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Metal Waste Management in Geothermal Drilling Systems- KenGen Olkaria Case Study

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ABSTRACT

Drilling operations generate significant amounts of waste metal in geothermal operation areas, which, to a great extent, subtracts from the effort put into conserving environments in such systems. Organizations involved always spend money in an effort to clear such waste, leading to additional costs in the already expensive operations. This problem can be remedied by recycling metal waste within the geothermal systems. This, when adopted, will go a long way in not only contributing to environmental conservation but also earning additional revenue for the company, as well as creating employment opportunities.

This paper proposes the setting up of a steel milling plant within the Olkaria Geothermal area. The milling plant, when operational, will make use of the waste metal generated during drilling and other operations within the geothermal system to produce metal products for construction and other applications. These can be used internally, but the bulk can be sold to external markets. Advancement of this plant can be prospected to produce drilling materials for geothermal systems.

The steel mill proposed in this paper should be based on an electric furnace model, which will take advantage of available electricity and space within the Olkaria geothermal system.

1. INTRODUCTION

Recycling metal waste using an electric arc furnace is a method that has been used and proven to be economically viable. Coupled with the fact that significant waste metal is generated during geothermal drilling and other proceeding and preceding operations, this paper proposes recycling of the wastes through this method as a way of mitigation to curb the negative impact that the waste poses to the environment, especially because the Olkaria Geothermal system is located within the Hell's Gate national park.

The case study in this paper is the Kenyan Olkaria Geothermal system, which attracts the largest geothermal drilling operations in Africa. The practice regarding metal waste management has been collecting and disposing of the metal waste as scrap metal, according to government-laid-down procurement and disposal procedures, which often delay the collection process. This has led to the piling up of waste to the detriment of environmental conservation efforts. Some of the photos attached clearly illustrate this challenge.

1.1 Objectives

The main objectives of this proposal are

- ✓ To properly manage waste metal in a manner that conserves the environment.
- ✓ To reduce additional costs associated with other methods of waste metal management and disposal.
- ✓ To generate additional revenue for the company

2.0 PLANT SETTING

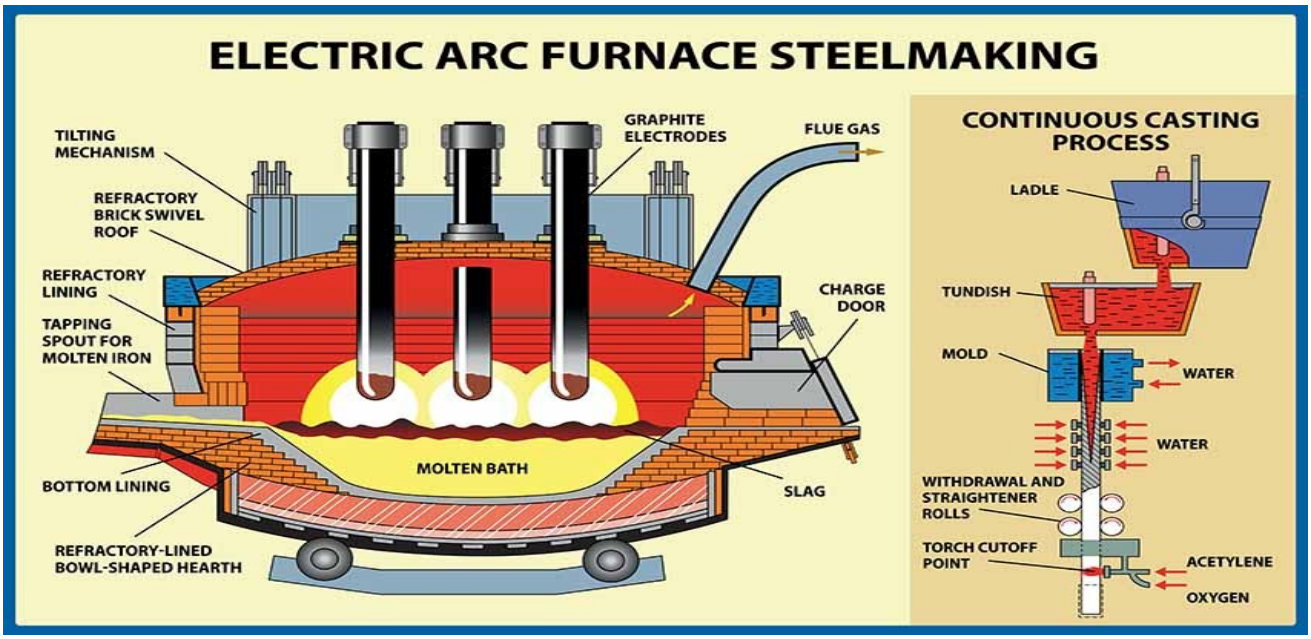
2.1 Location

The recycling plant should be put in an area with a stable and sufficient electric power supply. The area must also be easily accessible by vehicles expected to deliver waste metals in and carry products out.

