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MOBILITY & PRODUCTION

Fields of Expertise TU Graz

Viktor Hacker
Mobility & Production
Source: Lunghammer – TU Graz

The future energy supply and especially the fuel used in mobility quickly become the trigger for very emotional discussions. Currently initiated by Germany's withdrawal from the agreement to phase out cars with combustion engines by 2035, e-fuels are being brought back into the race as a possible compromise for the future greenhouse gas-neutral use of combustion engines. The technically complex and inefficient production of e-fuels from green hydrogen for mobility has only the one advantage that existing technologies can continue to be used. This is countered by global agreements on the introduction of hydrogen or the comprehensive initiatives to bring electric vehicles to the market.

In the middle of July the Institutes of Automotive Engineering and of Thermodynamics and Sustainable Drive Systems organised a symposium with more than 40 PhD students presenting and discussing their results on vehicle and drive technology. In September, our university once again hosted a conference and showed the latest research results in the area of Mobility and Production. Our FoE participated with six speeches and three posters.

There is also good news in the area of funding. The Institute of Production Engineering, which also the runs the smartfactory @tugraz together with Vienna University of Technology and the JKU University in Linz, was able win a five-year funding programme to network their pilot factories in order to generate sustainable innovation on basis of the new European Platform Gaia-X. This funding programme goes hand in hand with the article that follows, which gives deeper insights into the new era of industry 5.0. It shows that TU Graz is again proactive in this new dimension of using highly up-to-date technology in order to create competitive worlds of production.

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Iron Oxide – The Energy Carrier of the Future

The need for large-scale energy storage and transport will continue to rise in a post-fossil world, along with the world's population and standard of living.

According to the IEA, global energy demand will increase by around 25 % by 2040, with much of this growth coming from emerging economies, which have so far had very low per capita energy consumption. In 2020, 360 million tonnes of liquefied natural gas (LNG) and 4.6 billion tonnes of oil were consumed worldwide. Replacing these two liquid fossil fuels with green energy, a continuous electricity production (24/7) of approx. 8 TW (equivalent to 1 kW per capita of the world population) is required. In addition to the challenge of developing renewable energy sources such as wind and solar power at this scale, it is also important to be able to transfer energy from regions that produce a surplus of renewable energy to regions with high energy demand. To transport large amounts of energy nationally and intercontinentally, we need safe, environmentally friendly and cost-efficient routes and methods. Figure 1 shows a cost comparison of the different transport routes by the direct transport of electricity via high-voltage lines, the transport of hydrogen via pipelines and transport routes of hydrogen in chemically bound form.

A new and unusual way to transport energy is via metals and metal oxides. Recent studies have focused on iron and its oxides for economic and environmental reasons, as iron is both inexpensive and non-toxic. Energy is stored in the storage material by reducing the iron oxide to metallic iron. This can even be done directly from natural ores, as explained in a recent study by our research group [1]. Reduction takes place where large amounts of renewable energy are available. The reduced iron is transported by ship to areas where the energy is needed.

