

VIII/C1 Metal Forming Data

Part 1: Ferrous Alloys

Contents

	Overview of steel grades with page number references	1
1	Definitions	4
1.1	Flow stress	4
1.2	Plasticity	5
1.3	Deformation behaviour	6
1.4	Methods to determine the deformation behaviour	8
1.4.1	Overview and specifications	8
1.4.2	Simulation test method	11
1.4.3	Technological tests	15
1.4.3.1	Deep drawing test	15
1.4.3.2	Cold rolling test	15
1.5	References	16
2	Flow stress	17
2.1	Influence of the chemical composition	17
2.1.1	Hot working	17
2.1.2	Cold deformation	20
2.1.2.1	General remarks	20
2.1.2.2	Heat treatment state	22
2.2	Influence of forming conditions	23
2.2.1	Hot forming	23
2.2.1.1	Influence of deformation temperature	23
2.2.1.2	Influence of strain	25
2.2.1.3	Influence of the strain rate	27
2.2.2	Cold forming	28
2.2.2.1	Forming degree	28
2.2.2.2	Forming rate	30
2.3	Modelling	31
2.3.1	Influence of the chemical composition	31
2.3.2	Influence of forming conditions	33
2.3.2.1	Hot working	33
2.3.2.1.1	Modelling by means of the thermodynamic factors	34
2.3.2.1.2	Calculation using the activation energy of hot deformation	37
2.3.2.2	Cold deformation	39
2.3.2.2.1	Effect of the deformation degree	39
2.3.2.2.2	Influence of deformation degree, deformation temperature and deformation rate	40
2.4	References	42
3	Plasticity	43
3.1	Hot plasticity	43
3.1.1	Influence of the material	44
3.1.2	Influence of temperature and strain rate	45

3.1.3	Influence of the stress condition	46
3.2.1	Factors influencing cold plasticity	46
3.2	Cold plasticity	46
3.2.2	Cold plasticity parameters	47
3.3	Modelling of the plasticity by hot working	51
3.3.1	Modelling of the influence of the chemical composition	51
3.3.2	Influence of deformation conditions	53
3.3.2.1	Modelling of temperature influence	53
3.3.2.2	Modelling of strain rate influence	54
3.3.2.3	Modelling the influence of temperature, strain rate and stress	54
3.4	Considerations on metal physics	55
3.5	Calculation of boundary deformation degrees at rolling	57
3.5.1	Calculation of boundary deformation in first passes of a rod rolling mill	58
3.5.2	Boundary deformation degrees at cold rolling	59
3.6	References	61
4	Mechanical and physical properties	62
4.1	Mechanical properties after cold deformation	62
4.1.1	Yield point and tensile strength	62
4.1.2	Elongation	63
4.2	Young's modulus	64
4.2.1	Definition and fundamental relationships	64
4.2.2	Temperature dependent modelling of the Young's modulus	65
4.3	Thermal conductivity	66
4.3.1	Definition of the thermal conductivity	66
4.3.2	Thermal conductivity calculation	69
4.4	Specific heat capacities	73
4.4.1	Definition and dependences	75
4.4.2	Specific heat capacity calculation	73
4.5	Thermal expansion coefficient	75
4.5.1	Definition and factors of influence	75
4.5.2	Influence of temperature on the coefficient of expansion	77
4.6	Density	79
4.6.1	Definition and factors of influence	79
4.6.2	Modelling the dependence on temperature	80
4.7	References	82
5	Data bank of deformation parameters	83
5.1	Introduction	83
5.1.1	Base of the data bank	83
5.1.2	Hot and cold flow curves	83
5.1.2.1	Remarks to the flow stress constants	84
5.1.2.2	Extrapolation	84
5.1.3	Plasticity curves	85
5.1.4	Mechanical and physical properties	86
5.2	Hot and cold forming data	87
5.2.1	Non alloy, alloy quality and special steels	87
5.2.2	Tool steels, wear resistant and bearing steels	272
5.2.3	Stainless steels	384
5.2.4	Heat resistant and high temperature resisting steels	519
5.2.5	Alloy special steels: Structural steels	599
5.2.6	Alloy special steels: High strength weldable structural steels	771
5.3	References	795