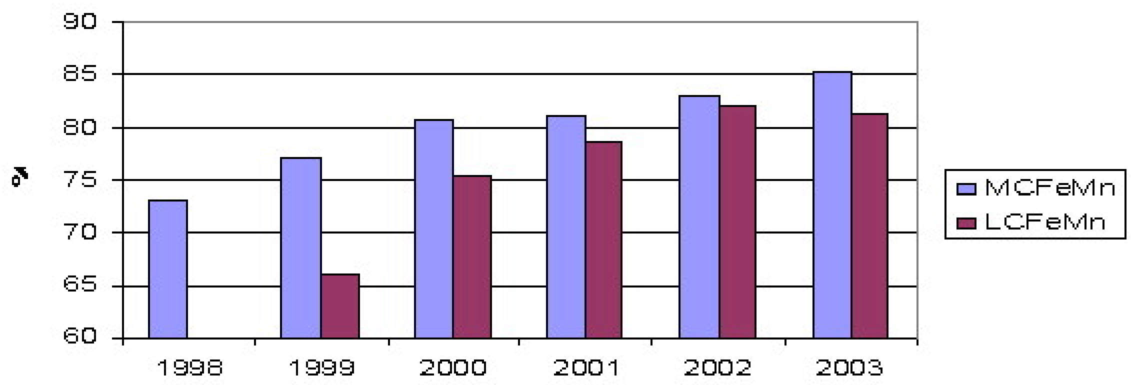

Figure 2. CRA crushing and screening plant yield.

4.1.6 Redesigned pallets

The pallets used for the cooling of the metal before being crushed were unsuitable, resulting in material falling off the pallets and having to be picked up and moved to the crushing and screening plant with a front-end loader. The pallets were replaced with pallets that prevented the spillage of metal from off the pallets and allowed for the movement of the metal to the crushing and screening plant by crane. This resulted in a reduction of 2% in the generation of −12mm material.

4.1.7 Improved inventory control

Due to the large amount of fine metal on stock unexplained losses of this material occurred. A computerized system was created to track the movement of this material. The information on the system is updated continuously when material is moved. This made it possible to know at any one time the amount of material in each location as well as the amount of material consumed and where it is consumed.

4.2 Improved Manganese Yield

The refining process mass yield was improved year by year by improving the manganese yield. The improvement in the mass yield is given in figure 3 below.

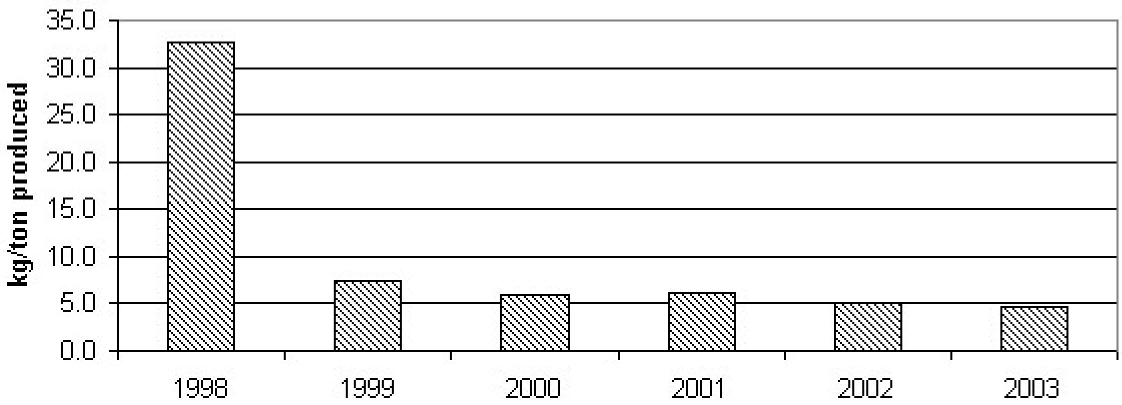

Figure 3. Mass yield improvement at CRA.

The manganese yield was improved by implementing the following:

4.2.1 Slag conditioning

The initial results during the plant startup were disappointing. After investigation it was found that analyses of the metal supplied by the electric furnaces differed from that of the shaft furnace being used at MZK resulting in a different slag forming during the refining process. Changing the flux additions to the converter rectified this and gave the required slag composition for refined manganese production.

4.2.2 Statistical process control

With the implementation of statistical process control it was possible to reduce the standard deviation from the average carbon content of the refined product. This enabled the operators to increase the average carbon of the product to 1.45% from 1.36% in the case of medium carbon FeMn and to 0.95% from 0.86% in the case of low carbon FeMn. (See figure 4 below) This reduced the length of blow times and thus improved the manganese yield.

