

# ZIMBABWE ALLOYS FERRO CHROMIUM PRODUCTION: FROM CRADLE TO GRAVE SUSTAINABLY

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## ABSTRACT

*Initiatives that enhanced sustainability for Zimbabwe Alloys operations involved the retreatment of the chrome ore dumps maximizing the recovery of chromium units, the efficient use of chrome ores in the furnace and progressive recovery of alloy entrained in slag. These initiatives enhanced efficiencies at unit operations from mining, through furnaces and the Metal Recovery operations. The resultant slag from the Metal Recovery Plant retreatment has been successfully used to produce a variety of secondary products and has been already used for other practical uses as well. The Low Carbon Ferrochrome slag was used as a binder for briquettes during agglomeration, for PH control in Gold Plants, Construction and Agricultural purposes.*

*In addition, coke fines that had accumulated over the 50 year life of the operation were agglomerated and substituted virgin coke in the furnace saving on reductant cost.*

*Off the plant, initiatives involved the setting up of a productive irrigation scheme utilizing a water body from one of the Company's underground mines. This initiative has contributed significantly to the well being of a community in which Zimbabwe Alloys operates.*

## 1 INTRODUCTION

Mining and production activities commenced at Zimbabwe Alloys in 1953. This plant was the first ferrochrome plant in the continent. Operating costs for both mining and smelting processes were contained for most of the years Zimbabwe Alloys existed.

The mining was mainly open cast with minimum cost of production. Fines generated in the 50 year of mining activities were discarded. These fines were not suitable for furnace feed at the time.

Zimbabwe Alloys's production profile has seen it producing Low Carbon Ferrochrome, Ferrosilicon Chrome, High Carbon Ferro Manganese, High Carbon Ferrochrome and the different slags whose content included metal entrained disposed in a single stock pile.

Fluctuations in Ferrochrome prices which bottomed during recession times resulting in production cuts or streamlining of furnace operations gave rise to the focus on initiatives that enhanced sustainability for Zimbabwe Alloys operations. This included benefiting the communities in which the company operates.

This paper details the sustainable developments which to date have kept the business a step better than other ferrochrome producers in the country.

## 2 MINING

### 2.1 Chrome Ore Dumps Utilisation

Initially mining activities focused on extracting lumpy chrome ore with fines, irrespective of grade, being accumulated as dumps at the mining sties. The fines generated from lumpy ore in transit to the Refinery were screened off and formed another stockpile on site.

Fines dumps amounted to over 1.5 million tonnes were left at mining sites as they were considered to have no economic value. These fines resulted from lumpy chrome ore mining activities; jigging and spirals plants which were producing chrome ore concentrates for Low Carbon Ferrochrome production.

Shrinking margins in the ferrochrome industry due to falling ferrochrome prices and the high cost of underground mining operations impacted negatively on the Company's profitability. This compelled the Company to investigate possible use of chrome ore fines dumps. Fines that met a predetermined grade were briquetted and used as furnace feed. Fines that were low in grade were sent through an upgrading process using jigs and spirals. For most of these fines the process was a rerun. It was found out, however, that natural weathering had enhanced the upgradeability of the fines. The product of the upgrading process was briquetted and used as furnace feed.

Some fines dumps, however, could not be upgraded as they were too fine for further processing in the spirals plants. These were simply blended to form a suitable feed for briquetting. These dumps are shown in Table 1. They constituted 40% of the total dumps.

The use of fines as furnace feed impacted positively on the profitability of the Company and enabled the Company to absorb the shock of falling ferrochrome market prices which would have been otherwise devastating.

**Table 1:** Analysis of the dumps and the blended feed to the furnace without upgrading

	<b>%Cr<sub>2</sub>O<sub>3</sub></b>	<b>%Feo</b>	<b>Cr/Fe</b>	<b>%Mgo</b>	<b>%SiO<sub>2</sub></b>	<b>%Al<sub>2</sub>O<sub>3</sub></b>	<b>COI</b>
Jester Dump	47.0	29.5	1.4	7.3	7.1	6.8	1.3
Vanad Dump	27.0	10.5	2.5	27.0	16.8	5.6	6.0
Weighted average (60% Jester & 40% Vanad)	39.0	21.0	1.8	15.18	11.58	6.92	3.18

The final cost of the briquette delivered to the furnace was 12% of the delivered cost of lumpy chrome ores. Product quality was not comprised as this material delivered a product within the acceptable range for High Carbon Ferrochrome when further blended with high grade lumpy chrome ore or concentrates from the plants.

