Designing a characterisation toolkit to provide frequent and objective measurements of ferrous scrap quality.

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ABSTRACT

Amongst the carbon emission reduction solutions available to the steel industry, increasing the proportion of recycled content in new steel is a method with a technology readiness level suitable for immediate deployment. There are many barriers to using more steel scrap in the production of steel, one being the ability to measure the quality (chemical composition) of this end-of-life material. This poster reviews preliminary X-Ray Fluorescence (XRF) work showing that surface contamination has an influence on the reliability of XRF results. In addition, exploratory X-Ray Computed Tomography (X-Ray CT) and radiography scans indicate promising results for identifying different materials to metallurgically meaningful parameters due to differing X-Ray absorption behaviours. Ready detection of extrinsic contaminants has been shown to be possible under ideal conditions. The development of this technique to more industrially representative environments (increased and more variable feedstock) will follow as an essential next step to real life use.

BACKGROUND

- Increased volumes of ferrous scrap whether in a Blast Furnace (BF), Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF), are known to provide significant carbon dioxide emission and raw material savings.[1]
- End-of-life scrap has the potential for detrimental levels of undesirable extrinsic and intrinsic residual elements.[2,3] Extrinsic contaminants e.g., Cu and intrinsic elements Cu, Sn, Ni, Cr & Mo.
- Handheld XRF devices are used in scrap yards to determine the types of scrap present.[4]
- Handheld XRF unable to monitor large volumes of material in an appropriate timescale.
- Knowledge gap: There is a limited availability of rapid, scalable, characterisation techniques suitable for analysing the composition of end-of-life scrap.

Figure 1. Typical 3B Fragmented scrap.

Handheld XRF of Fragmented scrap

Surface condition	Fe (%)	Si (%)	Mn (%)	P (%)	S (%)	Cu (%)	Ni (%)
As-received	95.04	3.76	0.39	0.20	0.16	0.06	0.07
Ground	98.88	0.61	0.33	0.11	0.02	0.02	0.02

Table 1. XRF data from single piece of 3B Fragmented scrap showing the effect of surface contamination (oxidation).

- Table 1 shows that surface contamination affects the elemental analysis results.
- Surface preparation, recommended by device manufacturers, is not practical for large scrap volumes.
- Handheld XRF is a time-consuming analysis technique with limited reliability due to influence of the surface composition.

X-Ray Computed Tomography (X-Ray CT)

- X-Ray CT scan of non-magnetic shredder fraction containing Al, Cu, brass and polymeric material (figure 2).
- Slow scan times with too much detail for scanning large volumes of end-of-life scrap.
- X-Ray CT could give **offline** quality control sampling to estimate:
  - Surface area and volume of sample.
  - Volumes of 'denser' materials (e.g. copper - figure 3).
- Surface area and packing density data could be useful for steelmaking process models.

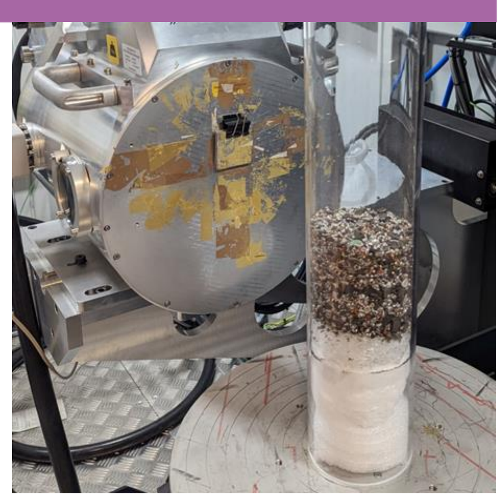


Figure 2. X-Ray CT scanning of non-magnetic shredder fraction.