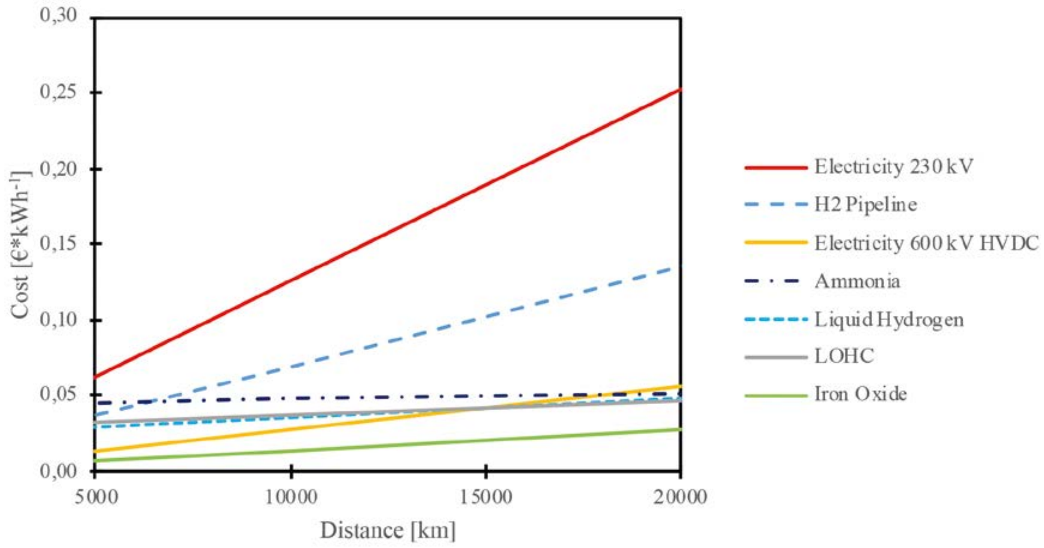

Figure 1: Cost comparison for different intercontinental energy transport systems.
Source: TU Graz

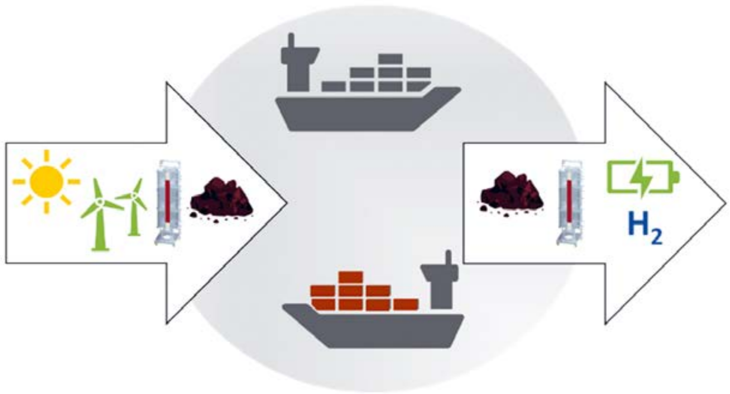

Figure 2: The concept of using iron as an energy carrier: iron is transported to the consumer and iron oxide (magnetite) is brought back and recharged.
Source: TU Graz

The transport routes for solid iron oxide are already involved in global trade and transport. The reoxidation of this oxygen carrier material with steam releases the stored chemical energy in the form of pure hydrogen and heat.

The Fuel Cell and Hydrogen Working Group at the Institute of Chemical Engineering and Environmental Technology is at the forefront of innovative iron-based process and material development in the field of hydrogen production and storage. The Reformer Steam Iron Cycle (RESC), a chemical looping hydrogen process with iron oxide as the contact mass, was developed from scratch at the Institute. The process was originally developed to purify synthesis gas, but can also be used for energy storage.

Due to its thermodynamic properties, iron oxide shows a comparably large reduction potential. This directly relates to the potential of releasing hydrogen and thermal energy during the oxidation of metallic iron. Making use of the cycling between oxide and metal provides the opportunity for a gravimetric storage density of 4.8 %. This theoretical storage density is thus comparable to a 700 bar hydrogen gas tank filled with 5-6 kg hydrogen per 100 kg mass of the tank system. Due to the material properties of iron oxide, environmentally friendly storage processes and easy handling is guaranteed. Another important aspect is the overall availability of iron oxide. The world-wide resources are approx. 180 billion tons, which ensures long-term usability. Furthermore, the transport and storage infrastructure for iron oxide, which has been developed in the iron and steel industry for decades, can be adapted to energy storage with ease. All these aspects make the use of iron a potentially efficient and economically viable solution in the field of medium- and long-term energy storage. >

