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„Design and construction of a solar thermal miniplant“

Liquid-phase high-temperature processes such as the recycling of aluminum scrap are of increasing industrial interest. Crucial to the conversion of this melting process into a solar thermal operation are the design of the reactor system and the final concentrator to enhance the overall efficiency.

The application of CFD-Software is an important aspect of the development of a reactor system. As the costs of experiments are high and the weather in western European countries is hardly to predict it is necessary to collect additional data by simulation.

Up to now reactors with an open receiver area which directly absorb radiation have been analysed. A reactor of this type for high temperature aluminum melting processes is developed at the University of Dortmund. Simulations of the projected receiver/reactor with the CFD-Software FLUENT have shown that it is necessary to calculate the buoyant-driven convective heat losses inside the open-air cavity receiver. Because of the open receiver area convection and radiation losses strongly affect the temperature of the melting phase. This influence is discussed and quantified.

Based upon these investigations a new reactor system has been developed. In contrast to the reactors with an open receiver area the new type is a closed reactor system. Compared to the reactor system with an open receiver area this closed reactor system has many decisive advantages:

1. Convective losses are reduced to a great extent.
2. Within the reactor the optical properties of the process materials are not significant.
3. There are no emissions to the environment.

For the projected process it is expected that the closed reactor has a higher overall efficiency and can therefore be used in a wider range of applications.

Another important equipment to increase the overall efficiency is the utilization of final concentrators. There is scientific evidence that a small cone with a low average reflection number improves the performance of a cavity receiver considerably. First a cone concentrator as a simple approximation of the Compound Parabolic Concentrator (CPC) combined with a solar cavity receiver was developed. There has to be a compromise between the size of the entrance diameter for maximum solar input and minimum heat loss through the opening. Secondly a Tri-Cone-Concentrator as a better approximation of a CPC was developed. Cone-and Multi-Cone-Concentrators can be produced more easily than CPC-Concentrators and therefore are more economical. The two projected concentrators were tested at the solar furnace in Cologne and confirm the results of the simulations. According to the data obtained by Schöffel, who optimized Cone-Concentrators and CPCs in combination with an ideal black absorber the difference of the transmission efficiency is rather small.