



**2024 ENGINEERING INSTITUTION OF ZAMBIA
SYMPOSIUM**

**ADVANCES IN SCRAP METAL SORTING TECHNIQUES
FOR ENHANCED RECYCLING EFFICIENCY: A CRITICAL
REVIEW**

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Avani Victoria Falls Resort, Livingstone, Zambia



INTRODUCTION

- Recycling and waste management are critical for sustainability and resource conservation.
- There has been significant advancements in scrap metal sorting techniques, largely influenced by the rising demand for recycled metals.
- To optimize resource recovery and minimize wastage, the adoption of efficient sorting methods has become imperative.
- 85% of the total waste generated in zambia consists of valuable materials whose value is currently unrealised to its full potential.
- Metal scrap amounts to only 9% of the total waste generated in zambia.
- Zambia generates about 335.5 thousand tons of scrap metal annually of which steel and iron are the most recycled in zambia.



INTRODUCTION

- Only 12% of scrap metal recycling companies in Zambia use modern technology.
- 88% of scrap metal recycling companies in zambia use traditional sorting techniques.
- There is \$54 million in potential revenue from scrap metal.
- Due to lack of proper sorting machinery,most scrap metal in zambia is exported.
- Zambia spends an estimated \$909 million on importation of mechanical equipment.
- Market feedback suggests that while there is some activity in producing small parts for the mining industry, local parts' quality falls short in comparison to imported alternatives.



SCRAP METAL SORTING TECHNIQUES

TRADITIONAL

- Hand sorting
- Magnetic sorting
- Eddy-current separation
- Floation sorting
- Gravity based separation

MODERN

- Near infrared spectroscopy
- Xray fluorescence spectroscopy
- Laser induced breakdown spectroscopy
- Hyperspectral imaging
- optical based sorting
- Robotics and artificial intelligence
- Integrated sorting techniques

TYPES OF SCRAP METAL

HOME SCRAP

- Internally generated in the original production process of the metal.
- Rarely leaves the production area.
- Accounts for approximately 29% of total scrap metal.

(A. Javaid and E. Essadiqi 2003)



TYPES OF SCRAP METAL

NEW / INDUSTRIAL SCRAP

- Generated in metal-product manufacturing plants.
- Includes turnings,clippings and stampings left overs.
- Accounts for approximately 23% of total scrap metal.

(A. Javaid and E. Essadiqi 2003)



TYPES OF SCRAP METAL

OLD/ POSTCONSUMER SCRAP

- Generated when industrial and consumer products have served their useful life.
- Includes automobiles, appliances, buildings and railroads.
- Accounts for approximately 48% of total available scrap metal.

(A. Javaid and E. Essadiqi 2003)



FACTORS AFFECTING THE SELECTION OF APPROPRIATE SORTING TECHNIQUES

FACTORS

- Type of scrap waste material
 - Volume of scrap waste
 - Desired product quality
 - Available resources
- (Capuzzi, S., & Timelli, G. 2018)

- Effective recycling relies on effective and efficient sorting.
- Sorting is arguably the most integral part of the scrap metal recycling process.
- Thus, it is necessary to understand when the benefits outweigh the required investment.



TRADITIONAL SCRAP METAL SORTING TECHNIQUES

HAND SORTING

- **Working principle;** manual inspection and separation of scrap metal based on color, weight, texture and shape.
 - **Application;** remains essential, especially when automation is impractical or specific sorting criteria demand human judgment.
 - **Limitations;** labor intensity, human error, limited efficiency, safety concerns and inconsistencies.
- (Anderson & Larson, 1957;Rem et al., 2012)



TRADITIONAL SCRAP METAL SORTING TECHNIQUES

MAGNETIC SORTING

- **Working principle:** magnetic attraction.
- Variants include belt-type or the drum-type.
- **Application**
- Efficient separation of ferrous metals from other scrap materials.
- **Limitations**
- Exclusive focus on ferrous materials.
- dependence on magnetic field strength.

