APPENDIX 2

A2: Fitting parameters and equations of the mechanical property surfaces

A2.1:Steel F

Table A2.1(a): The fitting parameters for the YS/UTS ratio of steel F, in Equation (4.3)

		Fitting parameters in Equation (4.3)			
Austenitisation temperature	**Normalised austenitisation temperature T**	**a**	**b**	**c**	**Correlation coefficient**
800°C	-1	0.0365	0.0495	0.5224	0.992
850°C	-0.33333	0.0298	0.0477	0.5094	0.979
900°C	0.333333	0.0134	0.0522	0.496	0.975
950°C	1	0.0148	0.0501	0.4786	0.982

Table A2.1(b) The fitting parameters for the YS/UTS ratio of steel F, in Equation (4.4)

	Fitting parameters in (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	0.0155	0.0046	-0.0263	0.0211	1
b	-0.0073	-0.0002	0.0076	0.05	1
c	-0.002	-0.0025	-0.0199	0.503	1

Table A2.1(c): Fitting parameters for the ultimate tensile strength of steel F in Equation (4.3)

		Fitting parameters in Equation (4.3)				
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	117.6	-390.52	33.642	2163.8	0.97
850°C	-0.33333	202.71	-452.26	-230.58	2348.8	0.939
900°C	0.333333	122.3	-316.52	-316.87	2365.8	0.996
950°C	1	13.969	-195.43	-74.625	2029	0.978

Table A2.1(d): Fitting parameters for the tensile strength of steel F in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	0	-108.81	-58.695	174.6	0.95
b	0	102.84	108.15	-395.82	0.94
c	0	284.89	-61.664	-305.38	0.99
d	0	-293.51	-58.11	2389.9	0.98

Table A2.1(e): Fitting parameters for the Charpy impact energy of steel F in Equation (4.3)

		Fitting parameters in Equation (4.3)				
Austenitisation temperature	**Normalised austenitisation temperature T**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	-1.6946	2.3901	5.3945	10.33	0.995
850°C	-0.33333	-0.2232	1.2026	2.9669	6.2403	0.9946
900°C	0.333333	0.3044	0.3166	2.3285	8.6423	0.97
950°C	1	0.3809	0.5326	1.4276	7.5503	0.906

Table A2.1(f): Fitting parameters for the Charpy impact energy of steel F in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	0.2771	-0.7846	0.7606	0.1278	1
b	0.4503	0.7895	-1.379	0.6719	1
c	-1.1541	0.8588	-0.8294	2.5523	1
d	-5.617	1.68682	4.2271	7.2539	

A2. Eq1. Equations for the mechanical properties of steel F

$$\frac{YS}{UTS} = \left(0.0155T_{an}^{\ 3} + 0.0046T_{an}^{\ 2} - 0.0263T_{an} + 0.0211\right)\times T_{tn} + \left(-0.0073T_{an}^{\ 3} - 0.0002T_{an}^{\ 2} + 0.0076T_{an} + 0.05\right)\times T_{tn} + \left(-0.002T_{an}^{\ 3} - 0.0025T_{an}^{\ 2} - 0.0199T_{an} + 0.503\right)$$

(A2.Eq1(a))

$$UTS = \left(-108.81T_{an}^{\ 2} - 58.695T_{an} + 174.6T_{an}\right)\times T_{tn}^{\ 3} + \left(102.84T_{an}^{\ 2} + 108.15T_{an} - 395.82\right)\times T_{tn}^{\ 2} + \left(284.86T_{an}^{\ 2} - 61.664T_{an} - 305.38\right)\times T_{tn} + \left(-293.51T_{an}^{\ 2} - 58.11T_{an} + 2389.9\right)$$

(A2. Eq1(b))

$$CIE\left(-40^{0}C\right) = \left(0.2771T_{an}^{\ 3} - 0.7846T_{an}^{\ 2} + 0.7606T_{an} + 0.1278\right)\times T_{tn}^{\ 3} + \left(0.4503T_{an}^{\ 3} + 0.7895T_{an}^{\ 2} - 1.379T_{an} + 0.6419\right)\times T_{tn} + \left(-1.1541T_{an}^{\ 3} + 0.8588T_{an}^{\ 2} - 0.8294T_{an} + 2.5523\right)\times T_{tn} + \left(-5.617T_{an}^{\ 3} + 1.68682T_{an}^{\ 2} + 4.2271T_{an} + 7.2539\right)$$

