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落管中Ni-Pb偏晶型合金的快速凝固组织特征及形成机制

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Microstructure Formation Mechanism of Ni-Pb Monotectic Alloys Rapidly Solidified in Drop Tube

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摘要 Ni基偏晶合金是一种优良的自润滑耐磨材料,其组织形成规律对力学性能的影响十分关键。在自由落体条件下,对不同成分二元Ni-Pb偏晶型合金的快速凝固进行了实验研究。随着液滴直径的减小,Ni-20%Pb亚偏晶合金中α-Ni枝晶生长经历"粗大枝晶→等轴晶→蠕虫状枝晶"的转变。Ni-31.4%Pb偏晶合金的凝固组织以偏晶胞为主,偏晶胞的体积分数随液滴直径的减小而增大。过偏晶合金的快速凝固过程中均发生液相分离。Ni-50%Pb过偏晶合金中L_2(Pb)相平均尺寸和最大尺寸均随液滴直径的减小先增大后减小。当液滴直径小于400 μm时,Ni-60%Pb过偏晶合金由壳核组织演变为L_2(Pb)相分布在α-Ni相枝晶间的偏析组织。根据Borelius脱溶模型、Gibbs-Thomson关系和LSW(Lifshitz-Slyozov-Wagner)理论,分析了合金成分、液相分离时间和第二液相体积分数对凝固组织形成的作用机制。

关键词: 偏晶合金 液相分离 偏晶胞 枝晶生长 自由落体

Abstract: Four different Ni-Pb binary monotectic alloys have been rapidly solidified during free fall in drop tube. With the decrease of droplet diameter, the primary α-Ni dendrite in Ni-20%Pb hypomonotectic droplets shows a morphology transition of "coarse dendrite→equiaxed dendrite→vermiculate dendrite". The solidification microstructure of Ni-31.4% Pb monotectic alloy is mainly composed of monotectic cells, the volume fraction of which increases with the decrease of droplet diameter. Liquid phase separation has happened during the rapid solidification of both Ni-50%Pb and Ni-60%Pb hypermonotectic alloys. The grain size of L_2(Pb) phase in Ni-50%Pb alloy increases and then decreases when the droplet diameter decreases. The microstructures of Ni-60%Pb alloy droplets display a "core-shell→dendrite" transformation as the droplet diameter becomes smaller than 400 μm. Theoretical analyses of Borelius model, Gibbs-Thomson equation and Lifshitz-Slyozov-Wagner(LSW) theory reveal that alloy composition, phase separation time and volume fraction of minor phase play important roles in the formation of core-shell microstructure.

Keywords: monotectic alloy phase separation monotectic cell dendritic growth free fall

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