Investigations of Contact Mass Stability in the Reversible Iron-Steam Process

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Introduction:

Hydrogen is part of the future green energy mix that will replace fossil fuels from the energy market [1]. Currently large scale hydrogen production depends on using fossil fuels that will have to be replaced by more sustainable means.

Production, storage and purification are the main issues of interest for hydrogen use in fuel cells. The Iron-Steam process offers solutions for production and storage without the need for additional purification step [2].

Measurement and Apparatus:

Current work concentrates on the metal-steam-process:

$$xMe + yH_20 \rightarrow Me_xO_y + yH_2 \quad (1)$$

$$Me_xO_y + yH_2 \rightarrow xMe + yH_2O \quad (2)$$

$$Me_xO_y + yCO \rightarrow xMe + yCO_2 \quad (3)$$

It is known that many metals are theoretically viable for the metal-steam-process but most of them have significant disadvantages e.g. melting, evaporation, toxicity or expensiveness.

Therefore our interest is focused on iron for the use as the contact mass. Iron has none of the above disadvantages but can't be used in pure form as iron sponge because of sintering and loss of active surface [Fig.1].

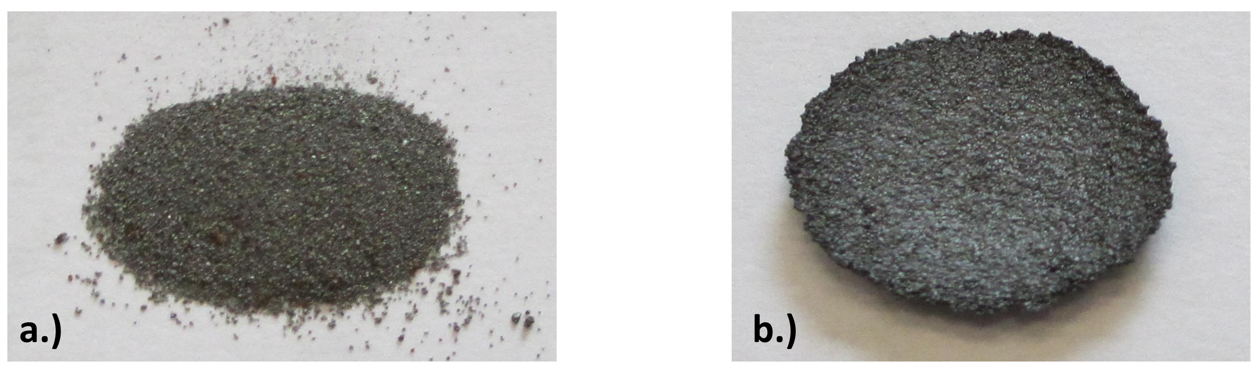

Fig. 1) a.) pure unreacted iron sponge powder b.) sintered iron sponge after two redox cycles at 600 C.

To avoid this the addition of other metal oxides is necessary. In our case the effects of adding 5% (w/w) aluminum oxide to the contact mass are measured [3].

Fig. 2) a.) unreacted 5% sample b.) 5% sample after ten cycles at 750 C c.) 5% sample after ten dynamic cycles.

Measurements were carried out on a Netzsch Thermo balance STA 449C Jupiter [Fig. 3.]. This apparatus allows to measure the variation of the contact mass in different conditions at different temperatures.

The measuring conditions were evaluated in two ways. One follows a heating ramp up to a defined degree, followed by a isothermal reduction segment, a purge phase and finally oxidation. This process was measured for 10 redox cycles[Fig.4]. The other also started with a heating ramp and an isothermal reduction but during the purge phase the temperature decreases and oxidation was carried out at a lower temperature [Fig. 5].

