

Table of Contents

Abstract	iii
Table of Contents.....	v
List of Figures	ix
List of Tables.....	xiii
List of Symbols	xv
Greek symbols	xvi
Subscripts	xvi
1. Introduction.....	1
1.1. Catalytic reactors in Space Propulsion	1
1.2. Demand for green propellants for Space Propulsion applications	4
1.3. Green alternatives to hydrazine	8
1.2.1. Hydrogen peroxide.....	9
1.2.1.1 Main features of hydrogen peroxide solutions.....	9
1.2.1.2 Past and present applications of <i>H₂O₂</i> in propulsion systems.....	11
1.2.1.3 Researches on heterogeneous catalysts for <i>H₂O₂</i> decomposition	13
1.2.2. Nitrous oxide	16
1.2.3. Blends.....	17
1.2.4. Propellants comparison: synthesis table	19
1.4. Research objectives and thesis structure	19
2. Flows in Porous Media	25
2.1. Porous media	25
2.2. Pressure drops in porous media	29
2.2.1. Absolute permeability.....	31
2.2.2. Inertial effects.....	32
2.2.3. Flow regimes classification	33
2.2.4. On the formulation of momentum equation for flows in porous media	35
2.3. Heat transfer in porous media.....	35
2.3.1. Effective thermal conductivity	37

2.3.2. Convective heat transfer	38
2.4. Reactions and mass transfer in porous media	40
2.4.1. Mass transfer in porous media	44
3. Multiphase Flows in Porous Media	47
3.1. Transport properties of multiphase flows in porous media	47
3.1.1. Flow maps	47
3.1.2. Bubbles formation and phase change in porous media	49
3.1.3. Pressure drops	52
3.1.4. Heat and mass transfer	53
3.2. Modelling multiphase flows in porous media	54
3.2.1. Multiphase Mixture Flow Model (MMF)	55
3.2.2. MMF model: limitations and proposed solutions	59
4. Extending the validity of MMF	65
4.1. Reconsidered assumptions and further considerations	65
4.2. Final set of governing equations	71
4.3. Code development	72
4.3.1. Discretization of equations and calculation sequence	73
5. Numerical results	79
5.1. Flows of single-phase single-component fluids in porous	79
medium	79
5.2. Flow boiling of single-component fluids in porous media	83
5.2.1. Flow boiling in packed bed of randomly stacked fibres	83
5.2.2. Flow boiling in metal foam	99
5.3. Multiphase reactive flows in packed-bed reactors	107
5.4. Additional numerical results	123
6. Conclusions and Outlook	127
Appendices	131
A. Properties of $H_2O_2 - H_2O$ liquid solutions	131
A.1 Density	131
A.2 Specific heat capacity and latent heat	132
A.3 Vapour pressure	132
A.4 Viscosity	132
A.5 Thermal conductivity	133
A.6 Diffusivity (Wilke-Chang formula)	133

B. Properties of H_2O_2 , H_2O , O_2 vapour mixtures	134
B.1 Viscosity.....	134
B.2 Thermal conductivity.....	135
B.3 Diffusivity.....	135
B.1 Specific heat capacity	136
References.....	137