Derusting the Energy Carrier of the Future

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INTRODUCTION

Maintaining grid stability will become increasingly important when we switch to renewable energies. Batteries and hydrogen might act as short time buffers, but for longer timescales a different carrier is required. Metals (in powder form) pose a solution. We can envision a “metal fuel cycle” (see Figure 1) in which metal powder is combusted in various equipment and the produced metal oxides are reduced back to iron. This research focuses on tackling this recharging of the combusted iron using hydrogen.

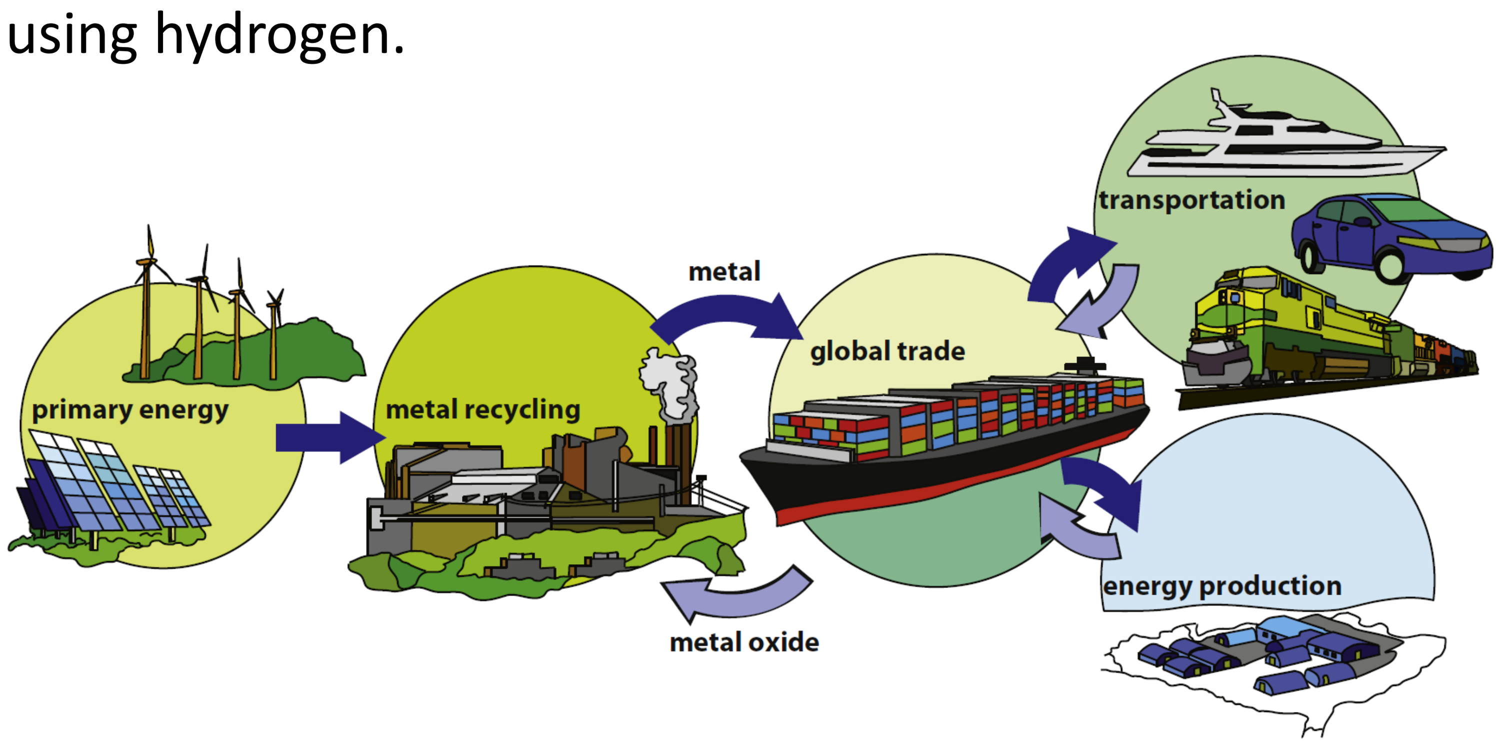

Figure 1: The envisioned metal-fuel cycle [1].

