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论文

TWIP钢中晶粒尺寸对TWIP效应的影响

王书晗 , 刘振宇, 王国栋

东北大学轧制技术与连轧自动化国家重点实验室, 沈阳 110004

摘要:

冷轧TWIP钢经1073, 1173, 1273和1373 K固溶处理10 min后, 得到了晶粒尺寸分别为7, 13, 30和63 μm 的奥氏体组织. 拉伸实验表明, 随着晶粒尺寸的增加, 加工硬化速率(dσ/dε)与真应变 (ε)的变化关系由2阶段变为3阶段. 当晶粒尺寸大于30 μm时, 加工硬化速率与真应变关系中的第2阶段对应的应变长度随着晶粒尺寸的增加而迅速增加. 当真应变为0-0.2时, 加工硬化指数随真应变的增加而迅速增加; 在随后的变形中, 与上述4个晶粒尺寸对应的试样的加工硬化指数分别稳定在0.47, 0.53, 0.56和0.68. OM和TEM观察显示, 随晶粒尺寸的增大, 变形过程中形变孪晶数量增多. 对于较大晶粒尺寸的试样, 形变孪晶在拉伸变形过程中形核的临界应力较低, 随变形量增加, 形变孪晶可持续形成, 使其加工硬化能力增加, 从而增大了TWIP效应; 相反, 晶粒尺寸减小使变形过程中的形变孪晶形核临界应力增大, 抑制形变孪晶的产生, 从而减小了TWIP效应.

关键词: TWIP钢 晶粒尺寸 加工硬化速率 加工硬化指数 TWIP效应

INFLUENCE OF GRAIN SIZE ON TWIP EFFECT IN A TWIP STEEL

WANG Shuhan, LIU Zhenyu, WANG Guodong

State Key Laboratory of Rolling and Automation, Northeastern University, Shenyang 110004

Abstract:

TWIP (twinning induced plasticity) steels possess very high plasticity and high strength. It has been pointed out that deformation twinning plays an important role in controlling the deformation behavior, which divides grains into nano--scale layer--like structures to result in high strain-hardening rate or the so--called “TWIP” effect. The formation of deformation twins is affected by deformation temperature, strain rate, pr--deformation and grain size. The generation of deformation twins in austenitic steel with low stacking fault energy (SFE) is closely related to grain size. However, the relationship between strain hardening rate and grain size in TWIP steels has yet to be clarified, which is important for optimizing the parameters of solution treatments. In the present paper, the specimens of a typical TWIP steel with grain sizes of 7, 13, 30 and 63 μm were fabricated through solution treatments at different temperatures. Mechanical properties were measured by tensile tests, and microstructure evolution was observed by OM and TEM. The results show that the strain-hardening exponent rapidly increases with increasing true strain when it is less than 0.2, but levels off in the subsequent process of deformation. The relationship between strain hardening rate and true strain consists of two stages for the specimen with small grain size and three stages for the specimen with large grain size. Microstructure observation demonstrated that the number of deformation twins increases with the increase of grain size, induced to greater“TWIP”effect in the coarse-grained specimen than in the fine-grained specimen. This can be attributed to the dependence of the critical stress for formation of deformation twins on grain size of $\sigma_{\tau}=\sigma_{\tau 0}+K_{\tau}\}d^{-A}$.

Keywords: TWIP steel grain size strain hardening rate strain hardening exponent TWIP effect

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通讯作者: 王书晗

作者简介: 王书晗, 女, 1982年生, 博士生

作者Email: nmwangshuhan@163.com

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