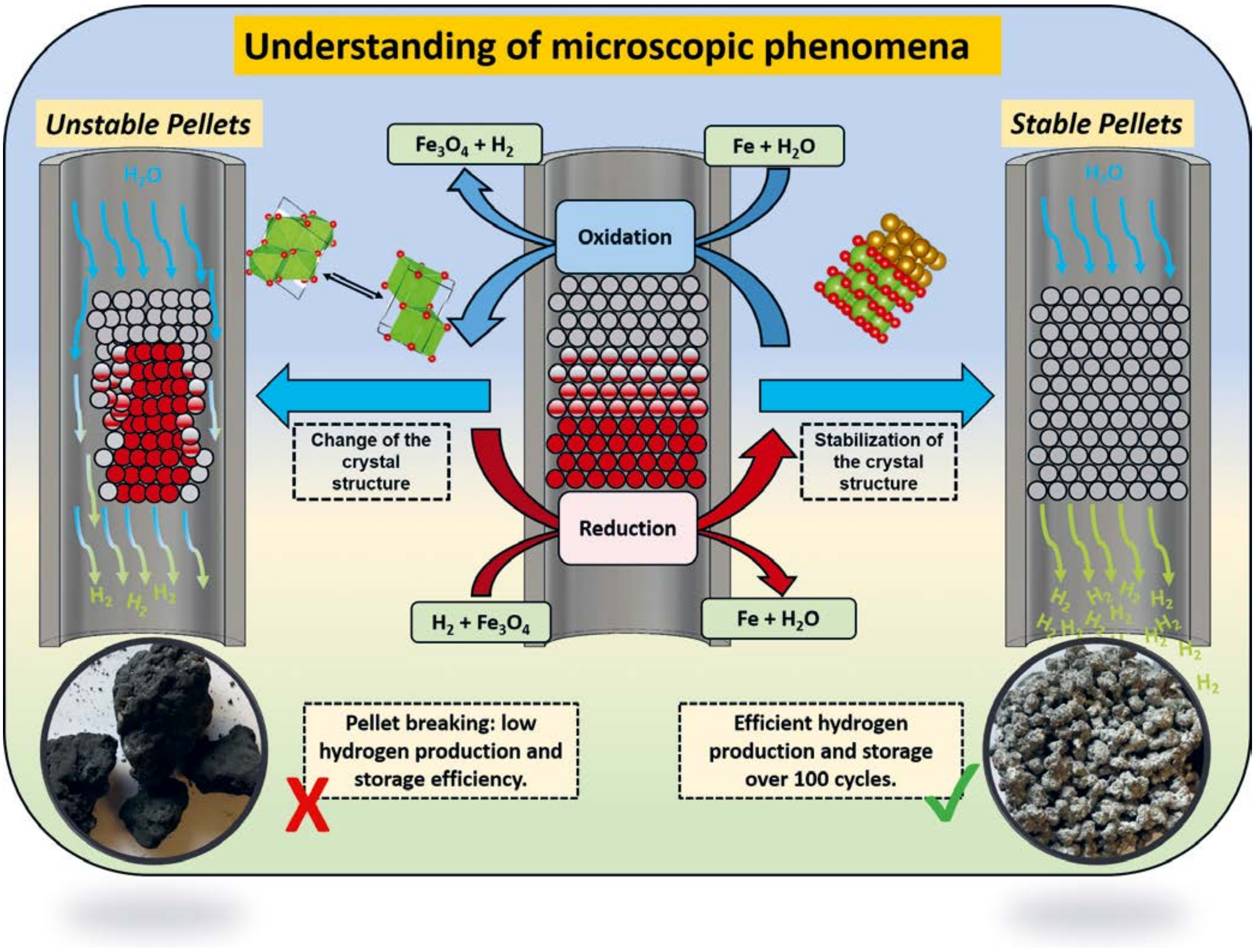

Figure 3: Long-term cycle test in a fixed-bed reactor; left: conventional material that degrades; right: new stabilised pellets with long lifetime.
Source: TU Graz

Mixed ion-electron conductors (MIEC) are being used for the first time in current research to develop novel, highly reactive, stable and environmentally friendly iron-based oxygen carriers [2]. By using an improved carrier material with yttrium oxide, an increase in reactivity of up to 40 % was achieved compared to conventional materials known in the literature. The exploration and discovery of microscopic phenomena leads to a new approach to oxygen carriers design. By stabilising the cubic/tetragonal crystal structure, the phase transition is suppressed and the activity is increased. Based on the results, new basic principles for the design of the oxygen carrier in chemical looping hydrogen have been developed, and have had a significant impact on the stability of the oxygen carriers. This was made possible by targeted material engineering to stabilise the pellets in the reactor. Successful lifetime tests over 100 cycles were carried out (Figure 3).

The working group's latest material developments on the structured oxygen carrier of the future have led to an international patent application and are simultaneously supported by the improvement and intensification of system and process design at the institute.

REFERENCES

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Source: Privat

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Source: Privat

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Source: Otto Stelzl

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Source: Privat

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Source: Lunghammer – TU Graz