APPROACH

A single particle model is developed, which later on will be used in CFDEM simulations. Thermogravimetric analysis (TGA) is used to obtained kinetic parameters. Scanning electron microscopy (SEM) and x-ray diffraction (XRD) are used to analyse the powder at different stages of reduction. Future research involves performing measurements in a lab-scale fluidized bed and comparing them with numerical simulations.

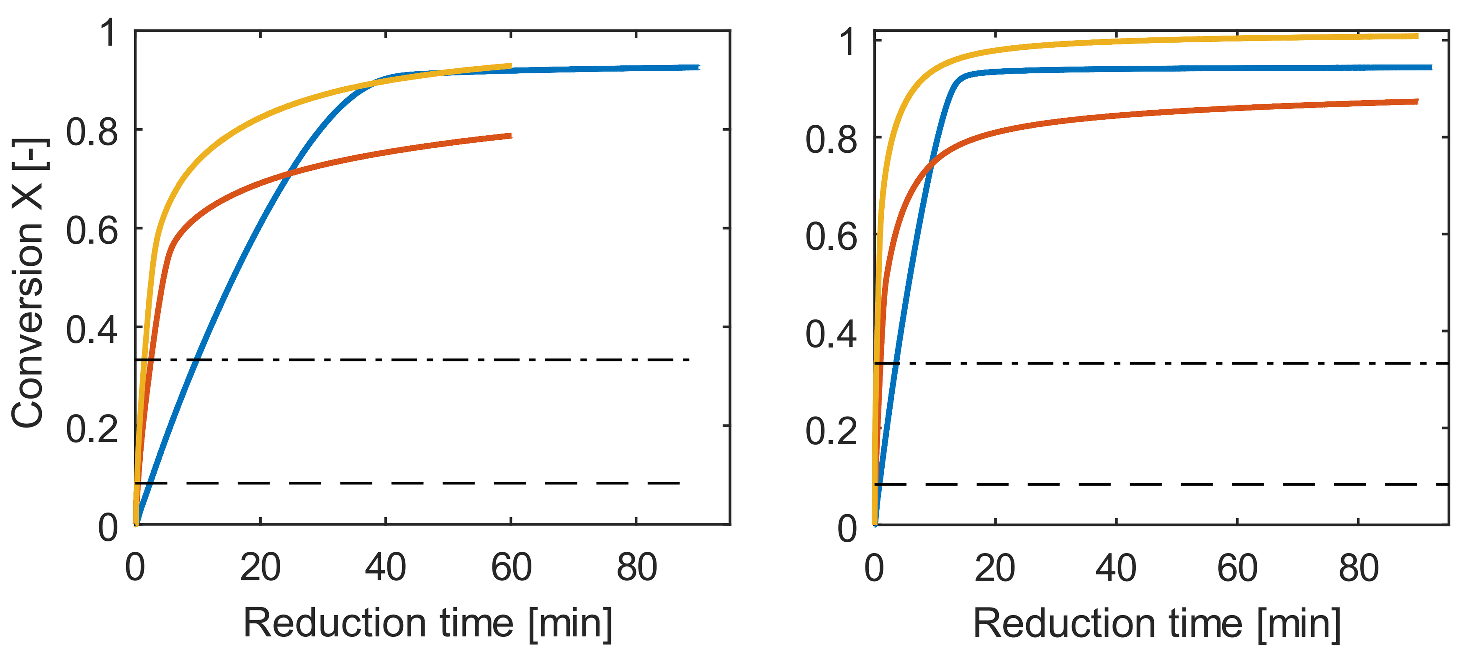

Figure 2: TGA results for reduction at 50% (left) and 100% (right) hydrogen concentration at three different temperatures: blue = 500C, red = 700C and green = 900C. The reference lines represent the conversion from hematite → magnetite and hematite → wüstite.

