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甲烷在金属铁及氧化铁表面还原NO的研究

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NO reduction by methane on the surface of iron and iron oxides

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摘要 在程序控温电加热水平陶瓷管反应器、N_2气氛和模拟烟气气氛及300~1 100℃时,对甲烷在金属铁及其氧化铁表面还原NO的特性进行了实验研究。为使甲烷在脱硝反应后完全燃尽以及脱硝反应过程生成的CO等中间产物完全燃尽,在第一段加热炉后串联了第二段加热炉,补充氧气,实现燃尽。结果表明,甲烷在金属铁及氧化铁表面能够高效地还原NO。在N_2气氛中,在900℃以上温度范围内甲烷在金属铁表面的脱硝效率超过95%,与甲烷在氧化铁表面的脱硝效率差别很小。在模拟烟气条件下,当过量空气系数小于1.0时,在900℃以上时,甲烷在金属铁和氧化铁表面的脱硝效率都能超过90%,且未燃尽和燃尽两种条件下NO的还原率相差不大。NO同时通过金属铁的直接还原和甲烷的再燃还原两种反应机理脱除。而甲烷则通过还原氧化铁为金属铁,从而使金属铁直接还原NO可持续进行。同时,甲烷再燃反应的中间产物HCN/NH_3等被氧化铁还原,从而使燃尽后的脱硝效率不下降。研究结果表明,甲烷和金属铁或氧化铁在富燃料条件下可有效地还原NO。

关键词: NO还原 甲烷 铁 氧化铁

Abstract: NO reduction by methane on the surface of iron and iron oxides was experimentally investigated in a one-dimensional temperature-programmed ceramic tubular reactor at 300~1 100℃ in both nitrogen and simulated flue gas atmospheres. To ensure that the residual methane after NO reduction and the intermediates (e.g. CO) formed during the NO reduction were completely burned out, a second furnace with a supply of O_2 was connected in series after the first furnace. The results indicated that methane can effectively reduce NO to N_2 over the surface of metallic iron and iron oxides. In N_2 atmosphere, more than 95% of NO is reduced by methane over metallic iron at a temperature above 900℃, which is very close to that for NO reduction over iron oxides. In the simulated flue gas atmosphere with an excessive air ratio being lower than 1.0, more than 90% of NO is reduced by methane over both metallic iron and iron oxides at a temperature above 900℃; there is little difference in NO reduction under both burnout or non-burnout conditions. NO is reduced simultaneously via two routes, i.e. the direct reduction by metallic iron and the reduction by reburning of methane. Iron oxides are reduced to metallic iron by methane through partial oxidation over iron oxides to maintain the sustainable reduction of NO by metallic iron. At the same time, the intermediate products during NO reduction by methane such as HCN/NH_3 are converted by iron oxides, which prevent the NO reduction efficiency from dropping after burnout. The present results then prove that methane can effectively reduce NO over iron or iron oxides under fuel rich condition.

Key words: NO reduction methane iron iron oxides

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