An investigation of soot formation in reduction reactions using natural gas

Halvor Dalaker SINTEF MK (2013.03.14)

The MSc task

Methane, CH_4, will have a higher reduction potential than traditional carbon sources when the gas exists in a metastable state at temperatures where C and H_2 are the stable phases [Ostrovski2006]. Substituting methane for coal and coke will thus make it possible to produce metals at lower temperatures and with lower energy consumption and CO_2 footprint. The challenge remains that the metastability also presents difficulties, as it might drive the spontaneous decomposition of CH_4 to C and H_2 before it can be utilised for oxide reduction.

The reason why methane is able to exist at elevated temperatures at all, is that the activation energy for its decomposition—or "cracking—is high:

$$CH_4 \rightarrow H_2 + C \qquad \Delta G<0;\ E_a>>0$$

This means that even though the reaction is thermodynamically spontaneous at temperatures above ~500^o C, elemental carbon (soot) is often not observed even in experiments at around 1000^0 C or even higher.

If methane decomposition can be supressed and the metastability of methane harvested for oxide conversion, the potential reductions in energy consumption and CO_2 emissions in metallurgical industries would be substantial.

The cracking of methane is influenced by a variety of factors, such as the composition of the gas atmosphere, and the surface chemistry between the methane and raw materials as well as surroundings.

The proposed project is to select a subset of variables and study how they influence the cracking of methane in a relevant oxide system.

The task is envisioned as being mainly experimental in nature.

For more information about the proposed task, or questions about oxide reductions using natural gas in general, do not hesitate to contact Halvor Dalaker by the e-mail below.

Qualifications and requirements

Knowledge of chemistry and experimental laboratory work is a requirement. Experience with high temperature experiments is an advantage.

A MsC student in Materials Science or Chemistry is thought suitable, students from Physics wishing for an applied thesis is not discouraged to seek further information.

Name of lecturer (tutor) with e-mail:

- Prof. Merete Tangstad, Institutt for Materialteknologi

Name of supervisor at SINTEF:

- Halvor Dalaker, Sintef Materialer og Kjemi: halvor.dalaker@sintef.no

Reference

[Ostrovski2006] O Ostrovski and G Zhang, Reduction and Carburization of Metal Oxides by Methane-Containing Gas, *AIChE Journal* 52(1): 300 – 310, 2006