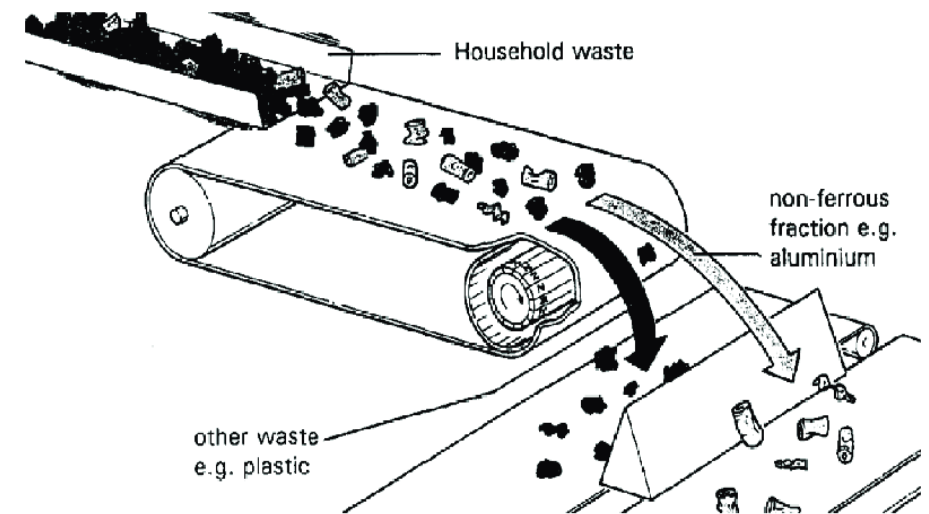
(Lin Jiexiong, 2020; Padamata et al., 2021)



TRADITIONAL SCRAP METAL SORTING TECHNIQUES

EDDY-CURRENT SORTING

- **Working principle:** electromagnetic induction.
 - **Application:** applied in the separation of non-ferrous metals like aluminum, copper and brass from scrap material streams.
 - **Limitations**
 - Issues of material conductivity
 - efficiency with fine particles
 - maintenance requirements
- (He et al., 2010)

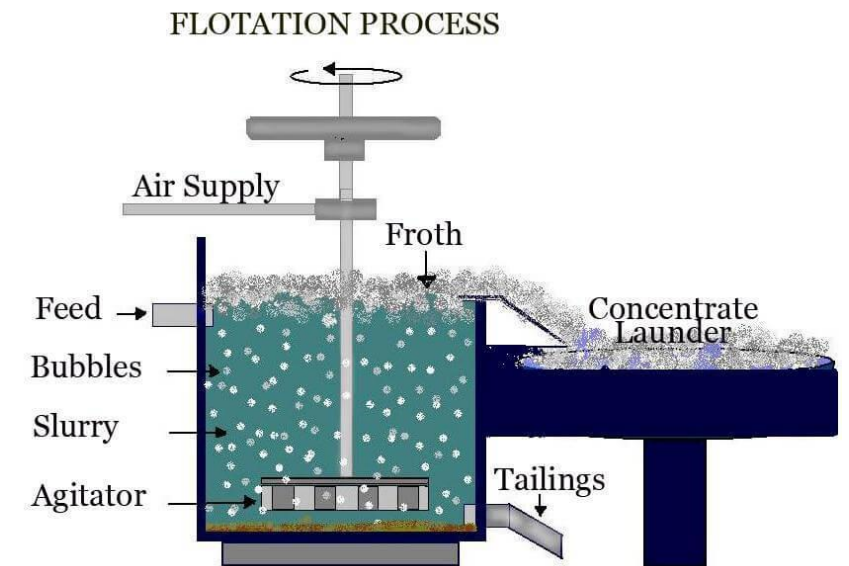


TRADITIONAL SCRAP METAL SORTING TECHNIQUES

FLOTATION SORTING

- **Workig principle:** differential hydrophobicity.
- **Application :** separation of non-ferrous metals from non-metallic materials usually at a very large scale.i,e copper.
- The multi-step process invloves preparation, reagent addition, froth creation, froth separation, concentrate collection, and tailings disposal.
- **Limitatons**
 - tailings management
 - energy consumption
 - maintenance requirements