Jigging and spirals plants were used to upgrade the low quality chrome ore fines. The grade of feed and product quality attained from upgrading process is shown in Table 2 below. A briquetted furnace feed product was delivered at 18.1% of the cost of on-grade lumpy chrome ore due to the extra upgrading cost.

**Table 2:** Feed grade and Product quality from the upgrading plants

	<b>% Cr<sub>2</sub>O<sub>3</sub></b>	<b>Cr/Fe</b>
Feed	19.28	1.4
Product	47.5	2.2



**Figure 1:** Concentrates stockpile from one of the upgrading plants

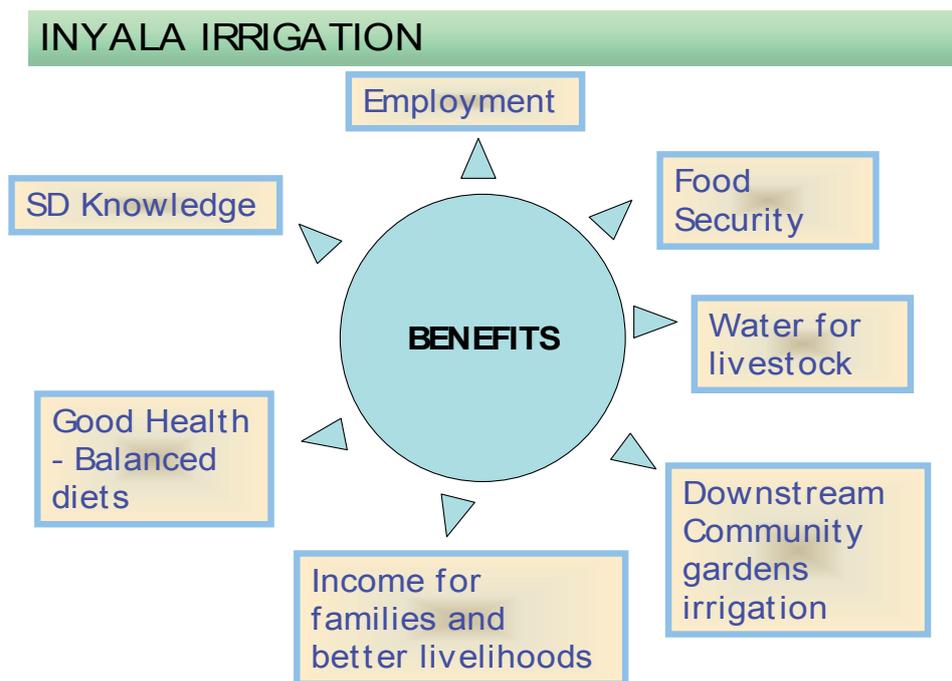
**2.2 Sustainable Community Engagement**

**2.2.1 The Need to Set Up An Irrigation Project**

One of the Mining areas lies South East of Gweru, the site of the Refinery. The area is prone to droughts as it lies in one of the regions receiving very low rainfall even in good years. The Community had depended on food handouts primarily due to the scarcity of water. The availability of a water body in the Company’s disused underground mine was seen as a way of alleviating this chronic water shortage. An initiative involving the setting up of a productive irrigation scheme using this water body was embarked upon. The project was initiated in 2003 after wide consultation with stakeholders including local leadership. A committee was selected to spearhead the irrigation scheme and underwent environmentally and other related project management training workshops to conscientise them on the best practices on such a project. Considerable social and economic benefits were derived from the Irrigation Scheme.

