

Contents

1	Introduction	1
1.1	Overview of sheet metal forming processes	2
1.2	State-of-the-art in the modelling of rate dependent plasticity and damage	4
1.3	Outline of the dissertation	7
2	Finite plasticity with nonlinear kinematic and isotropic hardening	9
2.1	Introduction	9
2.2	Constitutive modelling	10
2.3	Extension to ductile damage	12
2.4	Numerical implementation by an implicit formulation	14
2.4.1	Numerical computation of the consistent tangent operator	16
2.4.2	Implementation into ABAQUS/Standard	17
2.5	Numerical implementation by an explicit formulation	19
2.6	Conclusion	20
3	Robot based incremental sheet metal forming	23
3.1	Motivation	23
3.2	Finite element simulation	25
3.3	Conclusion	29
4	Nakazima stretch test	37
4.1	Motivation	37
4.2	Numerical investigation	38
4.3	Finite element simulation	44
4.4	Comparison with experiments	50
4.4.1	A1100 aluminium alloy sheets	50
4.4.2	A5182 aluminium alloy sheets	56

4.5	Conclusion	59
5	Coupled quasi-static and electromagnetic simulation	63
5.1	Motivation	63
5.2	Parameter identification by inverse methods	64
5.3	Numerical tests on a single element	65
5.4	Parameter identification by tensile tests	67
5.5	Coupled quasi-static and electromagnetic simulation results	71
5.5.1	Validation on the example of a cross-die forming	71
5.5.2	Validation on the example of a round cup forming	80
5.6	Optimization of the current impulse	93
5.6.1	Introduction	93
5.6.2	Simulation setup	94
5.6.3	Optimization	95
5.6.4	Results	98
5.7	Contactless electromagnetic sheet metal forming	99
5.8	Conclusion	104
6	Conclusion	107
	List of Figures	111
	List of Tables	117
	Bibliography	119