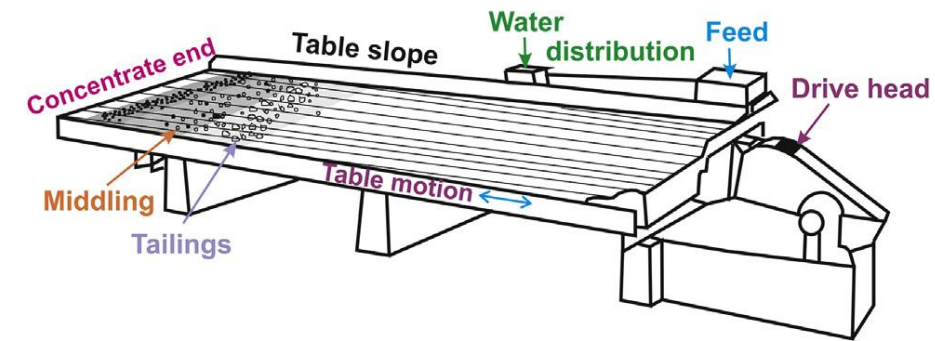
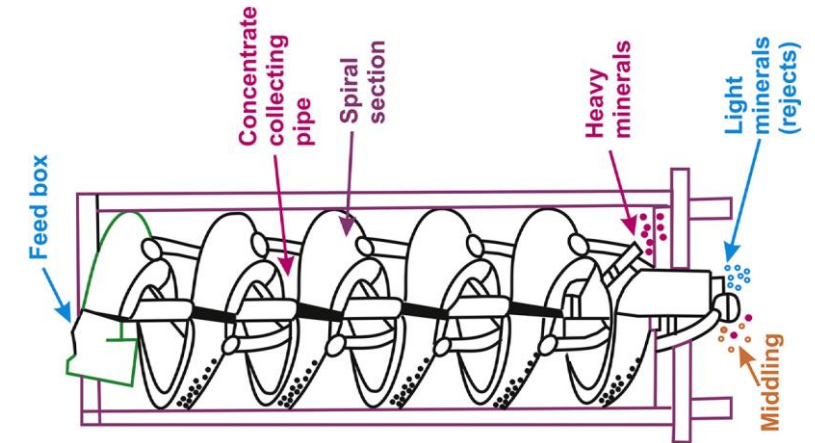
(Chen Shanhui et al., 2018, Lee Yeoung Hun, 2009)



TRADITIONAL SCRAP METAL SORTING TECHNIQUES

GRAVITY BASED SORTING

- **Workig principle:** Varying densisties .
 - **Application:** separation of heavy from lighter metals.
 - common techniques include shaking tables, spiral concentrators, jigs, heavy media separation, cyclones, hydrocyclones, and spirals.
 - **Limitatons**
 - incomplete separation ,
 - difficulty handling fine particles,
 - limited applicability to complex mixtures.
- (mineral processing,13.p260-290)



MODERN SCRAP METAL SORTING TECHNIQUES

NEAR INFRARED SPECTROSCOPY

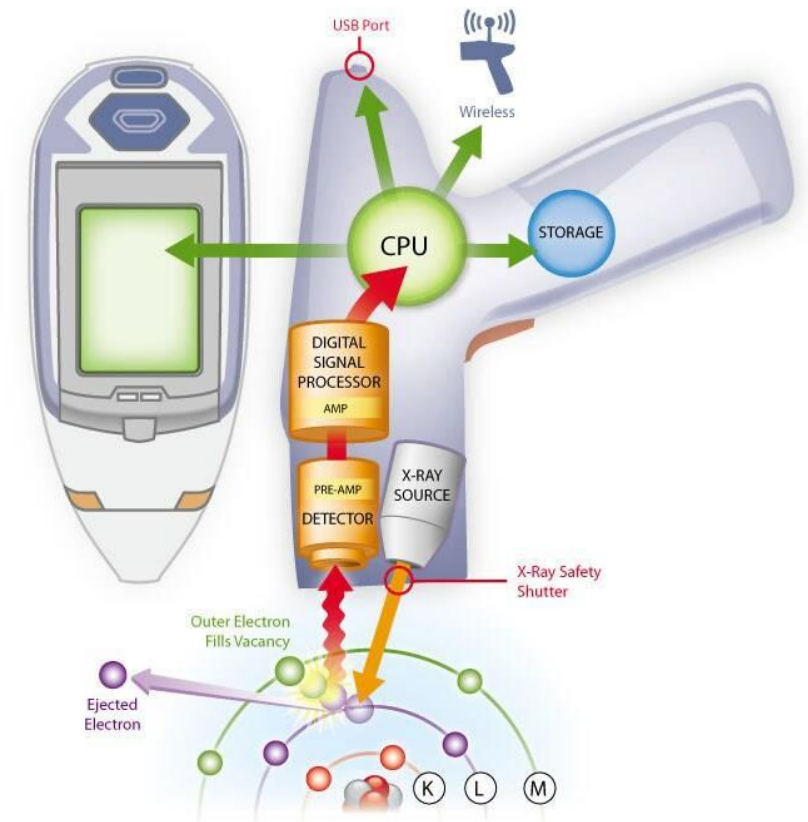
- **Working principle:** interaction between near-infrared light and the molecular vibrations of the sample.
 - Aids quick and contactless analysis
 - **Application**
 - Alloy identification
 - contaminant detection
 - quality control
 - **Limitations**
 - calibration requirements,
 - spectral interferences
 - cost and complexity
- (Brooks, 2021)



MODERN SCRAP METAL SORTING TECHNIQUES

X-RAY FLOURESCENCE SPECTROSCOPY

- **Working principle:** interaction between X-rays and the atoms of a sample
- types include EDXRF and WDXRF
- **Application:** applied in industrial automated sorting processes and Handheld Analyser.
- **Limitations:**
 - shallow depth of analysis,
 - susceptibility to matrix effects,
 - quantifying light elements
 - instrument calibration

