

Contents

Chapter 1 Introduction	001
1.1 Background	002
1.2 Motivation	004
1.3 Outline	005
Chapter 2 Investigation of the flow field in Laser-based Powder Bed Fusion manufacturing	007
2.1 Introduction	009
2.2 Simulation model of the L-PBF printer	012
2.2.1 Problem description	012
2.2.2 Geometric model of the L-PBF printer	013
2.2.3 Numerical model of the L-PBF printer	014
2.3 Simulation results	018
2.3.1 Distribution of the flow field	018
2.3.2 Distribution of the temperature field	023

2.3.3 Distribution of spatter particles	025
2.4 Conclusions	031
References	033
Chapter 3 Investigation of optimizing the flow field with fluid cover in Laser- based Powder Bed Fusion manufacturing process	037
3.1 Introduction	039
3.2 Simulation model of the L-PBF printer	041
3.2.1 Geometry of the L-PBF printer with a fluid stabilizing cover ..	041
3.2.2 Numerical model of printer with a fluid stabilizing cover ..	041
3.2.3 Mesh of the L-PBF printer with a fluid stabilizing cover ..	043
3.2.4 Model of the fluid stabilizing cover and particles	044
3.3 Simulation results and discussions	047
3.3.1 Influence of the fluid stabilizing cover on the flow field	047
3.3.2 Influence of the fluid stabilizing cover on particles distribution and removing rate	051
3.4 Summary and conclusions	055
References	057
Chapter 4 Numerical investigation of controlling spatters with negative pressure pipe in Laser-based Powder Bed Fusion process	059
4.1 Introduction	061
4.2 Simulation model of the L-PBF printer	064
4.2.1 Geometric model of the L-PBF printer	064
4.2.2 Numerical model of the L-PBF printer	066
4.3 Simulation results and discussions	069
4.3.1 Effect of pipe diameter	073

4.3.2 Effect of outlet flow rate	075
4.3.3 Effect of initial particle velocity	078
4.4 Summary and conclusions	080
References	082
Chapter 5 Evolution of molten pool during Laser-based Powder Bed Fusion of Ti-6Al-4V.....	085
5.1 Introduction	087
5.2 Modeling approach and numerical simulation.....	090
5.2.1 Model establishing and assumptions	090
5.2.2 Governing equations.....	092
5.2.3 Heat source model	092
5.2.4 Phase change.....	093
5.2.5 Boundary conditions setup.....	094
5.2.6 Mesh generation.....	095
5.3 Experimental procedures	096
5.4 Results and discussions.....	097
5.4.1 Surface temperature distribution and morphology	097
5.4.2 Formation and solidification of the molten pool	099
5.4.3 Development of the evaporation region	103
5.5 Conclusions	106
References	108
Chapter 6 Simulation of surface deformation control during Laser-based Powder Bed Fusion Al-Si-10Mg powder using an external magnetic field	113
6.1 Introduction	115
6.2 Modeling and simulation	118

6.2.1	Modeling of L-PBF	118
6.2.2	Mesh model and basic assumptions	119
6.2.3	Heat transfer conditions	120
6.2.4	Marangoni convection.....	121
6.2.5	Phase-change material	121
6.2.6	Lorentz force	122
6.3	Results	124
6.3.1	Velocity field in the molten pool	124
6.3.2	Lorentz force in the MP	127
6.3.3	Surface deformation of the sample	129
6.4	Conclusions	133
	References	134

Chapter 7	Influence of laser post-processing on pore evolution of Ti-6Al-4V alloy by Laser-based Powder Bed Fusion.....	137
7.1	Introduction	139
7.2	Experimental procedures	142
7.2.1	Sample fabrication	142
7.2.2	Determination of porosity by micro-CT	143
7.3	Modeling and simulation	146
7.3.1	Numerical model	146
7.3.2	Moving Gaussian heat source	149
7.3.3	Thermal boundary conditions	149
7.3.4	Marangoni effect, surface tension and recoil pressure	150
7.4	Numerical results and discussion.....	151

7.5 Conclusions	158
References	159
Chapter 8 Evolution of multi-pores in Ti-6Al-4V/Al-Si-10Mg alloy during laser post-processing	163
8.1 Introduction	165
8.2 Experimental procedures	168
8.2.1 Sample preparation	168
8.2.2 Detection of porosity by micro-CT	168
8.3 Model and simulation	171
8.3.1 Simulation model	171
8.3.2 Gaussian heat source	173
8.3.3 Latent heat of phase change	174
8.3.4 Level-set method	175
8.3.5 Boundary conditions	175
8.4 Numerical results and discussion	177
8.5 Conclusions	183
References	185
Chapter 9 Investigation of laser polishing of four Laser-based Powder Bed Fusion alloy samples	189
9.1 Introduction	191
9.2 Model and theoretical calculation	195
9.2.1 Physical model and assumptions	195
9.2.2 Governing equations and boundary conditions	197
9.2.3 Simulation results	199
9.3 Experimental methods	202

9.3.1	Sample fabrication	202
9.3.2	Morphology observation by 3D optical profiler	205
9.3.3	Experimental results	206
9.4	Conclusions	213
	References	215