

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	课程名称 Course Title	金属增材制造理论基础 Fundamentals of Additive Manufacturing of Metals
2.	授课院系 Originating Department	机械与能源工程系 Department of mechanical and energy engineering
3.	课程编号 Course Code	ME361
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业选修课 Major Elective Courses
6.	授课学期 Semester	春季 Spring
7.	授课语言 Teaching Language	中英双语 English & Chinese
8.	授课教师、所属学系、联系方式 (如属团队授课, 请列明其他授课教师) Instructor(s), Affiliation & Contact (For team teaching, please list all instructors)	朱强, 机械与能源工程系, 慧园 5-407。电话: 13811482782 Qiang Zhu, Department of mechanical and energy engineering, Wisdom Valley 5-407.TEL: 13811482782
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	TA: 周阳, 机械与能源工程系, 电话:18770668650 TA: Yang Zhou, Department of mechanical and energy engineering, TEL:18770668650
10.	选课人数限额(可不填) Maximum Enrolment (Optional)	

11. 授课方式 Delivery Method	讲授	习题/辅导/讨论	实验/实习	其它(请具体注明)	总学时
	Lectures	Tutorials	Lab/Practical	Other (Please specify)	Total
学时数 Credit Hours	46	2			48
12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	MSE207 材料科学基础 或者 ME261 工程材料—科学、工艺与设计 MSE207 Fundamentals of Materials Science or ME261 Engineering Materials - Science, Processing and Design				
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite					
14. 其它要求修读本课程的学系 Cross-listing Dept.	材料科学与工程, 力学与航空航天工程, 生物医学工程系 Materials Science and Engineering, Mechanics and Aerospace Engineering, Biomedical Engineering				

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

增材制造(Additive Manufacturing, AM)俗称 3D 打印, 其融合了计算机辅助设计、材料科学及材料加工成形技术等学科, 以数字模型文件为基础, 通过软件与数控系统将专用的材料按照逐层堆积的方法制造出实体物品。这种新的工艺为加工制造领域提供了新的方法和思路。虽然增材制造的基本原理很简单, 但其中的微观机理与传统制造方法大不相同, 尤其在金属增材制造这种急冷急热的极端条件下的凝固情况, 更需要考虑的是其亚稳态甚至瞬态的过程, 这与传统的金属凝固的稳态过程完全不同, 这是一门全新的科学与技术领域。

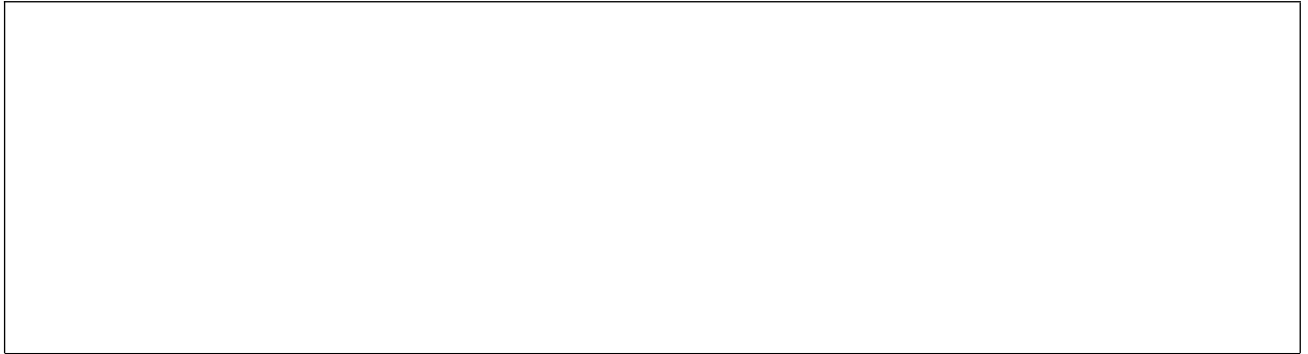
本课程从金属液固相转变开始, 逐步引导学生学习掌握晶体凝固热力学和动力学原理以及增材制造非平衡条件下的凝固过程和理论, 在此基础上讨论非平衡组织形成机理以及对后续材料工艺和性能的影响, 理解增材制造过程中的组织控制理论、缺陷形成机制和监测技术以及增材制造新金属材料研发技术等。通过该课程学习, 期望学生了解和掌握金属增材制造技术与材料制备技术的理论基础, 为学生未来进一步增材制造课程学习研究和工作(学术研究和企业技术开发)打下坚实基础。

