清华大学热能工程系学术报告

报告题目：Practical Oxygen Carrier Development for Chemical Looping Combustion

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报告人简介：

Dr. Tian's research focuses on the design, synthesis, and commercialization of metal oxide/zeolite catalyst for CO_2 capture, fossil fuel/biomass conversions, and clean coal technology. The research encompasses material development and chemical reaction engineering. Dr. Tian holds a joint appointment as principal research engineer in US Department of Energy, and is the Lead-PI of related project in US National Science Foundation. Dr. Tian received his MS degrees from Dalian Institute of Chemical Physics, CAS in 2000; and Ph. D degree at Lehigh University in 2006. Dr. Tian has published >30 journal articles, chaired/co-chaired international conferences and invented/co-invented 4 patents. He has won numerous awards, including Kokes Award from North American Catalysis Society.

报告摘要

Chemical Looping Combustion (CLC) is a novel indirect combustion technology that offers an elegant and highly efficient scheme towards ultra-clean fossil fuel combustion by producing a sequestration-ready CO_2 stream without nitrogen dilution. As a result, CLC has received global attention in recent years, for example, CLC was included in the USDOE's CCS roadmap aiming for demonstration in 2025-2030.

The development of a regenerable and robust oxygen carrier (OC) is critical for successful deployment of CLC systems. A promising oxygen-carrier material must follow several stringent selection criteria including high reactivity, high mechanical strength and low carrier production costs. These criteria must be followed simultaneously through both fundamental and applied research activities so that the significant competitiveness of CLC system over existing technologies can be validated.

This presentation summarized major research activities on oxygen carrier development conducted by WVU and USDOE/NETL in last 8 years, which include: 1) Selection of active components: The combustion and re-oxidation properties of direct coal chemical-looping combustion (CLC) over CuO, Fe_2O_3, Co_3O_4, NiO, and Mn_2O_3 were investigated by using TGA and bench-scale fixed-bed flow reactor studies; 2) Preliminary hypothesis of combustion kinetics: It has often been assumed that the solid/solid reaction is slow and therefore requires that reactions be conducted at temperatures high enough to gasify the solid fuel, or decompose the metal oxide. In contrast, DFT, TGA XRD and SEM data demonstrates that solid/solid reactions can be completed at much lower temperatures, with rates that are technically useful as long as adequate fuel/metal oxide contact is achieved. 3) Synergetic effect of mixed iron and copper oxides oxide for coal and methane CLC: The components of CuO and Fe_2O_3 were optimized to obtain good reactivity while maintaining physical and chemical stability during cyclic reactions for methane-CLC and solid-fuel CLC. Thermodynamic calculations, XRD, TGA, flow reactor studies and TPR experiments suggested that there is a strong interaction between CuO and Fe_2O_3 contributing to a synergistic effect during CLC reactions. The research frontier and extension of chemical looping approaches will be briefly presented.