**2.2.2 Benefits Derived From The Irrigation Scheme**

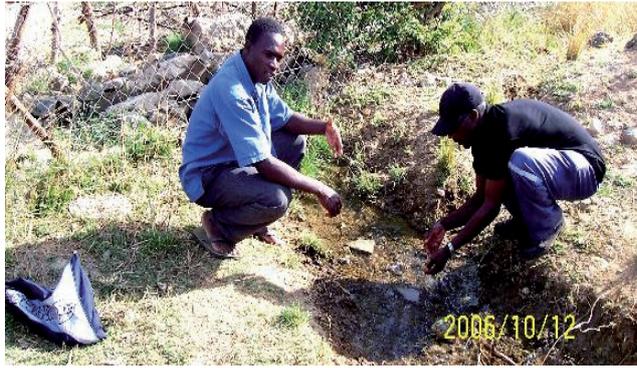
A number of benefits were derived from the project. Employment and the ability to generate income throughout the year made the Community self sufficient in many respects. The Community was not only able to feed itself but were also able to clothe and educate their children. This ability restored human dignity to the families involved as it obviated the need to receive the demeaning food handouts. The surrounding Community also benefited as they could purchase produce from the Irrigation Scheme without incurring huge transport costs due to proximity of the project to their homes.



**Figure 2:** Benefits derived from the irrigation project

Currently 10 000 m<sup>3</sup> /month of water is pumped from the shaft for irrigating the crops, which include wheat crop, balker wheat (which is not a winter crop can be grown all the year round), beans, tomatoes, vegetables and maize. 107 families have benefited from the scheme with a scope to integrate more families.

Below are some pictures from the community engagement irrigation project.



**Figure 3:** Trainee Arex Officer Showing the Water Supply



**Figure 4:** Beans, Tomatoes, Vegetables for the family



**Figure 5:** Balker Wheat on Trial



**Figure 6:** Winter Wheat Crop



**Figure 7:** Happy Family After Days' Wheat Harvest

## 3 REFINING

### 3.1 Briquetted Chrome Ore Fines Utilisation in the Furnace

Lumpy chrome ores remained the major expensive cost element in smelting which necessitated the need to increase the proportion of briquettes feed to the furnace sustainably. Increased use of fines resulted in improvement in production, power specific consumption, chromium recovery and chrome

ore specific consumption. Figures 8-11 illustrates the benefits and improvements realised when the proportion of briquette feed to the furnace was increased.

