Cu – Fe (Copper – Iron)

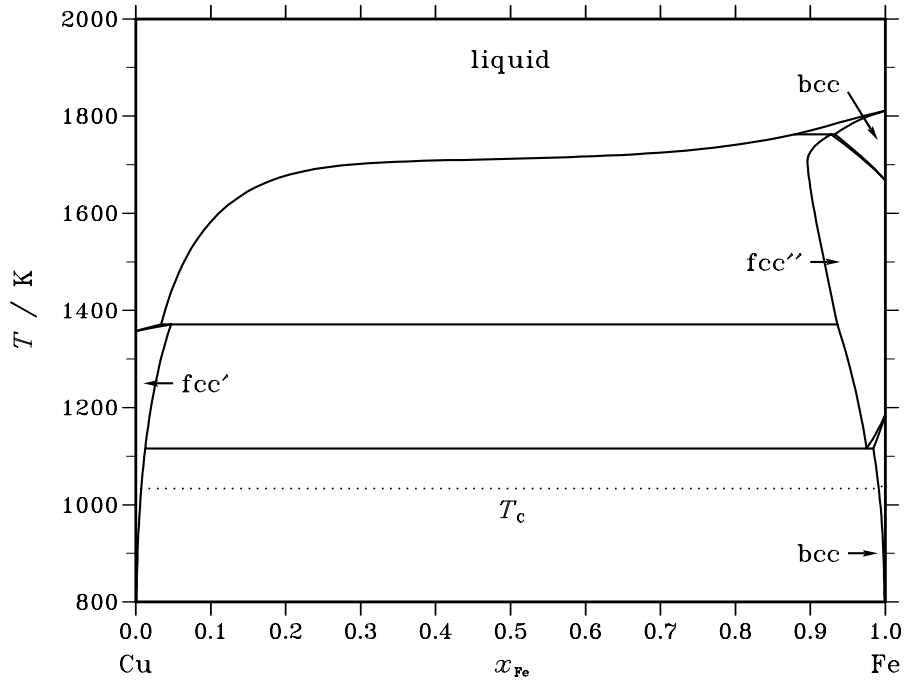

Fig. 1. Calculated phase diagram for the system Cu-Fe.

The Cu-Fe phase diagram is characterised by a large miscibility gap in the fcc phase. For the bcc and liquid phase there are also metastable miscibility gaps and the liquid immiscibility starts just below the liquidus. There are no intermetallic phases and an interesting fact is that the solubility of Cu in fcc-Fe decreases at high temperature just before the three-phase equilibrium with bcc. Such a behaviour is due to the fact that fcc-Fe must have a lower melting temperature than the stable bcc-Fe.
The amount of Cu in stainless steels is increasing mainly due to the recycling of scrap and small amounts can have a beneficial influence by forming particles but at higher concentration the low melting point of Cu causes problems when rolling or forming the steel.
The assessment presented here [98Ans] describes all known information well and is the most widely used.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Cu,Fe)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Cu,Fe)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Cu,Fe)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Fe}			$\Delta_r H$ / (J/mol)
liquid + bcc $\rightleftharpoons$ fcc″	peritectic	1762.4	0.879	0.933	0.927	−2587
liquid + fcc″ $\rightleftharpoons$ fcc′	peritectic	1371.2	0.034	0.936	0.047	−12079
fcc″ $\rightleftharpoons$ fcc′ + bcc	eutectoid	1115.9	0.975	0.013	0.984	−1691

Table IIIa. Integral quantities for the liquid phase at 1873 K.

x_{Fe}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	$G_{\mathrm{m}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{m}}^{\mathrm{E}}$ [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−1981	3868	3.122	3082	0.420	0.000
0.200	−2484	6402	4.744	5309	0.583	0.000
0.300	−2708	7954	5.692	6805	0.613	0.000
0.400	−2820	8776	6.191	7661	0.595	0.000
0.500	−2863	9022	6.346	7931	0.582	0.000
0.600	−2845	8745	6.188	7636	0.592	0.000
0.700	−2752	7899	5.687	6761	0.608	0.000
0.800	−2534	6339	4.738	5258	0.577	0.000
0.900	−2019	3821	3.118	3044	0.415	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Cu(liquid), Fe(liquid)