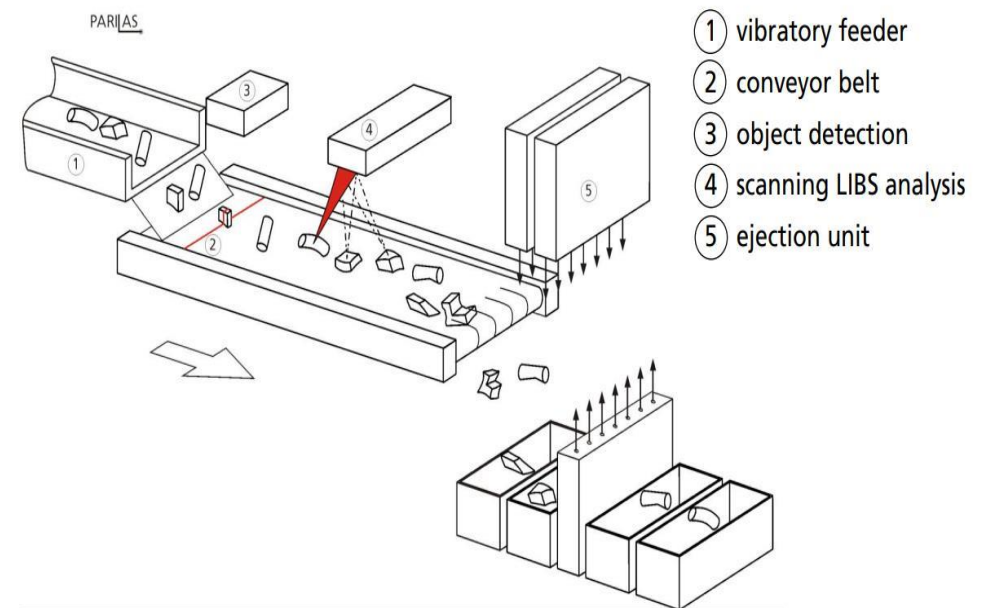


(Torek, 2012; Hasan et al., 2011; Y. Huang, 2018).

MODERN SCRAP METAL SORTING TECHNIQUES

LASER INDUCED BREAKDOWN SPECTROSCOPY

- **Working principle:** involves the use of a high-energy laser pulse to generate a plasma plume on the surface of the material being analyzed.
 - types include Bulk and Micro LIBS
 - **Application:** Applied in handheld analysers and offers rapid, non-contact elemental analysis of scrap materials,
 - **Limitations**
 - matrix effects,
 - limited detection sensitivity,
 - surface sensitivity
- (Brooks, 2021, Shen et al., 2020)



MODERN SCRAP METAL SORTING TECHNIQUES

HYPERSPECTRAL IMAGING

- **Working principle:** utilizes the principle of capturing and analyzing the spectral signature of materials.
- System types include: pushbroom, snapshot, whiskbroom, spatial scanning, spectrograph-based, and filter-based.
- **Limitations**
 - data processing
 - cost
 - complexity of the systems

(Deitermann Alex, 2018 Francesco Grazzi et al., 2019)



MODERN SCRAP METAL SORTING TECHNIQUES

ROBOTICS AND ARTIFICIAL INTELLIGENCE

- **Working principle:** integration of robotic systems with advanced AI algorithms to identify, classify, and sort different types of materials in scrap recycling facilities.
- **Limitations**
 - Scalability and Flexibility
 - Maintenance and Downtime
 - Limited Adaptability
 - initial investment cost

(Auer et al., 2019; X. Huang et al., 2021)



MODERN SCRAP METAL SORTING TECHNIQUES

INTEGRATED SORTING SYSTEMS

- **Working principle:** relies on the combination of various technologies.
- **Includes;**
 - Robotics and artificial intelligence
 - High-speed and high-resolution sensors
 - Machine learning algorithms for real-time sorting
- **Limitations**
 - complexity and cost
 - contamination and impurities
 - size and shape limitations
- (Wang Yanyan & Tian Yanqing, 2018)



CONCLUSION

- Traditional scrap sorting techniques have been widely used but come with limitations in terms of time consumption, labor-intensive processes and difficulties in distinguishing between similar metals.
- However, traditional techniques can be used where automation seems impractical to apply or where human judgement is required.
- The integration of conventional and advanced scrap metal sorting techniques has significantly improved the efficiency, accuracy, and environmental impact of scrap metal recycling.



The End

THANK YOU FOR YOUR ATTENTION.