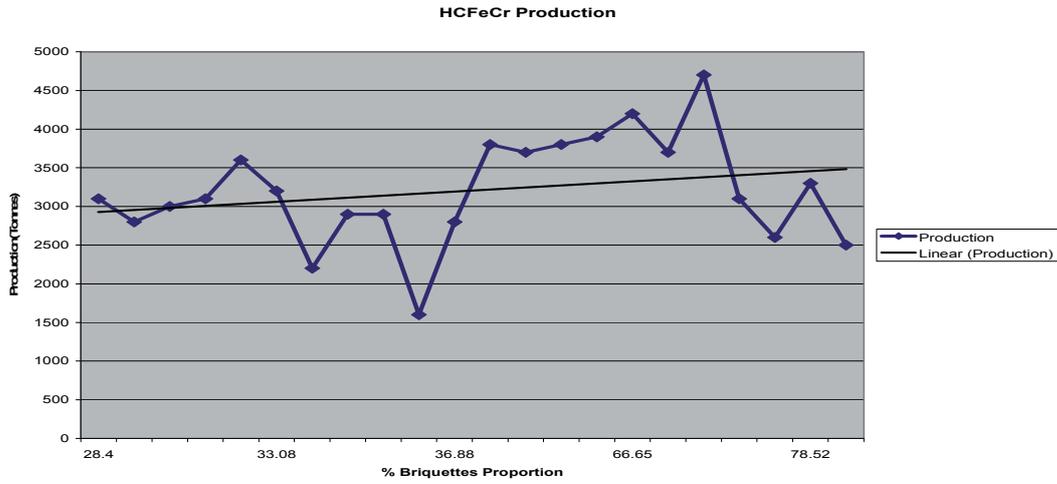


Figure 8: High Carbon Ferrochrome production

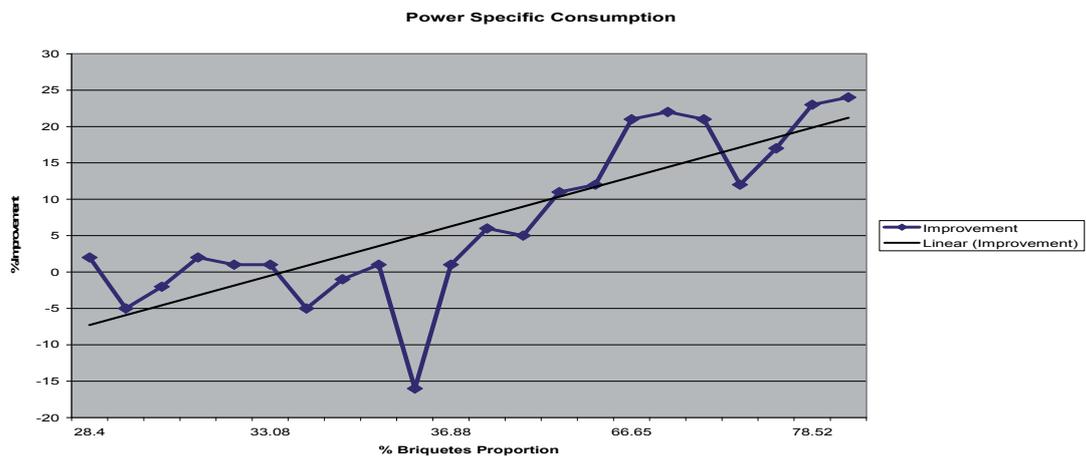


Figure 9: Power Specific Consumption

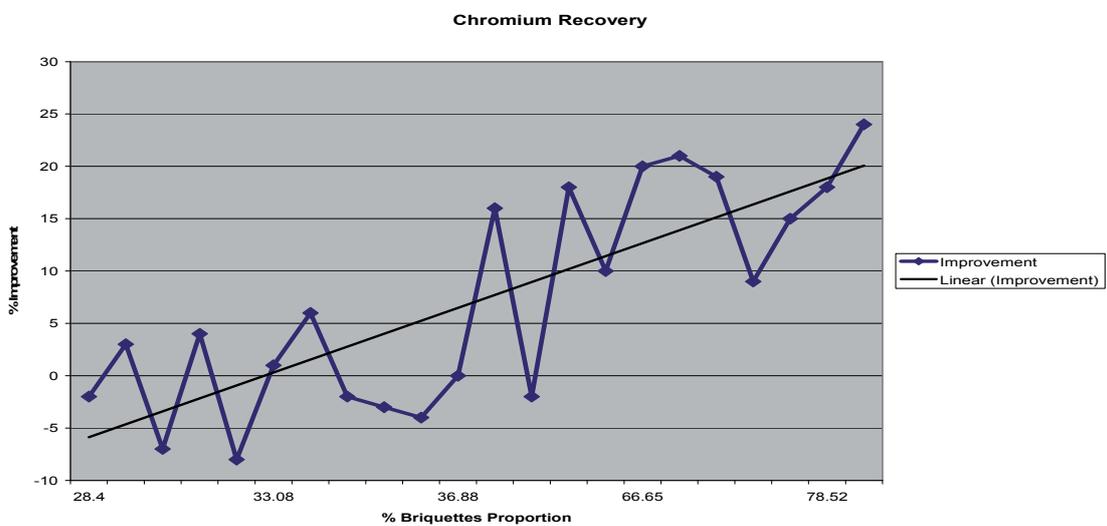
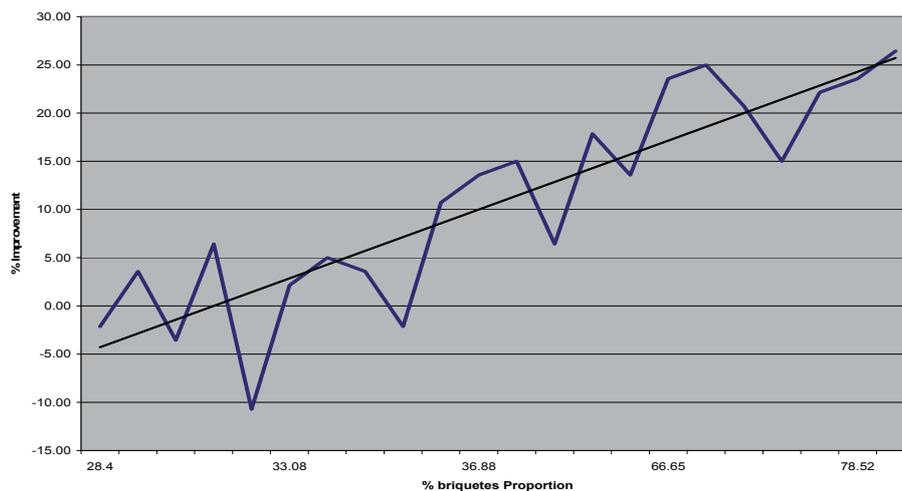


