

Contents

Vorwort des Herausgebers	II
Abstract	IV
Kurzfassung	VI
Nomenclature	IX
1 Introduction	1
2 Motivation for the present work	3
3 Computational Thermo-Fluid Dynamics	5
3.1 Numerical Discretization and Approximation Schemes	9
3.2 Numerical stability and dimensionless numbers	16
3.3 OpenFOAM	18
4 State of the art	21
4.1 Phase change problems	21
4.2 Multiphase flows	26
4.3 Coupled overlapping grid approaches	33
5 Numerical Modelling	41
5.1 Modelling solid-liquid phase change in a storage capsule	41
5.1.1 Multiphase modelling of a storage capsule	41
5.1.2 Simplified numerical modelling of a storage capsule	52
5.2 Modelling heat transfer in a latent heat thermal storage unit	59
5.2.1 Conjugate heat transfer (CHT) model	59
5.2.2 Local thermal non-equilibrium (LTNE) model for a thermal storage unit	66
6 Experimental methods	77
6.1 Optical investigation of phase change in a cubical cavity	77
6.2 Thermometry of phase change in a cylindrical tube	81
6.3 Investigation of conjugate heat transfer for thermal storage systems	84
6.4 Thermal charging and discharging of laboratory-scale latent heat thermal energy storage	88

7	Validation of numerical models with experimental results	93
7.1	Numerical discretization and simulation parameters	94
7.1.1	Validating numerical method for a convection driven melting problem	96
7.1.2	Validating numerical methods for solid settling in PCM capsule	97
7.2	Multiphase numerical model for melting of encapsulated PCM	100
7.3	Simplified numerical models for melting of encapsulated PCM	106
7.3.1	Simplified convective model	107
7.3.2	Simplified effective conductive model	110
7.3.3	Role of natural convection and solid settling in melting of salt hydrate inside a cylindrical enclosure	112
7.4	Conjugate heat transfer (CHT) model	115
7.5	Local thermal non equilibrium (LTNE) model	122
7.5.1	Discharging of laboratory scale latent heat thermal storage unit	123
7.5.2	Charging of laboratory scale latent heat thermal storage unit	127
8	Parametric study for an efficient thermal storage configuration	133
9	Summary	137
10	Zusammenfassung	141
	Bibliography	145
	Vorveröffentlichungen	161