



Ijaz Ul Mohsin

# **Kinetic Modelling of thermal debinding & sintering in MIM processes**

Metal Injection Molding

 **LAMBERT**  
Academic Publishing

## Table of contents

1	Introduction .....	1
1.1	Metal Injection Molding (MIM) .....	1
1.2	Solvent de-binding .....	3
1.3	Thermal de-binding .....	4
1.4	Sintering.....	5
1.5	Material systems.....	9
1.5.1	Pure Copper .....	9
1.5.2	Pre-mixed heavy alloy 90W - 8Ni - 2Cu (MT-150).....	9
1.5.3	Pre-mixed 88Fe - 12Cu (MT-150) .....	10
1.6	Thermo-physical analysis .....	12
1.6.1	Specific heat (DSC).....	12
1.6.2	Dimensional change (Dilatometry) .....	13
1.6.3	Mass change (Thermogravimetric analysis).....	14
1.6.4	Thermal Diffusivity and Conductivity .....	15
1.7	Evolved gas analysis.....	17
1.7.1	FTIR and Mass spectrometry.....	17
1.8	Kinetic Model description .....	18
1.9	Rate Controlled De-binding/Sintering (RCD/RCS) .....	20
1.10	Finite Element Method (FEM) .....	21
1.11	Project approach .....	23
2	Experimental techniques .....	25
2.1	Materials (base powder) .....	25
2.2	Chemical analysis of base powders.....	25
2.3	SEM investigation of powders .....	25
2.4	Feedstock preparation.....	28
2.5	Sample preparation.....	29
2.6	Injected samples (Green density, geometry).....	30
2.7	Solvent de-binding .....	31
2.8	Measurement of thermo-physical properties .....	35
2.8.1	Specific heat.....	35
2.8.2	Density.....	38
2.8.3	Thermal Diffusivity and Conductivity .....	43

3	Thermal de-binding of copper system .....	47
3.1	Material & Experimental .....	47
3.2	Results & discussion.....	47
3.3	Rate controlled de-binding (RCD) .....	63
3.4	TGA analysis of different copper feedstocks.....	65
3.5	FE modelling of thermal de-binding .....	66
3.5.1	Experimental verification: .....	71
3.6	Comparison with commercially available Debindo model .....	72
4	Sintering of copper system.....	76
4.1	Materials & Experimental.....	76
4.2	Result & discussion .....	76
4.3	Rate controlled sintering (RCS) .....	79
4.4	Dilatometric analysis of the effect of copper particle size (in brown specimen).....	81
4.5	Finite modelling of sintering.....	82
4.5.1	Experimental verification .....	88
5	Thermal de-binding of Fe - 12Cu system .....	89
5.1	Materials & Experimental:.....	89
5.2	Results & discussion.....	89
5.3	Rate controlled de-binding (RCD) .....	95
6	Sintering of Fe - 12 Cu system.....	98
6.1	Material and experimental .....	98
6.2	Results .....	98
6.3	Rate Controlled Sintering (RCS) .....	102
7	Thermal de-binding of W-8Ni-2Cu system .....	106
7.1	Materials & Experimental.....	106
7.2	Results & Discussion.....	106
7.3	Rate controlled de-binding (RCD) .....	112
8	Sintering of W-8Ni-2Cu system.....	114
8.1	Materials and experimental.....	114
8.2	Results .....	115
8.3	Rate controlled sintering (RCS).....	123
9	Summary and conclusions.....	126
9.1	Further suggestions.....	128
10	References .....	129