2.2 Equipment and machinery

2.2.0 Electric arc furnace.

An electric arc furnace with a power efficiency of 280-400 KwH/Ton is ideal for this project. Such a furnace is capable of handling 30 tons at a time. Modern electric furnaces available in the market now come with a furnace body, a lifting platform, a water-cooled furnace cover, and a smoke-collecting device. They also come with hydraulic systems, Argon blower system, and a ladle furnace transformer.



2.2.1 Rebar machine

The proposed plant will require a rebar-producing machine, which will use the red-hot iron produced from molten iron to make construction rebars of different sizes, as this is the proposed initial product expected when the plant is set up and operational. These machines are available in the market.


2.2.2 Metal shredder

Metal shredder is essential in this proposed plant as waste metal produced in drilling and related operation are quite bulky, and requires slicing up into workable pieces. This also helps in the efficient melting of the metals.

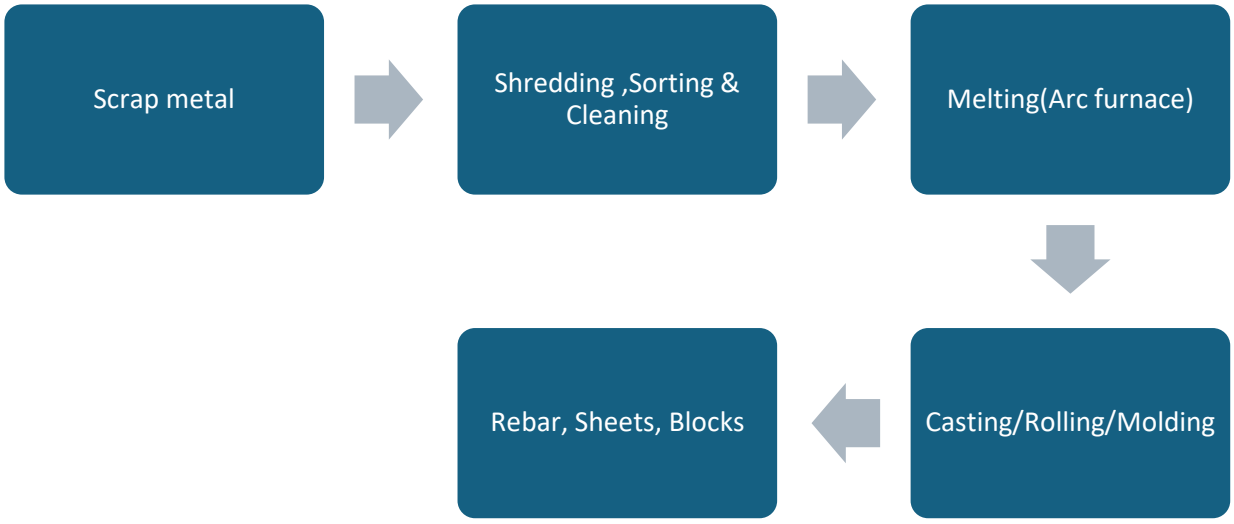
2.2.3 Magnetic lifts/Excavator fitted with grab/Magnetic separators

Any of the above equipment can be used to feed metals in both the shredder and the electric arc furnace.

3.0 METHODS AND PROCEDURE

- ✓ **Collection & Sorting**-Waste metals are collected to a central place, sorted, and shredded.
- ✓ **Furnace feeding**-A crane fitted with a grab, or a magnetic holder drops the shredded scrap metal into the electric arc furnace.
- ✓ **Liquefaction**- The furnace roof is closed and the graphite electrodes lowered, after which a high voltage electric arc is struck between the electrodes and the scrap, generating temperatures of up to 3000 °C, which is high enough to liquefy the metal.
- ✓ **Purification**-Oxygen and Carbon are injected to remove non-metal impurities such as Sulphur and Phosphorus.

  $C+O_2$----------$\rightarrow CO_2$
  $4P+5O2$----------$\rightarrow P_4O_{10}$
  Carbon (IV) Oxide can be scrubbed off by using a strong alkali. Phosphorus pentoxide is acid anhydride of Phosphoric acid, and can be useful both as a dehydrating agent in other applications and as a desiccant.
  Lime is also added to remove the solid impurities as slag.
- ✓ **Deslagging**-The furnace is then tilted to pour out the slag
- ✓ **Tapping**- Once the molten steel is sufficiently cleared of impurity, it is finally tapped from the bottom into the transport ladle.
- ✓ **Secondary treatment**- the molten steel can then be directed by the ladle to a secondary furnace where improvements on the quality can be done, such as alloying to further improve its properties depending on the anticipated use.
- ✓ **Casting/Molding –** The molten steel is then poured into a caster to solidify into semi-finished shapes, which can later be used to produce products like sheets. The liquefied metal can also be solidified and fed into rebar production.



