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APPENDIXES

APPENDIX I

DESCIPTION OF DTA

The Differential Thermal Analysis (DTA) is applied to determine liquidus, solidus and phase transformations temperature during solidification of steel. It is a technique that is recording the temperature difference between a sample and a reference material. The equipment is comparing the temperature of the two specimens. Both are cooled down or heated up under the same condition. The reference material is Alumina (Al_2O_3) which makes no transformation of phases or changing of the inner energy due to lattice transformations or solidification. Therefore a change in the temperature is indicating a transformation due to the exothermic or endothermic effect during the phase transformation of the sample.

The major parts of the DTA, brand name is Netzsch 404s, are shown in Fig.A1-1. The equipment consists mainly of vacuum furnace, specimen carrier, temperature measurement system and controlling unit and power unit.

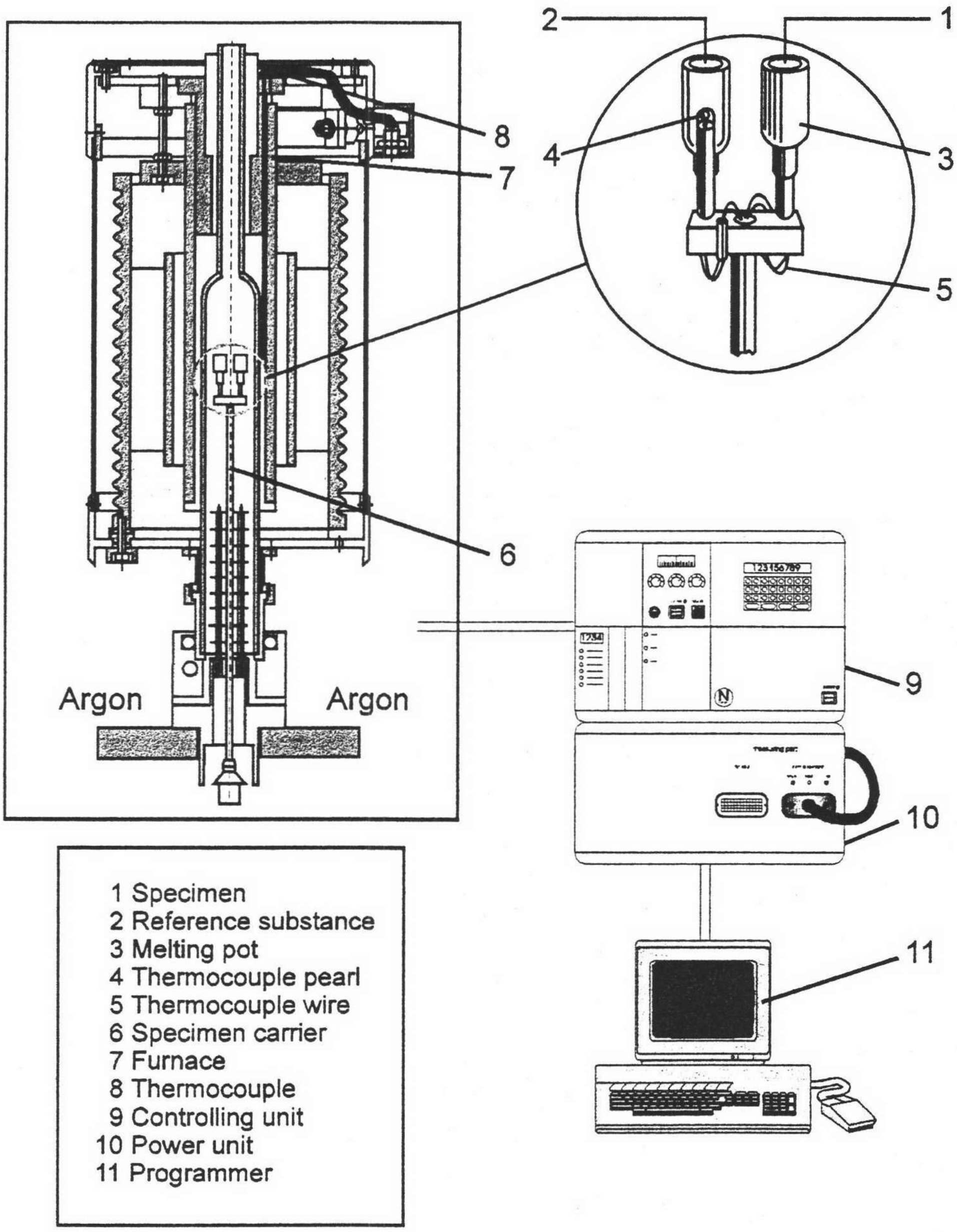

Fig.A1-1 Differential-Thermal Analysis (DTA) equipment.

The samples are heated up and cooled down with a certain cooling down or heating up velocity under argon atmosphere. During the tests the data are then transferred in a DTA-curve. The curve shows series of peaks that correspond to a phase transformation of the sample.