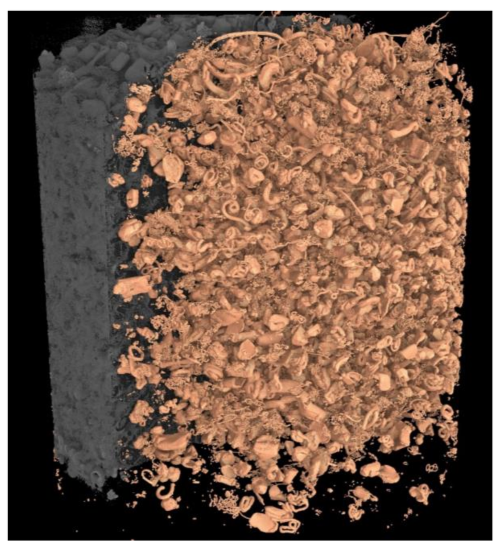
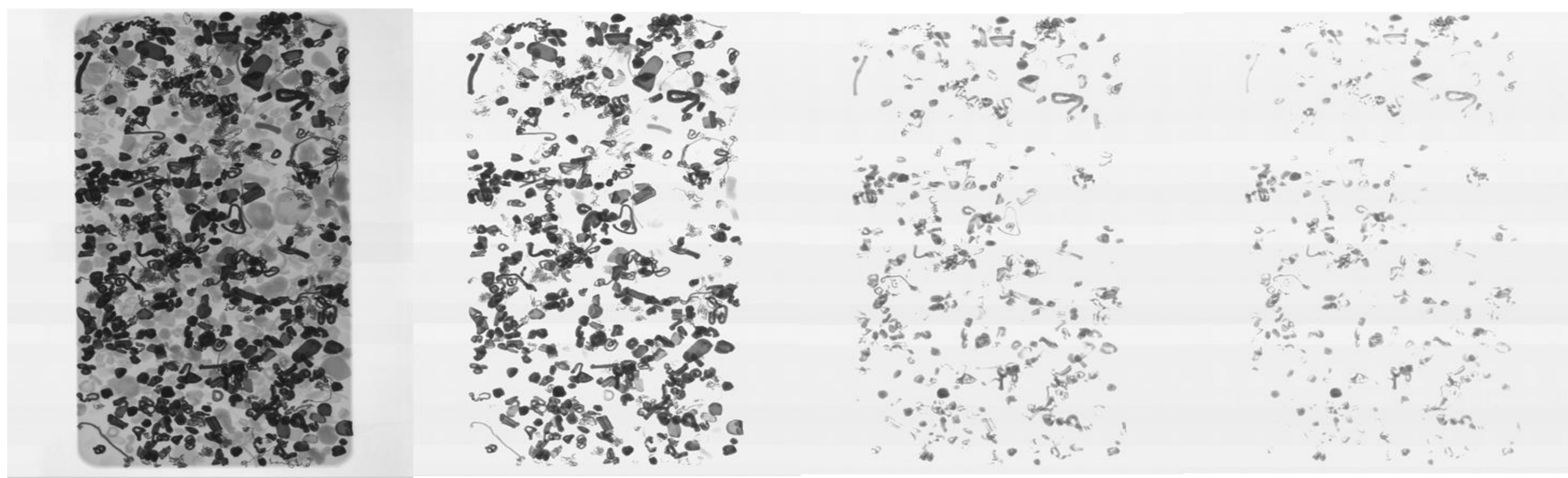


Figure 3. X-Ray CT scan result, denser fraction (12% Copper) highlighted.

The X-Ray Computed Tomography (XCT) data used in this poster was acquired using the Free-at-Point-of-Access scheme at the National Facility for X-Ray Computed Tomography (NXCT) and carried out at the Centre for Imaging, Metrology, and Additive Technologies (CiMAT) at the University of Warwick under the EPRSC Project Number (EP/T02593X/1).

Rapid Radiography Scans

- X-Ray CT is too slow for large scale rapid scanning.
- Could single <u>rapid</u> **radiograph** scans identify different densities?



100 kV Radiograph | 140 kV Radiograph | 200 kV Radiograph | 225 kV Radiograph

Figure 4. Series of Radiographs taken at increasing X-Ray voltages showing differentiation by X-Ray attenuation.

- As X-Ray voltage increases less dense materials are 'washed out'.
- Multiple radiograph scans at different X-Ray voltage distinguished copper from the remainder of the non-magnetic shredder fraction.
- Next step: use radiographs to determine whether copper and ferritic stainless can be detected in a bed of mild steel scrap.

CONCLUSIONS

- XRF analysis of end-of-life scrap is affected by surface contamination. A slow but relatively accurate elemental analysis.
- X-Ray Radiography. Rapid scans, unaffected by surface contamination. Can distinguish extrinsic metals such as copper from less dense metals.
- Next steps:
- Combination of XRF and Radiography on more industrially representative scrap samples.
- Produce a time versus accuracy benefit analysis of multiple techniques to design a characterisation toolkit.

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