4.2.3 Sample Taking Device

The taking of samples was improved with the installation of an in house developed sampling device. This device enabled the operators to take better samples closer towards the end of the blowing process. This allowed for better end point carbon prediction.

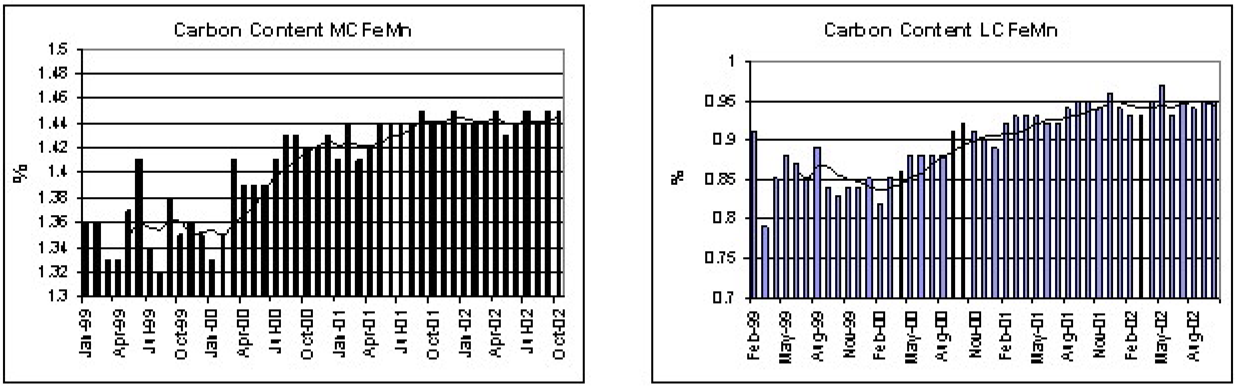

Figure 4. The average carbon content of MCFeMn and LCFeMn.

4.2.4 Changed blowing patterns

The blowing patterns were changed to improve the manganese yield.

The steps mentioned above resulted in an improvement of the manganese yield by 4.7% for medium carbon FeMn and 4.8% for low carbon FeMn.

4.3 Reduced refractory consumption

The following steps were instituted to improve the refractory consumption**:**

4.3.1 Converter refractory life

The following actions resulted in an increase in the converter life:

- Installation of cooling fans to increase the heat flow from the converter.
- The installation of thicker refractory in areas of high abrasion on the converters.
- Improved heating of new converters.
- Change the production schedules from producing LCFeMn in campaigns to producing LCFeMn between MCFeMn heats to allow for the cooling down of the converter.
- Slag conditioning through the addition of fluxing material.

The converter refractory life improve from an average life of 61.25 charges per working lining in 1997/1998 to 425.33 charges per working lining in 2002/2003. This represented graphically in Figure 5 as kg refractory consumed per tonne of product.

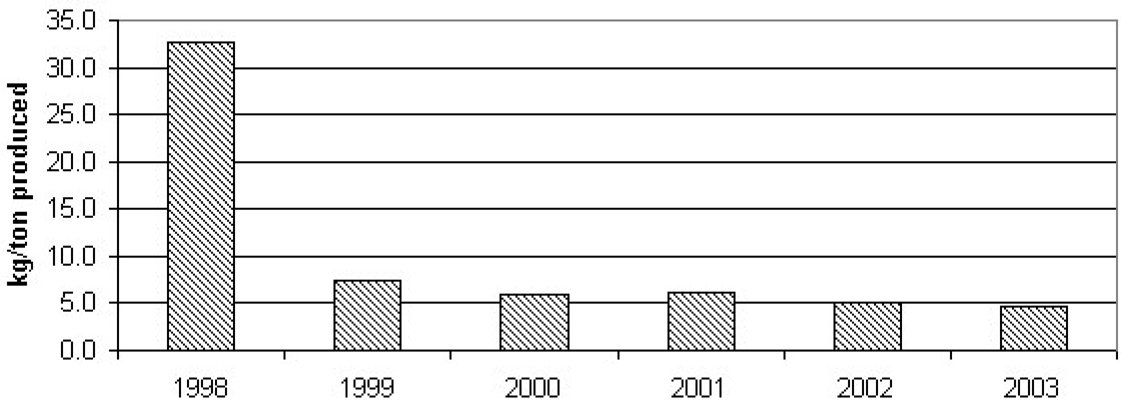

Figure 5. Improvement in converter refractory consumption, 1998 – 2003.

4.3.2 Ladle refractory consumption

The refractory consumption on the ladles was reduced by:

- Changing from 80% alumina brick to 80% alumina castable material.
- The use of a patch material that allowed for a partial repair of the ladles.
- Testing of various materials to find the material most suitable for the application.

The life of the refractory lining on the ladles increased from 45 charges to 450 charges per refractory lining.