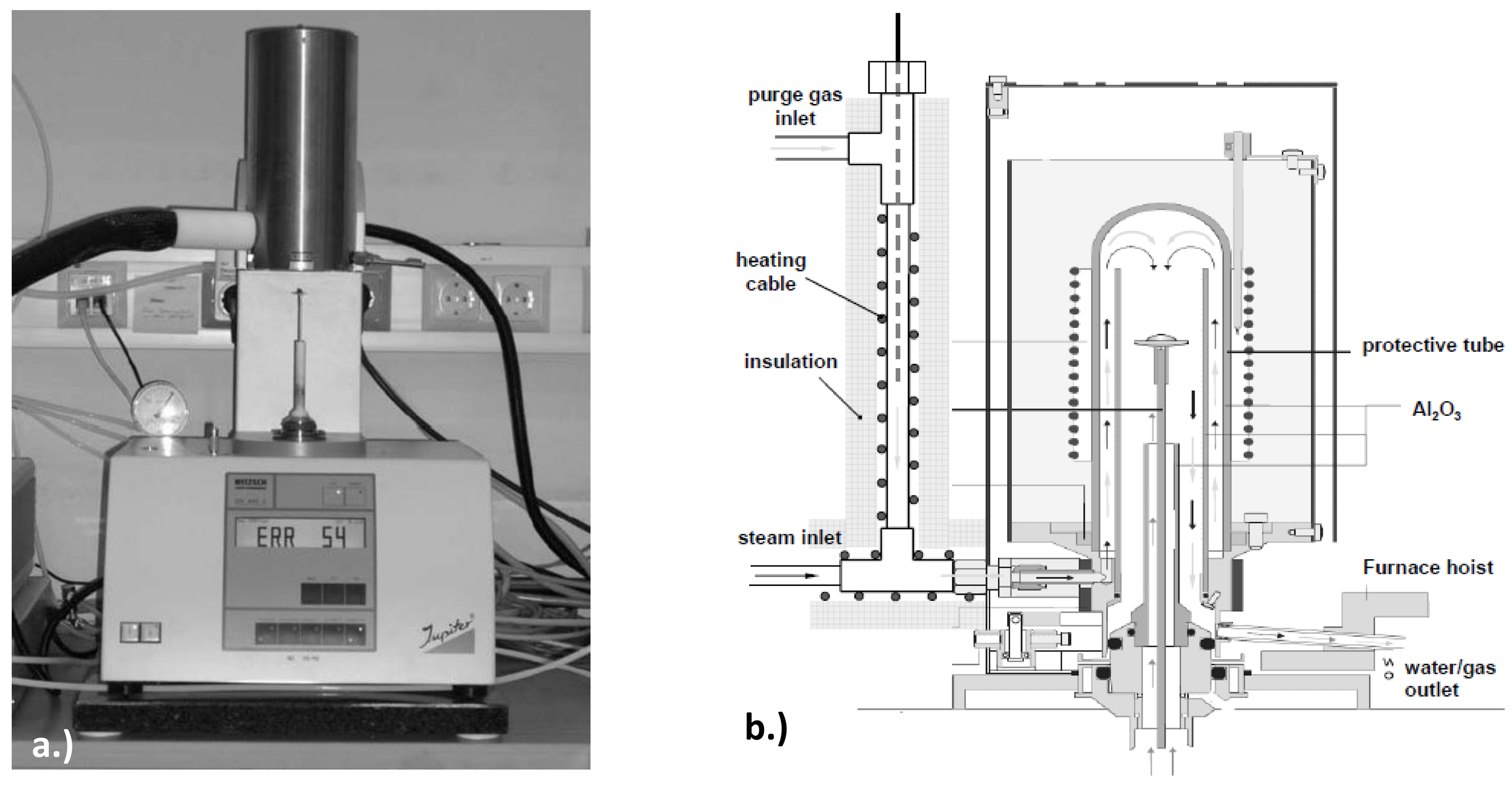

Fig. 3) a) STA449C Jupiter Netzsch . b) schematic gas flows.

Results and Discussion:

The measurements show that an isothermal process is less stressful for the contact mass than a dynamic process. The differences between the magnetite and the pure iron is in good agreement with the theoretical values. The stability of the doped mass is satisfactory. More research will focus on additives to obtain a better reaction rate.