The waste products associated with this process are mainly slag and sludge. Slag can be used on the rough roads within the park, while sludge can be used as landfill or repurposed for water filtration.

4.0 BENEFITS OF RECYCLING WASTE METAL IN OLKARIA GEOTHERMAL SYSTEM

- ✓ It is a mitigation measure in curbing pollution, contributing to environmental conservation.
- ✓ It has the potential to increase revenue for the company through sales of the products
- ✓ Creation of employment opportunities at the recycling plant.

Cost-Benefit Analysis

- **Introduction**

This report provides a brief cost-benefit analysis (CBA) for recycling 300 tons of metal waste generated annually from drilling operations in Olkaria using an electric arc furnace to produce metal rebars. The analysis incorporates updated details: equal production of D-10, D-12, and D-16 rebars (100 tons each), processing completed in one month at 10 tons per day, additional monthly costs of KShs 100,000 for maintenance and transport, free electricity, and four temporary workers employed for one month at KShs 50,000 each. All figures are converted to US Dollars (USD) using the current exchange rate of approximately 1 USD = 129 KES (mid-market rate as of January 30, 2026). A 100% yield is assumed, with all waste converted to rebars.

- **Key Assumptions**

  - Rebar weights per 12m bar (based on standard deformed steel specifications): D-10 ≈7.41 kg, D-12 ≈10.67 kg, D-16 ≈18.96 kg.
  - Revenue calculated precisely using per-bar prices and weights: D-10 at $6.59 (KShs 850), D-12 at $9.30 (KShs 1,200), D-16 at $18.60 (KShs 2,400).
  - The plant operates for one month annually to process the 300 tons, incurring labour and additional costs only during this period.
  - No other operating costs (e.g., consumables beyond specified) or taxes are included.
  - Analysis uses a 5-year time horizon with no discount rate applied. Equipment is assumed to last at least 5 years without depreciation.

- Market demand and prices remain stable; no inflation adjustments.

Costs

Initial Capital Costs (One-Time)

- Electric arc furnace: $77,519.38 (KShs 10,000,000)
- Heavy-duty rebar bender: $1,550.39 (KShs 200,000)
- Installation, labour, and fittings: $38,759.69 (KShs 5,000,000)
- **Total Initial Costs**: $117,829.46

Annual Operating Costs

- Labour (4 workers × $387.60/month × 1 month): $1,550.39 (KShs 200,000)
- Maintenance and transport: $775.19 (KShs 100,000)
- Electricity: $0.00
- **Total Annual Operating Costs**: $2,325.58

- **Benefits**

Annual Revenues

- Total rebars produced: 300 tons (100 tons each type)
- Revenue per ton: D-10 ≈$889.53, D-12 ≈$872.09, D-16 ≈$981.02
- **Total Annual Revenues**: $274,273.26

Net Annual Benefits

- Net Annual Benefits = Annual Revenues - Annual Operating Costs = $274,273.26 - $2,325.58 = $271,947.67

- **Analysis**
  - **Payback Period**: The initial investment of $117,829.46 would be recovered in approximately 0.43 years (about 5 months) based on net annual benefits.
  - **Total Revenues Over 5 Years**: $1,371,366.28
  - **Total Costs Over 5 Years**: $129,457.36
  - **Net Benefits Over 5 Years**: $1,241,908.91
  - **Benefit-Cost Ratio**: 10.59 (total revenues / total costs), indicating exceptional viability and profitability, driven by low operating costs (including free electricity) and strong rebar margins.

The project is highly beneficial, with revenues far exceeding costs. No additional information is required based on the provided updates.

5.0 CONCLUSION

This paper demonstrates that metal waste recycling within the OLKARIA geothermal system can be beneficial both to the organization involved and also greatly contribute to environmental conservation efforts. This paper, therefore, strongly recommends the adoption of this proposal and invites interest in improving it and filling any gaps that can enhance the implementation effort. As this is a novel idea in this area, there is a need to quantify the waste metal generated within an agreed period of drilling so as to come up with an accurate, cost-effective analysis of this proposal.

6.0 REFFERENCE

Electric arc furnace photo www.lmmgroup.com, https://share.google/VrmoqzdSqy8cd7TIk

Rebar machine photo Darhung Machinery, https://share.google/PDzY5kYYpeXIixsVM

The photos of waste metals (silencers, drilling pipes, et cetera were taken within the Olkaria Geothermal complex.