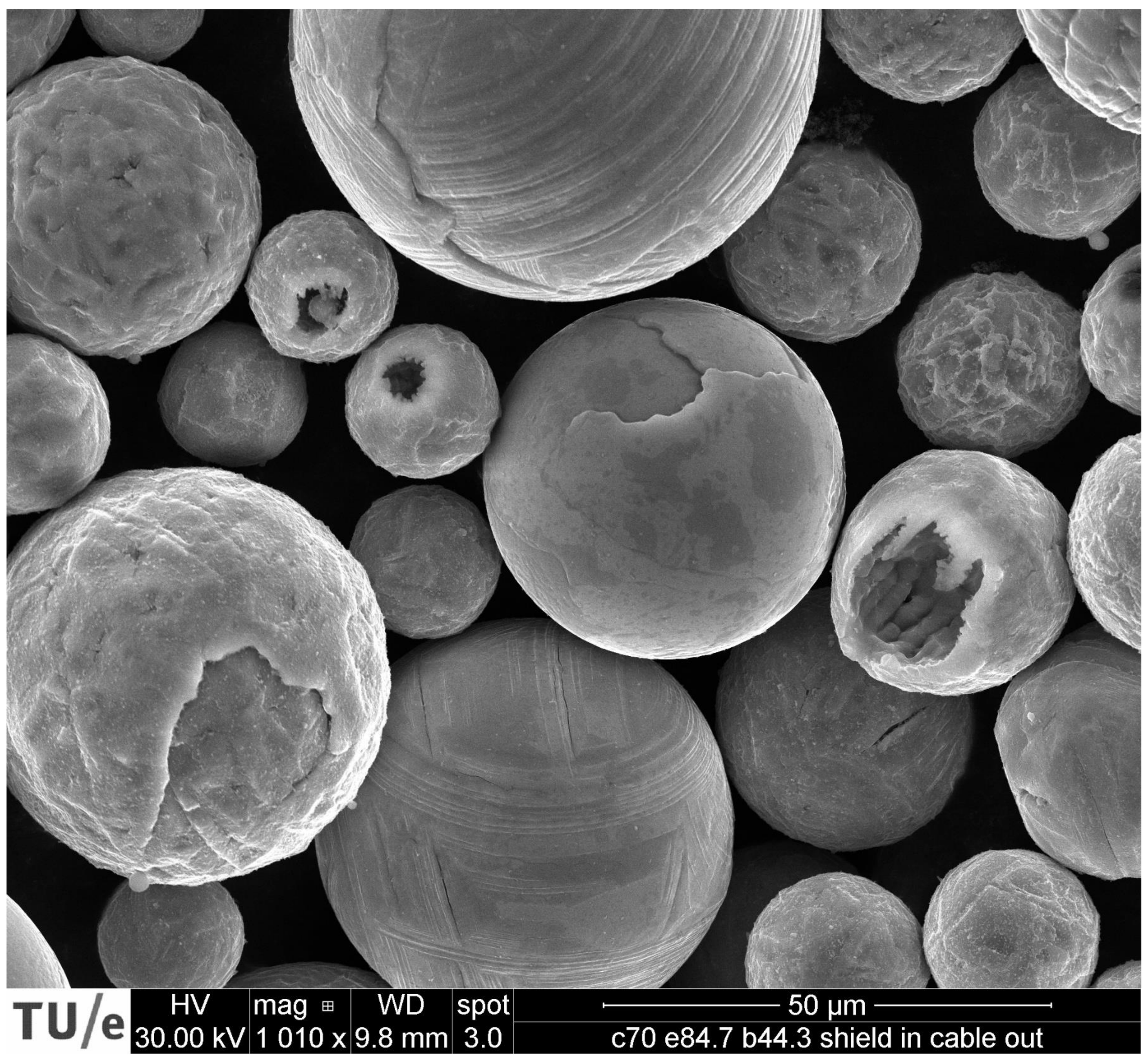

Figure 3: SEM image of combusted iron particles (~20 μm).

RESULTS

Scanning electron microscope (SEM) image of combusted iron powder can be found in Figure 3. Perfect spheres are observed, suggesting melting during combustion. The hollow shells are most likely caused by impurities boiling off during combustion. X-ray crystallography (XRD) showed no signs of unburned iron, suggesting (almost) complete oxidation.

Figure 2 shows [preliminary] TGA measurements of the combusted powder. Experiments above 600C showed sintering of the powder, resulting in eventually lower conversion rates. The experiments at 500C showed a full conversion limit of 95%.

CONCLUSIONS

- Combusting iron powder results in spherical, easy to fluidize particles
- No signs of unburned iron was found in the combustion products, suggesting a high combustion efficiency
- TGA experiments [preliminary] show sintering above 600C, while incomplete conversion below 500C.

[1] J.M. Bergthonson, S. Goroshin, M.J. Soo, P. Julien, J. Palecka, D.L. Frost, and D.J. Jarvis: *Appl. Energ.*, 2015, vol. 160, pp. 368-382

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