(A2.Eq1©)

A2.2: Steel G

Table A2.2(a): The fitting parameters for the yield to tensile strength ratio of steel G in Equation (4.3)

		Fitting parameters in Equation (4.3)			
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**Correlation coefficients**
800°C	-1	0.0287	0.0442	0.6758	0.99
850°C	-0.33333	0.0273	0.0621	0.6844	0.81
900°C	0.333333	0.0271	0.0592	0.5196	0.9881
950°C	1	0.0069	0.0739	0.5166	0.9249

Table A2.2(b): Fitting parameters for the objective function for Steel G

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	-0.0119	-0.0106	0.001	0.0284	1
b	0.0216	-0.0018	-0.0067	0.0609	1
c	0.1885	-0.0065	-0.2681	0.6027	1

Table A2.2(c): Fitting parameters for the tensile strength of steel G in Equation (4.3)

Austenitisation temperature	**Normalised austenitisation temperature T**	**Fitting parameters in (4.3)**				**Correlation coefficients**
		a	**b**	**c**	**d**	
800°C	-1	265.22	-670.08	-92.36	2177.8	0.963
850°C	-0.33333	122.37	-308.53	-261.59	2110.8	0.962
900°C	0.333333	38.471	-166.74	-245.45	2090	0.965
950°C	1	123.55	-289.29	-282.04	2036.6	0.986

Table A2.2(d): Fitting parameters for the tensile strength of steel G in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	0	128.21	-76.336	66.175	0.98
b	0	-272.31	192.62	-207.38	0.999
c	-133.93	74.61	39.091	-261.81	1
d	-44.325	7.65	-26.275	2099.6	1

Table A2.2(e): Fitting parameters for the Charpy impact energy of the sub-sized specimens of steel G

		Fitting parameters in Equation (4.3)				
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	1.4866	-4.2306	2.6199	18.178	0.9968
850°C	-0.33333	0.1438	-2.0506	3.9178	15.008	0.995
900°C	0.333333	0.7649	-2.7295	3.1999	16.611	0.986
950°C	1	-0.275	-1.0173	3.5676	14.176	0.993

Table A2.2(f): Fitting parameters for the Charpy impact energy of steel G in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	-2.039	0.1704	1.1582	0.4354	1
b	2.95531	-0.2631	-1.3465	-2.3608	1
c	1.7445	-0.5232	-1.2707	3.617	1
d	-4.9562	0.4134	2.9552	15.764	1

A2. Eq2. Equations for the mechanical properties of steel G

$$\frac{YS}{UTS} = \left(-0.0119T_{an}{}^{3} - 0.0106T_{an}{}^{2} + 0.001T_{an} + 0.0284\right)\times T_{tn}{}^{2} + \left(0.0216T_{an}{}^{3} - 0.018T_{an}{}^{2} - 0.0067T_{an} + 0.0609\right)\times T_{tn} + \left(0.1885T_{an}{}^{3} - 0.0065T_{an}{}^{2} - 0.2681T_{an} + 0.6027\right)$$

(A2.Eq2(a))

$$UTS = \left(128.21T_{an}{}^{2} - 76.336T_{an} + 66.175\right)\times T_{tn}{}^{3} + \left(-272.31T_{an}{}^{2} + 192.62T_{an} - 207.38\right)\times T_{tn}{}^{2} + \left(-133.93T_{an}{}^{3} + 74.61T_{an}{}^{2} + 39.091T_{an} - 261.81\right)\times T_{tn} + \left(-44.325T_{an}{}^{3} + 7.65T_{an}{}^{2} - 26.275T_{an} + 2099.6\right)$$

(A2.Eq2(b))

$$CIE\left(-40^{0}C\right) = \left(-2.039T_{an}{}^{3} + 0.1704T_{an}{}^{2} + 1.1582T_{an} + 0.4354\right)\times T_{tn}{}^{3} + \left(2.955T_{an}{}^{3} - 0.2631T_{an}{}^{2} - 1.3465T_{an} - 2.3608\right)\times T_{tn}{}^{2} + \left(1.7445T_{an}{}^{3} - 0.5232T_{an}{}^{2} - 1.2707T_{an} + 3.617\right)\times T_{tn} + \left(-4.9562T_{an}{}^{3} + 0.4134T_{an}{}^{2} + 2.9552T_{an} + 15.764\right)$$

