Thermophysical Properties Used for the Analysis and Design of Power Cycles with Carbon Dioxide Capture

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Atmospheric research has found that increasing green-house gas concentrations in the atmosphere result in global warming, an effect that may lead to threatening changes in the earth's climate. The most prominent among the green-house gases is carbon dioxide. In order to stabilize the carbon dioxide concentration in the atmosphere, carbon dioxide emissions from power industries have to be drastically reduced to well below the target defined in the Kyoto protocol. This constraint is probably the biggest challenge for the future use of fossil fuels in energy processes. While the Kyoto targets could be reached with efficiency improvements in all sectors of energy consumption, deeper cuts in carbon dioxide emissions require the development of completely new technologies. Since power plants are the biggest sources of carbon dioxide emissions, the emission-free use of fossil fuels in power plants becomes a key technology in most "post Kyoto scenarios".

During the last decade, a multitude of power cycles has been proposed, which allow for separation, capture and subsequently for sequestration of the carbon dioxide resulting from the combustion of fossil fuels. In general, one may distinguish between power cycles with pre-combustion carbon dioxide capture (fuel de-carbonization), integrated carbon dioxide capture (oxy-fuel processes, chemical-looping processes, or processes with integrated carbon dioxide scrubbing) and post-combustion carbon dioxide capture (carbon dioxide scrubbing from the exhaust gas). Different roots have to be followed for natural gas and coal. With regard to sequestration, options are utilization in enhanced oil recovery, different types of ocean storage and, more likely, different types of geological storage. All together, a multitude of processes has to be analyzed and a more detailed design has to follow for the most promising one. Funded by industry and governments, this R&D process goes on.

However, in many of these processes thermophysical properties of mixtures have to be calculated, which contain water and carbon dioxide, but also nitrogen, oxygen, hydrogen and other components. Neither the accurate ideal gas models, which are commonly used in gas-turbine design, nor the phase equilibrium focused models used in the chemical industry are adequate for use in analysis and design of these processes. The fundamental research, which is necessary to overcome this problem, is commonly neglected in the ongoing, process oriented R&D programs.

This presentation will give a brief overview over the options discussed for emission-free power processes and for sequestration of the captured carbon dioxide. The resulting demands on thermophysical property models for mixtures containing carbon dioxide and water, but also other components, will be discussed in more detail.