The sample (200 mg) was put in the sample holder inside the equipment. The operation is controlled by computer program. After closing the furnace the tests will be started in an inert atmosphere to minimize sample oxidation. The sample is heated up automatically with a heating rate of 10°C/min and cooled down with the same rate. A specific recording device records the data of DTA.

A simplified curve of DTA is shown in Fig.A1-2. The figure displays the way to determine the solidus and liquidus temperature with the help of the DTA-curve. For the cooling curve the solidus temperature takes place at the point where the base line and incline line (solidification path) meet. The heating curve indicates the liquidus temperature at the peak of the curve.

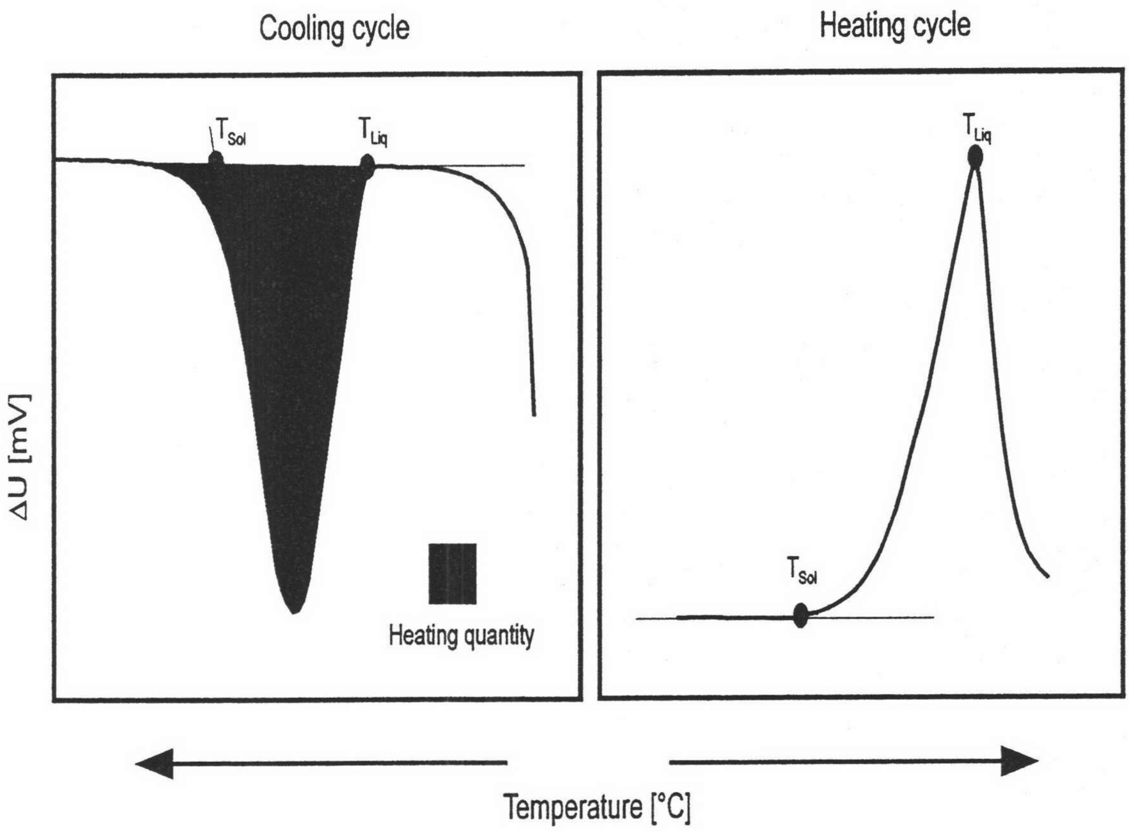

Fig.A1-2 Schematic diagram of a simple heating and cooling curve of DTA.

APPENDIX II

DATA OF HOT TENSILE TEST

Four groups of hot tensile test of steel grade AISI L3 are shown in Table A2-1 to A2-4, whereas the last four tables are the results of hot tensile test of steel grade AISI O1.

Table A2-1 Data of hot tensile test of steel grade AISI L3, group L3-1 (Strain rate: $2x10^{-3}$/s, Cooling rate: 0.5°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
11/S1	897	14.24	4.7	95	
10/S1	1000	9.15	1.7	99	
9/S1	1096	5.96	0.0	100	
14/S1	1157	5.32	0.0	100	
1/S1	1198	4.14	12.5	63	
2/S1	1230	3.57	19.5	11	
3/S1	1245	2.84	20.1	5	
4/S1	1255	2.54	20.4	2	
12/S1	1263	2.53			ZDT
5/S1	1264	2.62			
13/S1	1271	2.92			
6/S1	1357	0.81			
8/S1	1382	0.29			
15/S1	1389	0.00			ZST
7/S1	1397	0.00			

