

论文

单晶高温合金DD6再结晶晶界析出相特征及其形成机制

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摘要:

对单晶高温合金DD6进行表面吹砂处理, 然后进行固溶与时效真空热处理, 采用SEM, TEM, EPMA和Thermo-Calc的方法研究了单晶合金DD6再结晶晶界析出相的特征及其形成机制. 结果表明, 经过吹砂处理的DD6合金在固溶与时效热处理过程中发生再结晶. 再结晶晶界出现析出相, 分析表明析出相为 M_6C 碳化物, 该碳化物呈粒状析出, 尺寸约为 $0.5\ \mu\text{m}$, 数量极少, 富含W, Re和Mo, 且Cr, Nb和Co的含量与合金名义成分差别不大, 而Al, Ta和Ni含量较低. 由于再结晶晶界上C元素的聚集效应, C原子在晶界上达到一定浓度后即与一定数量的W, Mo等 μ 相形成元素发生相变反应, 抑制了合金析出 μ 相的倾向. 又因为DD6合金W含量较高, 而Cr含量较低, 抑制了 $M_{23}C_6$ 碳化物, 有利于析出 M_6C 碳化物.

关键词: 单晶高温合金 DD6 再结晶 析出相

CHARACTERISTIC AND FORMATION MECHANISM OF PRECIPITATES AT RECRYSTALLIZATION GRAIN BOUNDARIES OF SINGLE CRYSTAL SUPERALLOY DD6

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Abstract:

Single crystal superalloys have extremely good elevated temperature capability in advanced gas turbine aero engines due to no highly stressed grain boundaries in them. With the removal of grain boundary strengthening elements such as C, B and Zr, the occurrence of recrystallization may be detrimental to their performance. Therefore, recrystallization becomes critical in industrial manufacture of single crystal superalloy blades. In the present study, specimens of single crystal superalloy DD6 were grit blasted, solution treated and aged at vacuum atmosphere, and then the precipitates at recrystallization grain boundaries were investigated by SE, TE, EPMA and Thermo-Calc. The results show that a few of M_6C carbides precipitate at recrystallization grain boundaries, and their size is about $0.5\ \mu\text{m}$. These M_6C carbides are rich in W, Re and Mo, but poor in Al, Ta, Ni, the contents of Cr, Nb, Co in them are almost the same as the nominal composition of DD6 alloy. The carbon accumulation at recrystallization boundaries and combination with μ phase forming elements such as W and Mo restrain the μ phase forming. $M_{23}C_6$ phase hardly forms in DD6 alloy due to its high W and low Cr content.

Keywords: single crystal superalloy DD6 recrystallization precipitate

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