4.4 Reduction in final product nitrogen

The nitrogen content of the refined product was initially very high. This resulted in problems with the marketability of the product. A procedure was developed whereby material with a nitrogen content of below 600 ppm can be manufactured.

The reduction of the amount of fine metal generated also assisted in bringing down the nitrogen content of the normal product to below 1000 ppm. This was achieved through the use of lumpy material that has a lower nitrogen content than the fine metal to replace a portion of the fine metal that is normally used as coolant. This resulted in less nitrogen being introduced into the refined ferromanganese during the production process.

4.5 General improvements

4.5.1 Replacement of mehanite casting trays

Assmang utilized mehanite casting trays for the cooling of high carbon ferromanganese metal. This practice was taken over by CRA. The mehanite casting trays could not however withstand the higher temperature at which the refined metal is cast. (1550ºC for refined material against 1350ºC for high carbon ferromanganese) The failure of the mehanite casting trays resulted in excessive loss of product.

The mehanite casting trays were removed and the refined metal is currently cast into metal fines beds. New Jersey Barriers are used to contain the fine metal. This change in practice resulted in a reduction of 80% in the annual cost for the casting trays and a 0.3% reduction in the production costs. An additional benefit obtained with casting into metal fines beds was the sintering of the fine metal resulting in the fines being converted to a lumpy product. The amount of sintering taking place was never determined due to other variables influencing the generation of fine metal at the time this practice was implemented. It would have however, contributed to the reduction in the generation of fine metal.

The use of the fine metal beds was so successful that this practice was transferred to the high carbon production as well, with great success.

4.5.2 Installation of sonic horns on Baghouse

Blockages were experienced in the baghouse due to dust bridging in the hoppers. After various alternatives was considered it was decided to install sonic horns on the baghouse. The sonic horn emits a low frequency sound that, due to the vibration, allows the dust to flow. These sonic horns are sounded in unison with the cleaning cycle on a baghouse compartment. The bridging was eliminated.

4.5.3 Improved welding on water cooled lances

Water cooled copper lancing tips are imported from Japan. The tips on the lances had to be changed after a period due to erosion. Premature failure of these tips was experienced with the start of CRA. It was found that the weld metal penetrated into the water channels. (See Figure 6 below) A welding specification was implemented. The welding of the copper tips to the lances was improved preventing obstructions in the water channels and thus improved the cooling. This increased the life of the lance tips from 116 blows to more than 1500 blows per tip.

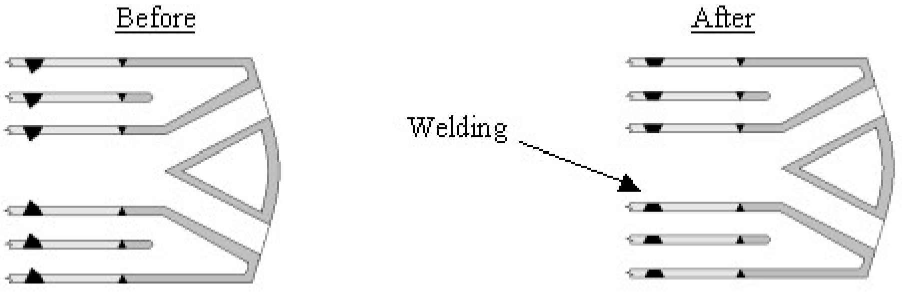

Figure 6. Joining of lance tips to lance before and after implementation of welding specification.

5. ACKNOWLEDGEMENTS

The authors want to acknowledge the contributions made by the personnel of Assmang, Manganese Division, Cato Ridge in compiling this report. The authors also acknowledge the permission from the Board of Directors of Cato Ridge Alloys (Pty) Limited to publish this paper.

6. CONCLUSION

The problems experienced during the startup of the refining plant of Cato Ridge Alloys PTY (LTD) were overcome through the implementation of various initiatives resulting in improved operations and increased profitability.

The following conclusions can be made from the experience gained during the startup:

- The most efficient manner to re-melt metal fines through the converter was through re-melting the metal fines with coke addition, with a mass yield of 76% being obtained.
- Through reducing the transfer points of molten metal during tapping of the converter it was found that coolant addition could be increased as tapping temperatures into the ladle can be increased and the casting temperature can be reduced.
- Manganese yields can be improved by changing flux additions to the molten metal, to be similar in analysis to the metal produced by MZK shaft furnace.
- A statistical, process control method and by varying blow patterns further improved manganese yields.
- Converter refractory life can be extended by improving heat flow around the converter, ensuring that the converter is not overheated through excessive low carbon FeMn production and through conditioning of the slag.
- Nitrogen levels in metal can be reduced primarily through charging larger sized coolant.
- Sonic horns using low frequency sound prevents bridging of dust in the baghouse.