(A2.Eq2©)

A2.3: Steel H

Table A2.3(a): The fitting parameters in Equation (4.3) for the YS/UTS ratio of steel H

		Fitting parameters in Equation (4.3)			
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**Correlation coefficients**
800°C	-1	0.0224	0.0545	0.4888	0.92
850°C	-0.33333	0.0193	0.058	0.4754	0.95
900°C	0.333333	0.0137	0.0378	0.4662	0.99
950°C	1	0.0129	0.0273	0.4444	0.9833

Table A2.3(b): The fitting parameters in Equation (4.4) for the YS/UTS ratio of steel H

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	0	0.0013	-0.0051	0.0164	0.96
b	0.0188	-0.0079	-0.0324	0.0488	1
c	0	-0.0047	-0.0214	0.4713	0.99

Table A2.3(c): The fitting parameters for the ultimate tensile strength of steel H in Equation (4.3)

		Fitting parameters in Equation (4.3)				
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	231.81	-791.9	489.98	1932.8	0.994
850°C	-0.33333	230.63	-704.14	388.36	1864.1	0.996
900°C	0.333333	262.13	-668.63	100.07	2151.2	0.992
950°C	1	166.59	-563.7	286.23	1839.1	0.996

Table A2.3(d): The fitting parameters for the ultimate tensile strength of steel H in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	-89.842	-53.078	57.232	252.28	1
b	68.439	9.6581	45.661	-687.46	1
c	371.88	161.88	-473.75	226.23	1
d	-537.19	-136.91	490.34	2022.9	1

Table A2.3(e): The fitting parameters of the Charpy impact energy for steel H in Equation (4.3)

		Fitting parameters in (4.3)				
Austenitisation temperature	**Normalised austentisation temperature**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	1.9032	-7.6936	2.2175	19.296	0.988
850°C	-0.33333	2.2313	-5.9804	-0.9373	15.176	0.972
900°C	0.333333	3.3711	-9.3431	-0.2485	18.372	0.9657
950°C	1	0.597	-4.4147	1.8897	13.246	0.926

Table A2.3(f): The surface fitting parameters of the Charpy impact energy for steel H in Equation (4.4)

	Fitting parameters in Equation (4.4)				Correlation coefficients
	A	**B**	**C**	**D**	
a	-2.6581	-1.745	2.005	2.9951	1
b	7.5189	1.8086	-5.8795	-7.8627	1
c	-1.3467	2.9773	1.1828	-0.9237	1
d	-8.7964	-0.5659	5.7714	16.837	1

A2. Eq3. Equations for the mechanical properties of steel H

$$\frac{YS}{UTS} = \left(0.0013T_{an}^{\ 2} - 0.0051T_{an} + 0.0164\right)\times T_{tn}^{\ 2} + \left(0.0188T_{an}^{\ 3} - 0.0079T_{an}^{\ 2} - 0.0324T_{an} + 0.0488\right)\times$$
$$T_{tn} + \left(-0.0047T_{an}^{\ 2} - 0.0214T_{an} + 0.4713\right)$$

(A2.Eq3(a))

$$\times T_{an}^{\ 5} + \left(3.1788T_{an}^{\ 3} + 1.0781T_{an}^{\ 5} - 4.3215T_{an}^{\ 5} + 5.5603\right)\times T_{an} + \left(-2.3151T_{an}^{\ 3} - 1.3603T_{an}^{\ 5} + 4.0033T_{an}^{\ 5} + 5.0553\right)$$
$$UTS = \left(-8.0484T_{an}^{\ 3} - 2.3705T_{an}^{\ 5} + 2.0533T_{an}^{\ 5} + 5.2553\right)\times T_{an}^{\ 3} + \left(6.4308T_{an}^{\ 3} + 3.0628T_{an}^{\ 5} + 4.2033T_{an}^{\ 5} - 6.4215\right)$$