Figure 10: Chromium Recovery



**Figure 11:** Chrome Ore Specific Consumption

Improvements were attributed to an enhanced thermo-chemistry of a closely sized briquette feed consisting of temporarily bound fines with a higher specific surface area which in turn leads to improved reaction kinetics

The chromium recovery greatly improved resulting in less entrained alloy in slag as compared to the previous process.

**3.2. The Use of Briquette Coke Fines in the Furnace**

Zimbabwe as a country has always been producing abundant high quality coke for several years at affordable cost to the smelting companies. Economic difficulties the country has gone through saw the increase in cost of most inputs to the different manufacturing and Refining processes. The mining costs in the production of coke affected the delivery cost of the product to the customers. Cost of coke and deterioration in quality resulted in the shortage of quality coke to the processes.

Zimbabwe Alloys’s process of coke utilisation involved the screening off, of less than 12mm fines over the 50 years it operated. These fines have been stockpiled for years. Supply of virgin coke and quality challenges lead to the investigation of the use of fines. The coke fines utilisation was one of the cost effective options at the time and these fines were derived from high quality coke and therefore high quality themselves except for size.

Coke fines were briquetted using the Zimbabwe Alloys briquetting plant for use as reductant. An initial coke fines feed rate of 10% by fixed carbon was used to substitute virgin coke. Substitution of up to 30% was used sustainably saving on reductant cost. Below is a picture depleting stockpile of coke fines being briquetted and product fed to the furnaces.



**Figure 12:** Coke fines stockpile being mined for use in the smelting process

Furnace performance was not affected, neither the quality of product since the phosphorus content in the fines was 45% lower than that of the primary coke which favoured the increased use of briquetted coke fines as a substitute for virgin coke.

**Table 3:** Quality of coke used in the furnace feed and the product

Material Type	Phosphorus Content In Alloy%
100% medium phosphorus coke	0.040
100% metallurgical coke	0.030
30% Fines and medium phosphorus coke	0.034
30% Fines & Metallurgical coke	0.021

The cost to furnace of agglomerated coke fines reported to be only 7 % of freshly mined coke at current value.

## 4 SLAG TREATMENT

### 4.1 Alloy Recovery from the Slags

Zimbabwe Alloys was established in 1949, with production first recorded in 1953 being Low Carbon Ferrochrome. Ferrosilicon Chrome, High Carbon Ferro Manganese, Ferrosilicon and High Carbon Ferrochrome were products produced as well up to 1993 before a Metal Recovery Plant was built. This plant was commissioned to recover the various alloys from the slags of different products mentioned above. Four million tonnes of the different slags were treated during the first pass that had a top size of 40mm material to the jig producing the following different alloys.

