Mn – N (Manganese – Nitrogen)

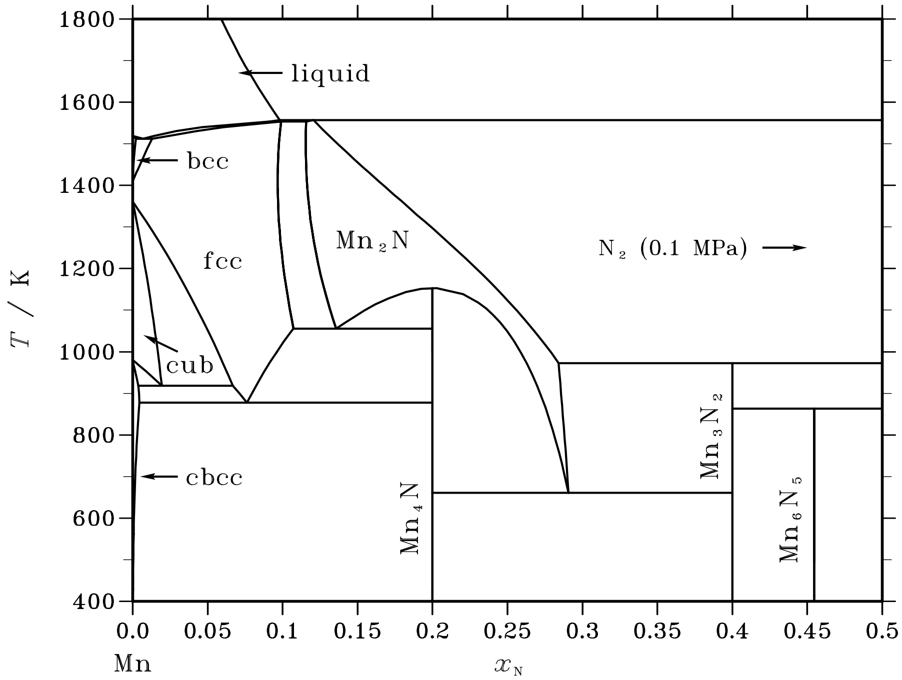

Fig. 1. Calculated phase diagram for the system Mn-N.

Mn and N are both important alloying elements in steel. By increasing the Mn content the solubility of N can also be increased in stainless steels. The solubility of N in the Mn phases are highest in the fcc-phase. At even higher N content there are several stable nitrides, at low temperature Fe_4N, Mn_3N_2 and Mn_6N_5, all modelled as stoichiometric. At higher temperature the hexagonal Mn_2N is stable with a broad composition range. A thermodynamic assessment of the Mn-N system has been reported in [93Qiu].

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Mn,N)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$Mn_1(N,\square)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$Mn_1(N,\square)_3$
cbcc	$A12$	αMn	$cI58$	$I\overline{4}3m$	CBCC_A12	$Mn_1(N,\square)_1$
cub	$A13$	βMn	$cP20$	$P4_132$	CUB_A13	$Mn_1(N,\square)_1$
Mn_4N	L'_1	Fe_4N	$cP5$	$Pm\overline{3}m$	FE4N	Mn_4N_1
Mn_2N	$L'3$	Fe_2N	$hP3$	$P6_3/mmc$	HCP_A3	$Mn_2(N,\square)_1$
Mn_3N_2	$L'2_b$	ThH_2	$tI6$	$I4/mmm$	MN6N4	Mn_3N_2
Mn_6N_5	$\cdots$	$\cdots$	$tF*$	$\cdots$	MN6N5	Mn_6N_5

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_N			$\Delta_r H$ / (J/mol)
liquid + gas ⇌ Mn_2N	gas-peritectic	1556.9	0.098	0.999	0.121	−22096
liquid + Mn_2N ⇌ fcc	peritectic	1553.7	0.091	0.116	0.099	−12756
liquid ⇌ bcc + fcc	eutectic	1511.6	0.007	0.002	0.013	−14103
Mn_2N ⇌ Mn_4N	congruent	1152.9	0.200	0.200		−6361
Mn_2N ⇌ fcc + Mn_4N	eutectoid	1055.1	0.136	0.107	0.200	−2265
Mn_2N + gas ⇌ Mn_3N_2	gas-peritectoid	972.9	0.284	1.000	0.400	−14050
cub ⇌ cbcc +fcc	eutectoid	918.0	0.019	0.004	0.067	−1513
fcc ⇌ cbcc + Mn_4N	eutectoid	877.8	0.076	0.004	0.200	−4006
Mn_3N_2 + gas ⇌ Mn_6N_5	gas-peritectoid	863.0	0.400	1.000	0.455	−6118
Mn_2N ⇌ Mn_4N + Mn_3N_2	eutectoid	661.0	0.291	0.200	0.400	−4006

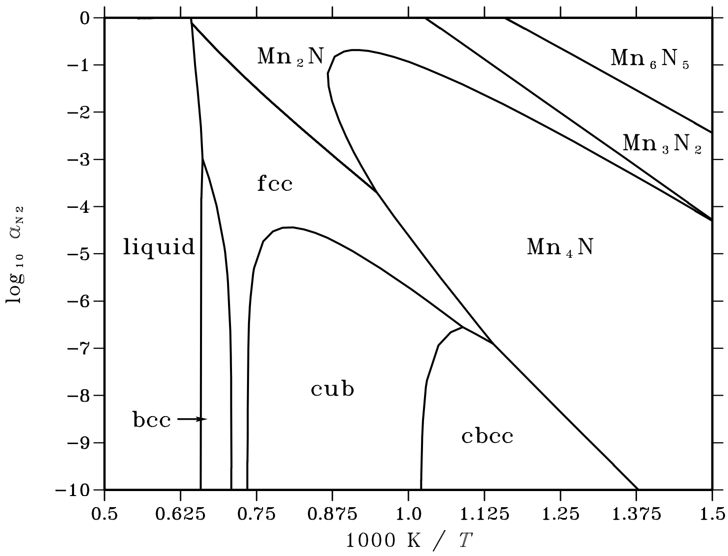

Fig. 2. Calculated temperature-activity phase diagram. Reference state: $\frac{1}{2}N_2$(gas, 0.1 MPa).

Table III. Standard reaction quantities at 298.15 K for the compounds per mole of atoms.

Compound	x_N	$\Delta_f G^\circ$ / (J/mol)	$\Delta_f H^\circ$ / (J/mol)	$\Delta_f S^\circ$ / (J/(mol·K))	$\Delta_f C_P^\circ$ / (J/(mol·K))
Mn_4N	0.200	−19474	−23177	−12.419	0.072
Mn_3N_2	0.400	−29143	−38378	−30.974	1.232
Mn_6N_5	0.455	−30690	−41426	−36.007	1.547

References

[93Qiu] C. Qiu, A. Fernández Guillermet: Z. Metallkd. **84** (1993) 11–22.