(A2.Eq3(b))

$$CIE\left(-40^{0}C\right) = \left(-2.6581T_{an}^{\ 3} - 1.745T_{an}^{\ 2} + 2.005T_{an} + 2.9951\right)\times T_{tn}^{\ 3} + \left(7.5189T_{an}^{\ 3} + 1.8086T_{an}^{\ 2} - 5.8795T_{an} - 7.8627\right)$$
$$\times T_{an}^{\ 2} + \left(-1.3467T_{an}^{\ 3} + 2.9773T_{an}^{\ 2} + 1.1828T_{an} - 0.9237\right)\times T_{tn} + \left(-8.7964T_{an}^{\ 3} - 0.5659T_{an}^{\ 2} + 5.7714T_{an} + 16.837\right)$$

(A2.Eq3©)

A2.4: Steel I

Table A2.4(a): The fitting parameters for the yield strength to ultimate tensile strength ratio of steel I in Equation (4.3)

		Fitting parameters in Equation (4.3)			
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**Correlation coefficients**
800°C	-1	0.0018	0.069	0.7226	0.96
850°C	-0.33333	0.005	0.1014	0.702	0.96
900°C	0.333333	0.0117	0.0737	0.5473	0.9577
950°C	1	0.0147	0.063	0.5193	0.98

Table A2.4(b): The fitting parameters for the yield strength to ultimate tensile strength ratio of steel I in Equation (4.4)

	Fitting parameters in Equation 4.4				Correlation coefficients
	A	**B**	**C**	**D**	
a	-0.004	-0.0001	0.0105	0.0084	1
b	0.0434	-0.0242	-0.0464	0.0902	1
c	0.1467	-0.0042	-0.2484	0.6251	1

Table A2.4(c): The surface fitting parameters for the tensile strength of steel I in Equation (4.3)

		Fitting parameters in Equation (4.3)				
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**d**	**Correlation coefficients**
800°C	-1	89.705	-159.9	-370.57	1982.3	0.992
850°C	-0.33333	60.44	-135.38	-284.47	1869	0.971
900°C	0.333333	62.015	-127.64	-284.9	1859	0.99
950°C	1	64.553	-226.13	-110.66	1725.3	0.993

Table A2.4(d): The fitting parameters for the tensile strength of steel I in Equation (4.4)

	Fitting parameters in Equation 4.4				Correlation coefficients
	A	**B**	**C**	**D**	
a	-16.806	17.889	4.2298	59.24	1
b	-50.316	-69.193	17.201	-123.82	1
c	146.92	49.579	-16.97	-290.19	1
d	-127.69	-11.475	-0.8125	1865.3	1

Table A2.4(e): Fitting parameters for the Charpy impact energy of steel I in Equation (4.3)

		Fitting parameters in Equation (4.3)				Correlation coefficients
Austenitisation temperature	**Normalised austenitisation temperature**	**a**	**b**	**c**	**d**	
800°C	-1	0.3737	-1.0494	0.8835	18.097	0.87
850°C	-0.33333	0.5935	-1.1198	0.519	18.97	0.95
900°C	0.333333	0.5948	-1.1983	0.7491	19.246	0.92
950°C	1	0.5647	-0.9749	0.9475	19.273	0.95

Table A2.4(f): Fitting parameters for the Charpy impact energy of steel I in Equation (4.4)

	Fitting parameters in Equation 4.4				Correlation coefficients
	A	**B**	**C**	**D**	
a	0.1052	-0.1406	-0.0097	0.6098	1
b	0.1744	0.1653	-0.1371	-1.1774	1
c	-0.3523	0.3166	0.3843	0.5989	1
d	0.1958	-0.4759	0.3923	19.161	1

A2. Eq4. Equations for the mechanical properties of steel I

$$\frac{YS}{UTS}=\left(-0.004T_{an}^{\ 3}-0.0001T_{an}^{\ 2}+0.0105T_{an}+0.0084\right)\times T_{tn}^{\ 2}+\left(0.0434T_{an}^{\ 3}-0.0242T_{an}^{\ 2}-0.0464T_{an}+0.0902\right)$$
$$\times T_{tn}+\left(0.1467T_{an}^{\ 3}-0.0042T_{an}^{\ 2}-0.2484T_{an}+0.6251\right)$$