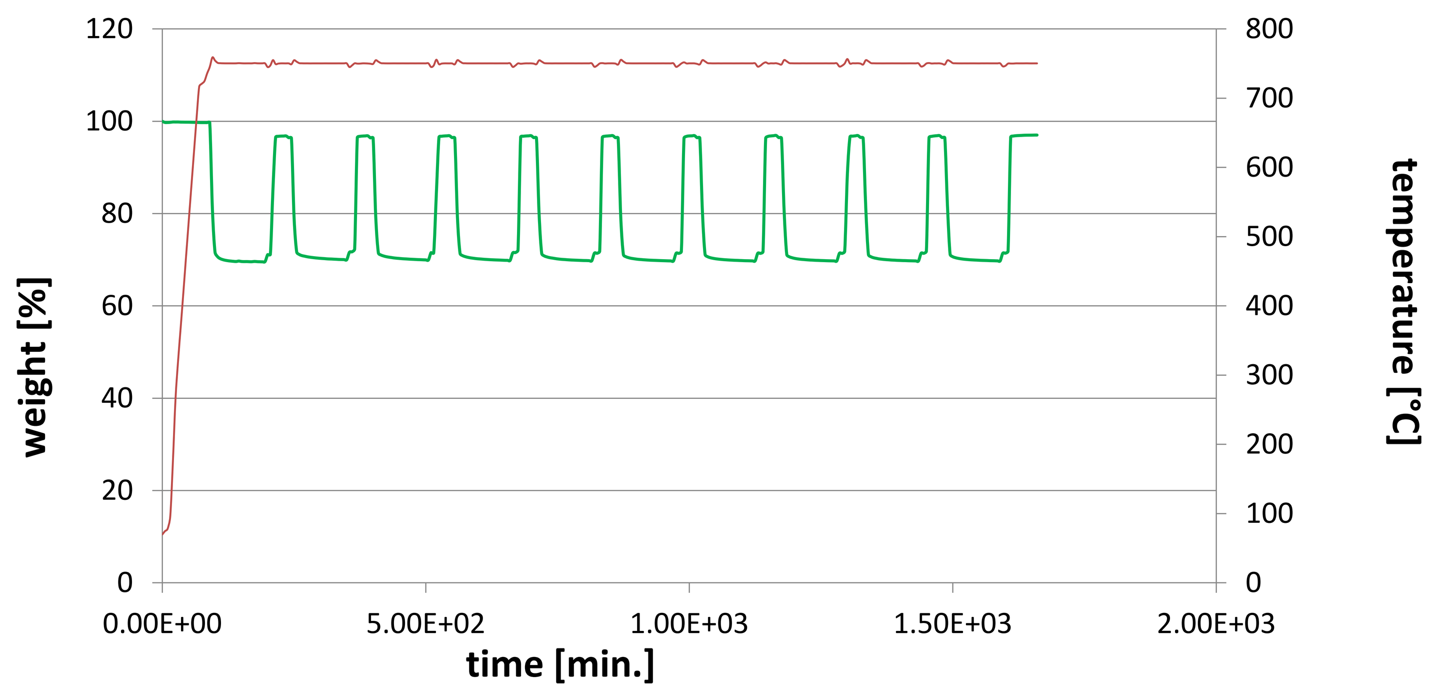

Fig. 4) isothermal measurement of 10 cycles.

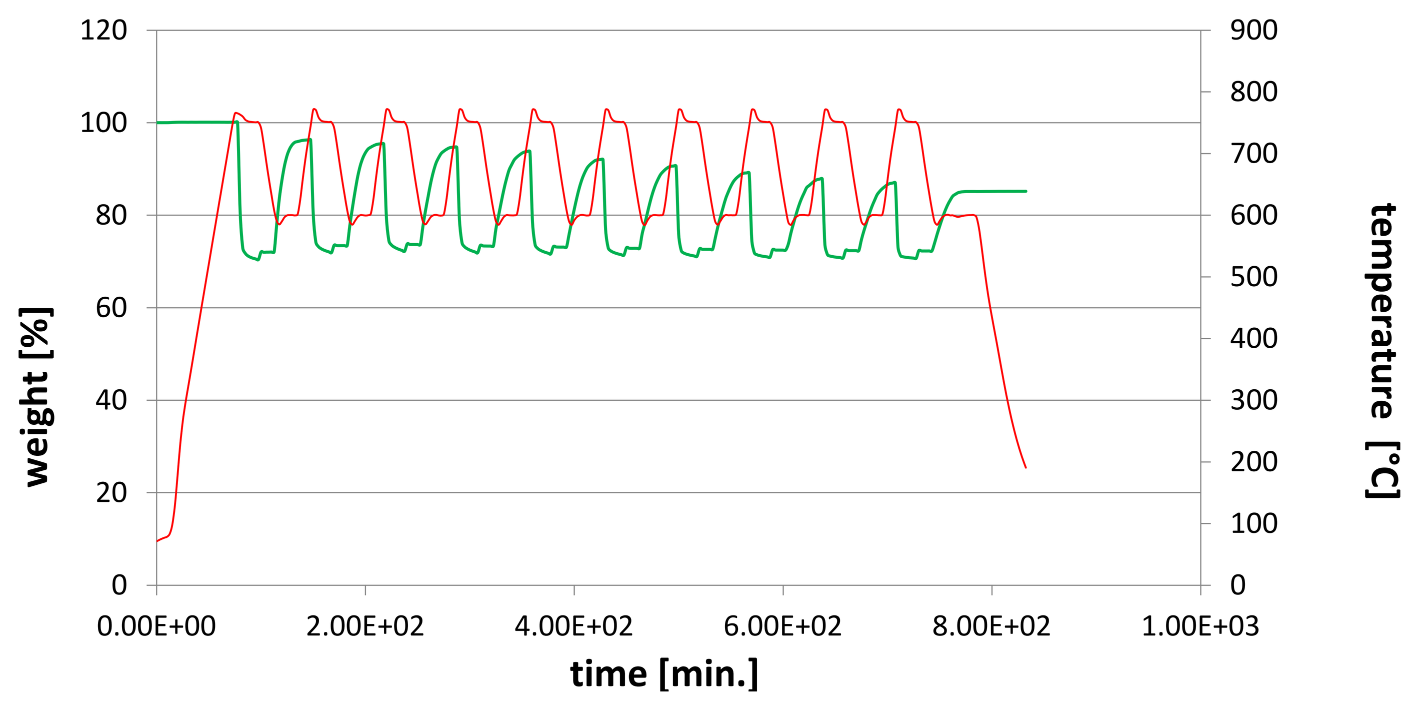

Fig. 5) dynamic measurement over 10 cycles.

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