Additive Manufacturing (AM), commonly known as 3D printing, combines computer-aided design, material science and materials processing technologies. Based on digital model files, the special materials are stacked layer by layer through software and numerical control system to make parts. This new process provides new methods and ideas for the manufacturing industry. Although the basic principle of additive manufacturing is very simple, the microscopic mechanism is quite different from the traditional manufacturing processes, especially in the case of the rapid heating and cooling of metals during AM processing. More importantly, it is considered to be metastable state or even transient process, which is completely different from the steady-state processes considered in traditional casting processes. The purpose of this course is to provide students with a deeper understanding of metal additive manufacturing. After completing this course, they will have a certain understanding of the micro-mechanism in the process of AM solidification, and cultivate student's ability of analyzing problems from steady state to transients in macro to micro scales.

16. 预达学习成果 Learning Outcomes

通过该课程学习, 期望学生了解和掌握金属增材制造技术与材料制备技术的理论基础, 为学生未来进一步增材制造课程学习研究和工作(学术研究和企业技术开发)打下坚实基础。

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17. 课程内容及教学日历（如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

课程内容	教学要求	学时分配
<p>绪论</p> <ul style="list-style-type: none"> 什么是增材制造 增材制造的历史 增材制造的应用 增材制造分类 金属增材制造的机遇与挑战 <p>Introduction</p> <ul style="list-style-type: none"> what's additive manufacture. the history of AM the application of AM the classification of AM the challenges and opportunities of metal AM 	<p>了解增材制造的背景及金属增材制造的机遇与挑战</p> <p>Understand the background of additive manufacture and the challenges and opportunities of metal AM</p>	2
<p>金属的基本知识</p> <ul style="list-style-type: none"> 金属的种类 金属的基本性质 晶体学简介 金属的微观结构 金属的应用 金属加工工艺 <p>The basics of metal</p> <ul style="list-style-type: none"> types of metal property of metal introduction to crystallography microstructure of metal application of metal metal processing technology 	<p>了解金属的基本性质以及金属的成型工艺</p> <p>Understand the basic knowledge of metal and metal processing technology</p>	6
<p>金属增材制造工艺</p> <ul style="list-style-type: none"> 金属增材制造工艺原理、应用和发展现状 增材制造的前处理过程 CAD/CAE 技术在增材制造中的应用 <p>Metal AM process</p> <ul style="list-style-type: none"> Principle, application and development of metal additive manufacturing technology 	<p>金属增材制造的工艺原理及材料设计，零件设计优化的相关知识</p> <p>The working principle of metal AM process and the knowledge about the design and optimization of material and components.</p>	4

