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超高强钢激光焊接热-冶金-力学耦合本构模型研究

徐加俊[1,2]，黄禹[1,2]，荣佑民[1,2,*]，王璐[1,2]，胡江[1,2]

[1]华中科技大学数字化制造装备与技术国家重点实验室，中国武汉，430074
[2]华中科技大学机械科学与工程学院，中国武汉，430074

*Email: rym@hust.edu.cn and ymrong1987@mail.com

超高强钢具有很好的吸能性，其激光焊接构件在实现汽车轻量化和提高车身安全性能方面起着非常重要的作用。热-冶金-力学耦合本构模型是准确预测超高强钢激光焊接接头宏观形貌、微观组织、显微硬度、应力应变的重要方法，可有效降低重复性工艺试验成本。为此，本文开展了超高强钢激光焊接热-冶金-力学耦合本构模型研究：在传热学方面，建立了考虑小孔半径和倾斜角的双柱体倾斜热源模型，提出了基于粒子群算法确定热源系数的激光焊接温度场模拟方法，实现了接头宏观形貌的准确预测；在冶金学方面，针对激光焊接过程超高加热速度的影响，改进了非等温奥氏体相变模型，研究了不同热循环下的马氏体回火演变过程，并推导了非等温马氏体回火模型，集成构建了考虑马氏体回火的激光焊接固态相变模型，实现了接头微观组织分布及显微硬度的准确预测；在力学方面，结合真实应力应变曲线、温度敏感，以及奥氏体、马氏体和回火马氏体的加工硬化特性，重构了超高强钢1700MS的流动应力模型，并考虑相变伴生应变（体积应变、塑性应变）对应变增量的影响，揭示了热-冶金力学耦合下的超高强钢力学本构关系，并开展了超高强钢激光焊接过程热-冶金-力学耦合数值模拟，实现了接头残余应力的准确预测。

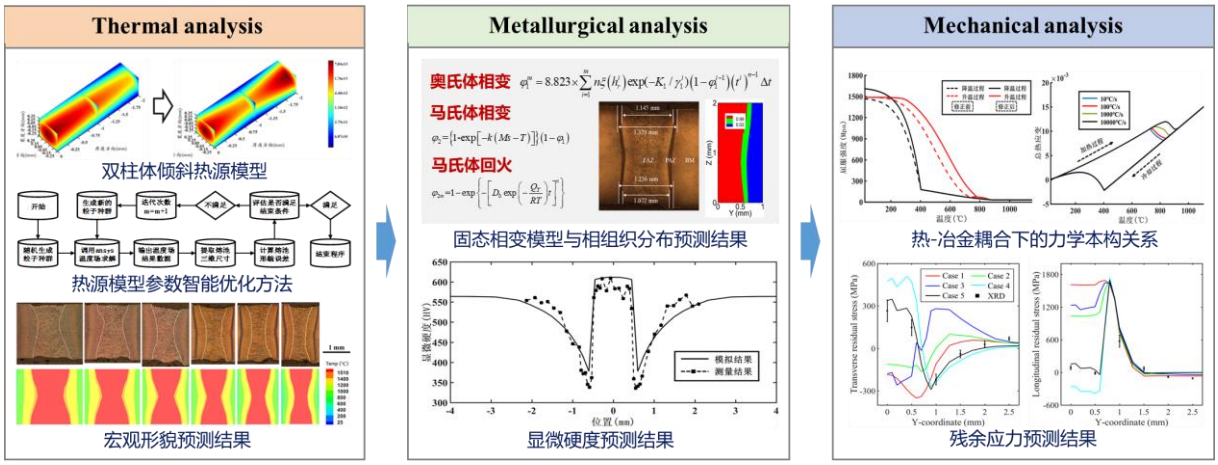

Fig. 1 Thermal-metallurgical-mechanical coupling numerical simulation in laser welding of ultra-high strength steel 1700MS

关键词：激光焊接；热-冶金-力学耦合模型；超高强钢；固态相变

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*第一作者（报告人）联系方式：徐加俊、18064117167、xujiajun0811@163.com