Table A2-2 Data of hot tensile test of steel grade AISI L3, group L3-2 (Strain rate: $2x10^{-3}/s$, Cooling rate: 3°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
H/S1	896	13.70	16.3	37	
G/S1	1000	8.04	15.7	42	
F/S1	1050	7.31	14.2	52	
E/S1	1129	5.64	12.9	61	
C/S1	1162	5.05	12.4	64	
A/S1	1203	4.21	14.1	53	
L/S1	1238	3.36	14.7	49	
I/S1	1253	3.53	14.1	53	
J/S1	1277	2.86	19.9	7	
K/S1	1284	2.82	20.2	4	
S/S1	1296	2.23			ZDT
Q/S1	1323	1.13			
R/S1	1343	0.82			
O/S1	1357	0.00			ZST

Table A2-3 Data of hot tensile test of steel grade AISI L3, group L3-3 (Strain rate: $2x10^{-2}/s$, Cooling rate: 0.5°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
IV/S1	900	17.49	6.5	90	
III/S1	1000	10.77	15.0	47	
II/S1	1150	6.02	17.2	30	
IX/S1	1158	4.85			ZDT
VII/S1	1169	4.53			
VI/S1	1184	3.57			
V/S1	1203	3.93			
I/S1	1303	0.80			
XII/S1	1304	0.90			
XIV/S1	1320	1.19			
X/S1	1335	0.00			ZST
XI/S1	1344	0.00			

Table A2-4 Data of hot tensile test of steel grade AISI L3, group L3-4 (Strain rate: $2x10^{-2}$/s, Cooling rate: 3°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
H1/S1	900	18.00	14.8	49	
I1/S1	902	17.77	14.7	48	
G1/S1	1002	9.51	13.5	57	
F1/S1	1100	7.60	14.9	48	
B1/S1	1203	5.47	14.7	49	
E1/S1	1238	3.74	20.0	6	
C1/S1	1256	3.49	20.3	2	
D1/S1	1266	3.00			ZDT
A1/S1	1308	2.45			
L1/S1	1324	1.71			
J1/S1	1335	0.00			ZST
K1/S1	1335	0.00			

Table A2-5 Data of hot tensile test of steel grade AISI O1, group O1-1 (Strain rate: $2x10^{-3}$/s, Cooling rate: 0.5°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
7/S2	893	17.08	11.2	70	
4/S2	1000	10.13	3.5	97	
3/S2	1103	6.56	0.0	100	
2/S2	1204	4.24	0.0	100	
5 S2	1255	3.47	17.5	28	
6/S2	1278	2.92	20.0	6	
12/S2	1290	2.53			ZDT
1/S2	1306	2.43			
8/S2	1400	0.58			
9/S2	1408	0.38			
10/S2	1415	0.00			ZST
11/S2	1421	0.00			

Table A2-6 Data of hot tensile test of steel grade AISI O1, group O1-2 (Strain rate: $2x10^{-3}/s$, Cooling rate: 3°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
E/S2	895	17.51	17.2	30	
D/S2	1007	9.98	15.6	43	
C/S2	1108	6.53	11.1	71	
B/S2	1203	4.75	14.0	54	
A/S2	1308	3.20	18.9	16	
H/S2	1312	2.63	20.0	6	
I/S2	1316	2.47			ZDT
G/S2	1325	2.35			
F/S2	1329	2.54			
J/S2	1355	1.24			
K/S2	1360	0.90			
L/S2	1380	0.86			
M/S2	1388	0.00			ZST

Table A2-7 Data of hot tensile test of steel grade AISI O1, group O1-3 (Strain rate: $2x10^{-2}/s$, Cooling rate: 0.5°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
IV/S2	900	23.54	14.4	51	
III/S2	1003	12.66	9.2	80	
II/S2	1102	10.09	1.7	99	
I/S2	1207	6.15	18.3	21	
VI/S2	1224	5.37	20.3	3	
V/S2	1230	4.97			ZDT
VII/S2	1308	3.27			
IX/S2	1377	0.60			
X/S2	1388	0.48			
XI/S2	1400	0.39			
XII/S2	1405	0.00			ZST

Table A2-8 Data of hot tensile test of steel grade AISI O1, group O1-4 (Strain rate: $2x10^{-2}$/s, Cooling rate : 3°C/s)

Trial number	T_{test} (°C)	F_{max} (kN)	D_F (mm)	RA (%)	Remark
B1/S2	894	19.50	17.4	29	
A1/S2	998	12.80	14.2	53	
C1/S2	1103	9.95	10.8	73	
D1/S2	1205	6.63	16.0	40	
F1/S2	1264	4.78	19.1	14	
G1/S2	1275	4.39			ZDT
E1/S2	1304	3.84			
H1/S2	1356	1.65			
I1/S2	1367	0.93			
K1/S2	1387	0.74			
J1/S2	1395	0.00			ZST

VITA

Mr. Sakhob Khumkoa was born in Khonkaen, Thailand on May 22, 1972. He received his certificate of high school in Namphong Suksa School, Khonkean, in 1990. He received his Bachelor Degree of Engineering in department of Metallurgical Engineering, faculty of Engineering, Chulalongkorn University in 1994. He was a student of Gradate School of Chulalongkorn University and began to study in the same department where he received Bachelor Degree of Engineering since academic year 1995.