<ul style="list-style-type: none"> • Pre-treatment of AM • CAD/CAE used in AM process 		
<p>金属熔焊工艺及理论</p> <ul style="list-style-type: none"> • 焊接中发生的物化现象 • 焊接过程中的晶粒生长及相变 • 焊接缺陷的产生及理论分析 <p>Metal Welding process and theory</p> <ul style="list-style-type: none"> • The physical and chemical phenomenon in welding • Grain grow and phase transformations in welding • The formation and theoretical analysis of welding defects 	<p>较为深入的了解金属在局部熔化和凝固过程中的一些现象及产生这些现象的原因</p> <p>Understanding the phenomenon happened in the process of local fusion and solidification, at the same time understand the theory between this phenomenon.</p>	4
<p>金属粉床熔融沉积工艺与熔焊工艺对比</p> <ul style="list-style-type: none"> • 金属粉床熔融沉积过程中产生的物化现象 • 焊接组织与金属增材制造组织的对比及形成机理分析 <p>The commons and difference between powder bed fusion (PBF) and fusion welding</p> <ul style="list-style-type: none"> • The physical and chemical phenomenon in welding • Compare the microstructure of PBF and welding, and analysis the formation mechanism 	<p>通过比较金属粉床熔融工艺与熔焊工艺的相同点与不同点，让学生了解在增材制造这种极端条件产生的一些独特的现象。</p> <p>Students will understand some special phenomenon in metal AM by analysis the commons and difference between PBF and fusion welding.</p>	2
<p>凝固热力学</p> <ul style="list-style-type: none"> • 液态金属结构 • 合金相平衡 • 液-固相界面成分及界面溶质分配系数 <p>Thermodynamics of metal solidification-liquid metal structure</p> <ul style="list-style-type: none"> • alloy phase balance • liquid-solid interface components and interfacial solute distribution coefficient 	<p>理解金属凝固过程中各种相变的热力学条件以及在平衡和非平衡条件下固液两相或固液界面的溶质成分</p> <p>Understand the thermodynamic conditions of phase transitions during metal solidification and the solute composition of solid-liquid two-phase or solid-liquid interface under equilibrium and non-equilibrium conditions</p>	6
<p>金属凝固动力学:</p> <ul style="list-style-type: none"> • 凝固形核与生长过程 • 晶体生长方式 <p>Solidification kinetics of metals</p> <ul style="list-style-type: none"> • Solidification nucleation and growth process • grain growth mode 	<p>理解金属凝固过程中的动力学条件，凝固形核和生长过程及晶体的生长方式</p> <p>Understand the kinetics of metal solidification, solidification nucleation and growth, and crystal growth</p>	6
<p>金属微观流体力学</p> <ul style="list-style-type: none"> • 过冷，偏析，溶质再分配 • 晶体形态及界面稳定性 <p>Microfluidics of metals</p> <ul style="list-style-type: none"> • Supercooling, segregation, solute redistribution • crystal morphology and interfacial stability 	<p>了解在增材制造过程中金属的微观流动行为及理论</p> <p>Understand the microfluidics of metals in AM process</p>	4

金属增材制造组织特征 <ul style="list-style-type: none"> 增材制造零件的金相组织形成原理及观测手段 Microstructural characteristics of metal additive manufacturing <ul style="list-style-type: none"> The formation principle of metallographic structure and the observation method of the additive manufacturing parts 	了解金属增材制造中形成特殊组织的原理以及组织的观测手段 Understand the principle of forming special microstructure in metal additive manufacturing and the observation method of microstructure	4
金属增材制造缺陷行为机理 <ul style="list-style-type: none"> 增材制造零件缺陷形成机理分析及减少缺陷的方法 Defect behaviour mechanism of metal additive manufacturing <ul style="list-style-type: none"> Analysis of defect formation mechanism and methods to reduce defects in additive manufacturing parts 	理解金属增材制造缺陷形成的机理 Understand the principle of defect formation	8
总复习 General review	考前复习 General review	2

18. 教材及其它参考资料 Textbook and Supplementary Readings

Teaching book: Ian Gibson, David Rosen and Brent Stucker, Additive manufacturing technologies, Springer, 2nd Edition, 2015. Reference: 1. W. Kurz and D. J. Fischer, Fundamentals of solidification, Third Edition, 1992. 2. Kou S. Welding Metallurgy, Second Edition[M]. 2003. 3. Dongdong Gu, Laser Additive Manufacturing of High Performance Materials, Springer, 2015.

课程评估 ASSESSMENT

19. 评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance		5%		
课堂表现 Class Performance		5%		
小测验 Quiz				
课程项目 Projects		20%		
平时作业 Assignments		20%		
期中考试 Mid-Term Test				
期末考试 Final Exam		50%		
期末报告 Final Presentation				

其它（可根据需要
改写以上评估方
式）
**Others (The
above may be
modified as
necessary)**

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20. **记分方式 GRADING SYSTEM**

- A. 十三级等级制 **Letter Grading**
 B. 二级记分制（通过/不通过） **Pass/Fail Grading**

课程审批 REVIEW AND APPROVAL

21. 本课程设置已经过以下责任人/委员会审议通过
This Course has been approved by the following person or committee of authority

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