HYDROGEN AS REDUCTANT FOR METALS: PILOT SCALE EXPERIMENTS AT SINTEF.

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ABSTRACT
The production of 1 ton of aluminium leads to the production of two tons of bauxite residue, an iron-rich waste product that is currently landfilled at a rate of 175 million tons per annum. In the HARARE[1] project, hydrogen is used to reduce the iron phases in bauxite residue, enabling the recovery of iron and the further application of the remaining waste in building materials.
The HALMAN[2] project is about prereduction of manganese ore. This allows hydrogen to substitute fossil carbon used in manganese ferroalloys production today. Both of these projects are Innovation Actions, which means that the developed processes are to be demonstrated in pilot-scale.

At SINTEF in Trondheim, a batch rotary furnace, shown in Fig. 1, is installed in the smelting hall. This furnace has been used in these two projects for the hydrogen reduction of several hundred kilo's of raw materials. The special feature of this furnace is that it is heated using a plasma torch. Conventional rotary furnaces are often heated with an oxyfuel burner which will not result in a reducing atmosphere is the furnace. The plasma torch is using hydrogen as plasma gas so there is no oxygen introduced into the furnace and a very reducing atmosphere is created. The furnace has several thermocouples mounted on the furnace shell which are used for the process control, shown in Fig. 2. The plasma torch is ignited by making a shortcut between the two electrodes, as shown in Fig. 3. The off-gas from the furnace is a mixture of unreacted hydrogen and water vapour. Hydrogen is flared just outside the furnace. In an industrial set-up, a plasma rotary furnace for continuous process operation with recycling of unreacted hydrogen would be used.

In the case of the HARARE project, the furnace is run for about 30 hours with 500 kg of bauxite residue (red mud) at a temperature of up to 1000°C. The hydrogen gas flow through the furnace is 200 litres per minute. Bauxite residue is a mixture of Fe, Si, Al and Ti-oxides. The bauxite residue is pelletized together with limestone fines (industrial waste) before the reduction. This is done to form a slag phase (mayenite) from which alumina can be easily leached to further recover alumina. A key element of the reduction with hydrogen of bauxite residue is that only the iron oxides are reduced, as shown in Fig. 4, in which the bright spots is metallic iron in an oxide matrix. After reduction, the pellets are crushed and the iron powder can be separated magnetically. A recovery rate of up to 90% of the iron has been obtained within the project.

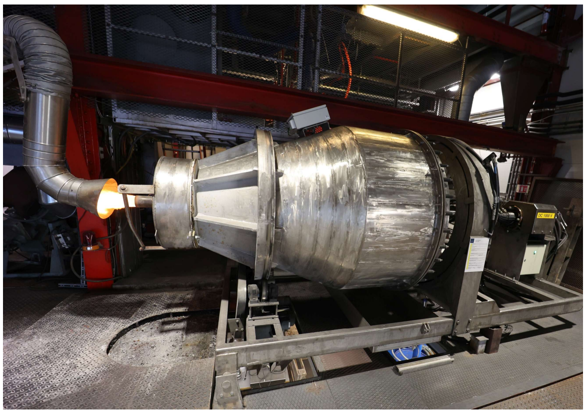

Figure 1. Plasma rotary furnace with hydrogen flame.

Figure 2. Control room of the rotary furnace

Figure 3. Ignition of the plasma torch.

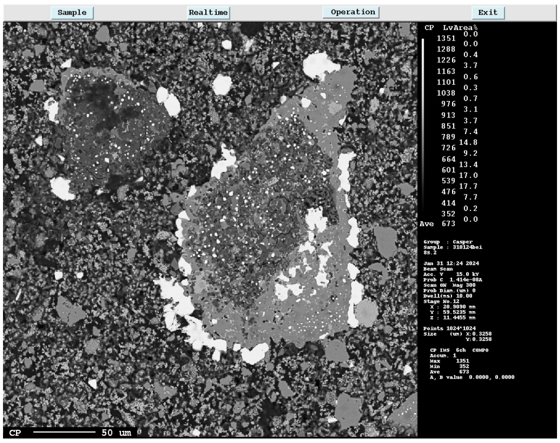

Figure 4. Backscattered EPMA image of bauxite residue after hydrogen reduction.

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References

1. https://h2020harare.eu/
2. https://halman-project.eu/