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钒钛铁精矿碳热还原制备铁基摩擦材料的热力学分析*

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Thermodynamics of Ferro-based Friction Material by *in-situ* Carbothermic Reduction Form Vanadium and Titanium Iron Concentrate

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摘要

利用钒钛铁精矿中的铁和钛元素, 以钒钛铁精矿、石墨为主要原料, 按铁基摩擦材料的成分添加其他组份, 采用原位合成技术, 实现合成与烧结一体化, 制备铁基摩擦材料。对钒钛铁精矿还原过程中的热力学进行计算和分析, 利用TG–DSC检测方法对还原过程中的质量变化进行分析。结果表明: 当温度高于979 K时, 钒钛铁精矿中Fe氧化物和Ti氧化物相继发生还原反应, 其还原过程为: 首先Fe_3O_4被还原, 其次是钛磁铁矿和钛铁矿发生反应生成Fe和Ti的氧化物, 最后是Ti的各阶氧化物反应生成TiC。本实验根据分析结果, 制定了合理的工艺路线, 获得了组织致密, 结合优良的铁基摩擦材料。

关键词: 钒钛铁精矿 铁基摩擦材料 原位合成 热力学

Abstract:

Ferro-based friction material was fabricated by reaction sintering technology, using Fe and Ti elements containing in vanadium and titanium iron concentrate as main raw materials, adding other ingredient on the basic of composition of ferro-based friction material, synthesis and sintering were accomplished unanimously in vacuum resistance furnace. Thermodynamic of the reduction of vanadium and titanium iron concentrate was calculated and studied, and the mass change of the reduction was studied by TG–DSC. The results show that the reduction temperature of Fe and Ti oxides is above 979 K, in the reduction process of vanadium and titanium iron concentrate, Fe_3O_4 is reduced by carbon firstly, and then titanomagnetite and ilmenite are reduced into Fe and Ti oxides, and finally different valent titanium oxides are reduced into TiC.Good interface bonding and compact structure have been got in experimental research by making reasonable process route.

Key words: vanadium and titanium iron concentrate ferro-based friction material *in-situ* thermodynamics

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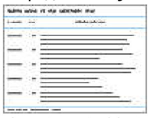

表1 钒钛铁精矿化学成分

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBC08.jpg)

图1 钒钛铁精矿的XRD谱

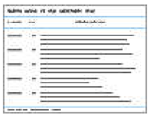

表2 Fe氧化物碳热还原反应及其基本热力学数据

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBC38.jpg)

图2 C还原铁氧化物的Δ G r 0 图

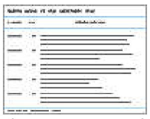

表3 FeTiO3碳热还原反应及其基本热力学数据

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBC58.jpg)

图3 C还原FeTiO3的Δ G r 0 图

表4 Ti的氧化物碳热还原反应及其基本热力学数据

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBC88.jpg)

图4 C还原Ti氧化物的Δ G r 0 图

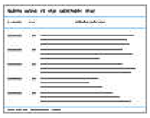

表5 其余氧化物碳热还原反应及其基本热力学数据

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBCA8.jpg)

图5 碳还原各氧化物反应自由能变化Δ G r 0 图

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBCC8.jpg)

图6 钒钛铁精矿-碳体系的DSC-TG曲线

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/grpBD07.jpg)

图7 烧结产物XRD谱

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/imgBD66.jpg)

图8 烧结产物显微组织

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/imgBDB5.jpg)

图9 烧结产物白亮区域的SEM和EDS图

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/imgBE23.jpg)

图10 烧结产物黑暗区域的SEM和EDS图

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/imgBE91.jpg)

图11 烧结试样的SEM像

(http://www.cjmr.org/fileup/1005-3093/FIGURE/1005-3093-2014-28-1-44/imgBEE0.jpg)

图12 颗粒状结构的SEM和EDS图

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