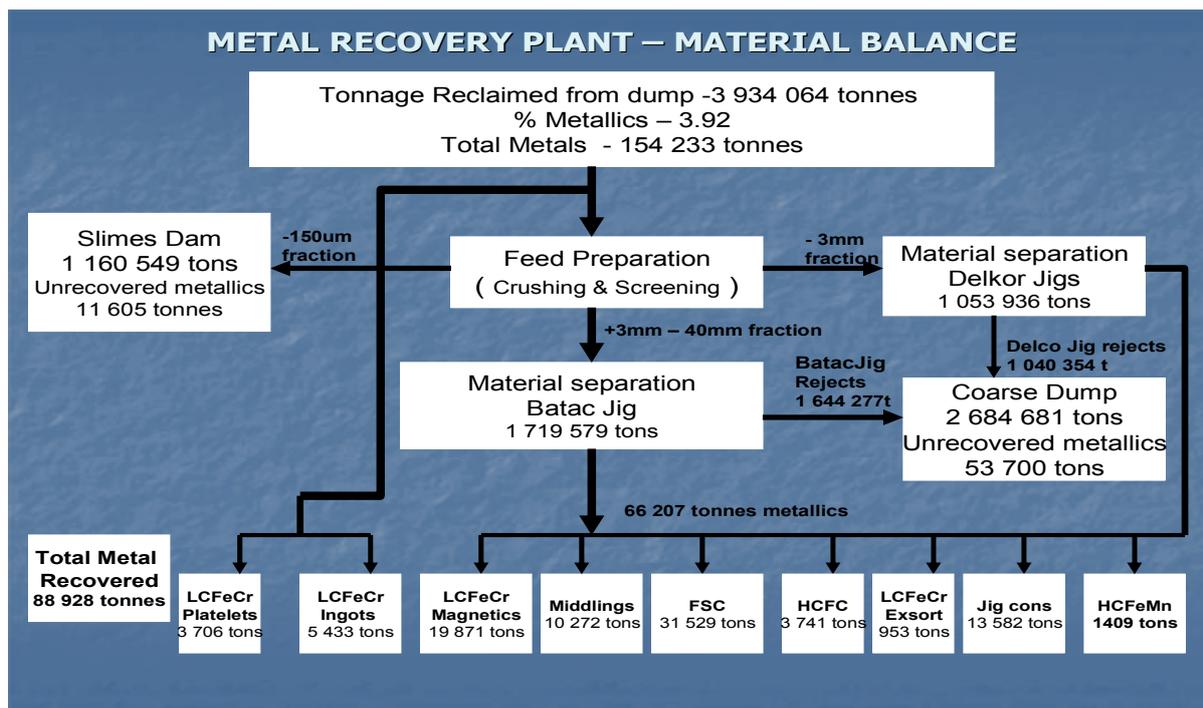


Figure 13: Breakdown of alloy production on first treatment of the slag stockpile

4.2 Retreatment of Slag

Due to continued challenges in the cost structure of the ferro alloys with margins decreasing in the conventional smelting processes Zimbabwe Alloys investigated the retreatment of the four million tonnes of slag from the first pass. A feasibility study was carried out and revealed further alloy production from the slag after liberating to less 19mm from a top size of 40mm from the first treatment process.



Figure 14: Part of the four million tonnes of slag dump from the first pass undergoing retreatment

A new separation plant was commissioned in September 2007 which is shown in figure below.



**Figure 15:** The Separation Plant to recover alloy from retreating the slag

The distribution of the alloy from the jig product is as follows:

- 60% Ferrosilicon
- 30% High Carbon Ferrochrome
- 7% Low Carbon Ferrochrome
- 2.1% High Carbon Ferro Manganese
- 0.75% Ferrosilicon

Alloys from the jiggling process were successfully separated using magnetic means. A huge tailings with a top value size of 19mm was created and this became an environmental challenge. The economic use of the tailings namely the 0-6mm fines and 6-19mm material was investigated. Production of bricks was the most successful for the 0-6mm fines realizing a production rate of 3.6 million units per year.

The 6-19mm material is being used for civil construction around the country. It is important to note that all the approval and tests were carried out by Independent bodies with certification thereafter.

## 5 CONCLUSION

Innovative initiatives must always form part of the strategic objectives for most ferrochrome operations to ensure sustainability in the short to long-term due to unpredictable demand changes in the market which impact on the selling price.

Community engagement is also as important as our business operations as this will create small enterprise development, empowerment and partnerships that lead to positive sustainability for both parties.