Table IIIb. Partial quantities for Cu in the liquid phase at 1873 K.

x_{Cu}	ΔG_{Cu} [J/mol]	ΔH_{Cu} [J/mol]	ΔS_{Cu} [J/(mol·K)]	$G_{\mathrm{Cu}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Cu}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Cu}	γ_{Cu}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1190	734	1.027	451	0.151	0.926	1.029
0.800	−1854	2416	2.280	1621	0.425	0.888	1.110
0.700	−2241	4493	3.596	3313	0.630	0.866	1.237
0.600	−2520	6708	4.927	5435	0.680	0.851	1.418
0.500	−2797	9103	6.354	7997	0.591	0.836	1.671
0.400	−3155	12018	8.101	11114	0.483	0.817	2.041
0.300	−3744	16091	10.590	15005	0.580	0.786	2.621
0.200	−5071	22260	14.592	19993	1.210	0.722	3.610
0.100	−9355	31758	21.950	26504	2.805	0.548	5.484
0.000	$-\infty$	46119	∞	35068	5.900	0.000	9.505

Reference state: Cu(liquid)

Table IIIc. Partial quantities for Fe in the liquid phase at 1873 K.

x_{Fe}	ΔG_{Fe} [J/mol]	ΔH_{Fe} [J/mol]	ΔS_{Fe} [J/(mol·K)]	$G_{\mathrm{Fe}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Fe}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Fe}	γ_{Fe}
0.000	$-\infty$	46768	∞	35595	5.965	0.000	9.832
0.100	−9099	32073	21.982	26760	2.837	0.558	5.575
0.200	−5004	22343	14.600	20060	1.218	0.725	3.626
0.300	−3796	16028	10.584	14954	0.573	0.784	2.612
0.400	−3269	11878	8.087	11000	0.468	0.811	2.027
0.500	−2929	8941	6.337	7865	0.574	0.829	1.657
0.600	−2638	6563	4.912	5317	0.665	0.844	1.407
0.700	−2326	4388	3.585	3228	0.619	0.861	1.230
0.800	−1900	2359	2.274	1575	0.419	0.885	1.106
0.900	−1203	717	1.025	437	0.149	0.926	1.028
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Fe(liquid)

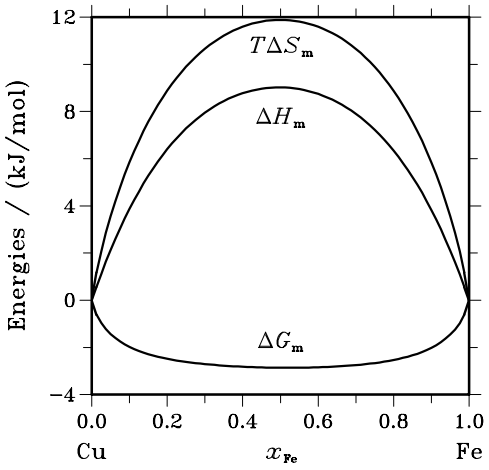

Fig. 2. Integral quantities of the liquid phase at T=1873 K.

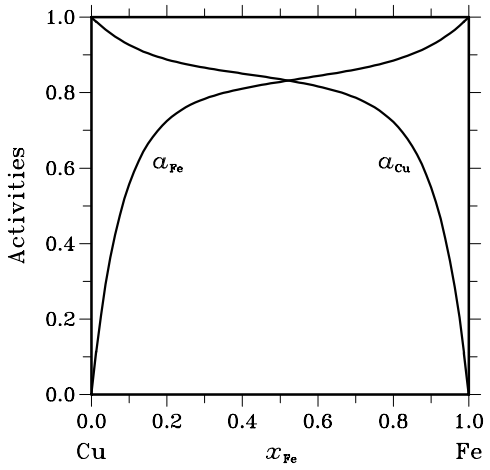

Fig. 3. Activities in the liquid phase at T=1873 K.

References

[98Ans] I. Ansara, Å. Jansson in: I. Ansara, A.T. Dinsdale, M.H. Rand (eds.): COST 507, "Thermochemical database for light metal alloys", Vol. 2, EUR 18499, 1998, 165–167.