(A2.Eq4(a))

$$UTS=\left(-16.806T_{an}^{\ 3}+17.889T_{an}^{\ 2}+4.2298T_{an}+59.24\right)\times T_{tn}^{\ 3}+\left(-50.316T_{an}^{\ 3}-69.193T_{an}^{\ 2}+17.201T_{an}-123.82\right)$$
$$\times T_{tn}^{\ 2}+\left(14.92T_{an}^{\ 3}+49.579T_{an}^{\ 2}-16.97T_{an}-290.19\right)\times T_{tn}+\left(-127.69T_{an}^{\ 3}-11.475T_{an}^{\ 2}-0.8125T_{an}+1865.3\right)$$

(A2.Eq4(b))

$$CIE\left(-40^{0}C\right)=\left(0.1052T_{an}^{\ 3}-0.1406T_{an}^{\ 2}-0.0097T_{an}+0.6098\right)\times T_{tn}^{\ 3}+\left(0.1744T_{an}^{\ 3}+0.1653T_{an}^{\ 2}-0.1371T_{an}-1.1774\right)$$
$$\times T_{tn}^{\ 2}+\left(-0.3523T_{an}^{\ 3}+0.3166T_{an}^{\ 2}+0.3843T_{an}+0.5989\right)\times T_{tn}+\left(0.1958T_{an}^{\ 3}-0.4759T_{an}^{\ 2}+0.3923T_{an}+19.161\right)$$

(A2.Eq4©)

APPENDIX A6.2:
Geometric characteristics of the steel E measured by means of Atomic Force Microscopy

Line 4							
dx	39.1997	79.168	33.8193	11.5293	109.1442	29.2076	58.4152
dy	9.259	-7.058	8.343	-0.06741	-10.5198	7.2356	-5.4776
Inclination(Degrees)	13.29647	-5.09716	13.86483	-0.33517	-5.50821	13.92083	-5.35968
Width	40.27835	79.482	34.83318	11.5295	109.65	30.09049	58.67146
Slope (nm/deg)	3.029251	-15.5934	2.512342	-34.3994	-19.9067	2.161545	-10.9468
TB/(TB+TA)		**0.69**			**0.78**		
Line 5							
dx	32.98	80.6177	40.3089	115.4299	29.3155	102.6044	
dy	9.4593	-6.142	9.3723	-10.5284	5.9052	-9.158	
Inclination(Degrees)	16.01203	-4.35897	13.09602	-5.21419	11.39481	-5.10303	
Width	34.30975	80.85133	41.38414	115.9091	29.90435	103.0123	
Slope(nm/deg)	2.142748	-18.5483	3.160055	-22.2295	2.624384	-20.1865	
TB/(TB+TA)		**0.66**		**0.79**			
Line 6							
dx	29.6402	67.3642	15.2692	26.0475	126.6447	27.8439	142.8121
dy	6.6714	-4.1958	0.019344	8.0066	-8.614	6.9449	-13.2485
Inclination(Degrees)	**12.69115**	**-3.56589**	**0.072623**	**17.09529**	**-3.89307**	**14.01221**	**-5.30278**
Width	30.38172	67.49474	15.26921	27.25028	**126.9373**	28.69694	**143.4253**
Slope(nm/deg)	2.39393	-18.9279	210.2539	1.594023	-32.606	2.047995	-27.0472
TB/(TB+TA)		**0.61**		**0.74**			
Line 7							
dx	36.6428	75.1648	33.8241	124.9614	27.2472	147.5109	
dy	7.9903	-4.7493	7.9828	-8.4291	6.9117	-13.1597	
Inclination(Degrees)	**12.30755**	**-3.61727**	**13.28607**	**-3.86092**	**14.24101**	**-5.10054**	
Width	37.50386	75.31469	34.75334	125.2454	28.11017	148.0967	
Slope(nm/deg)	**3.047224**	**-20.8209**	**2.615772**	**-32.4393**	**1.973889**	**-29.0355**	
TB/(TB+TA)		**0.68**		**0.81**			
Line 8							
dx	32.071	69.153	13.0288	34.0754	116.2573	32.071	
dy	9.8142	-7.1363	0.48034	9.4498	-11.4269	7.3269	
Inclination(Degrees)	**17.02352**	**-5.89482**	**2.11247**	**15.50764**	**-5.6164**	**12.87539**	
Width	33.53905	**69.52024**	13.03765	35.36144	**116.8175**	32.8973	
Slope(nm/deg)	1.97016	-11.7935	6.171757	2.28026	-20.7993	2.555052	
TB/(TB+TA)		**0.60**		**0.77**			