Mn – V (Manganese – Vanadium)

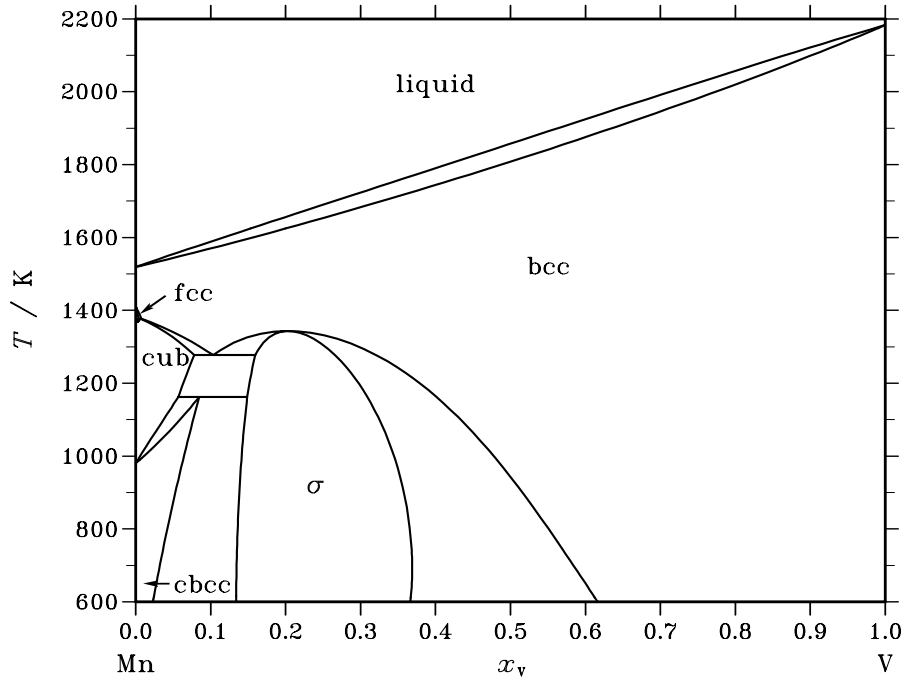

Fig. 1. Calculated phase diagram for the system Mn-V.

Mn and V are both alloying elements in steels and other alloys. There is complete solubility between Mn and V in the bcc phase and V dissolves also in the other Mn phases. There is one intermetallic σ phase but the experimental information is meagre. The proposed ordering transformation in bcc has not been modelled. The assessment has been reported in [91Hua], but the model for the σ-phase has been updated later in order to be compatible with the SGTE database.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Mn,V)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Mn,V)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Mn,V)_1$
cbcc	$A12$	αMn	$cI58$	$I\overline{4}3m$	CBCC_A12	$(Mn,V)_1$
cub	$A13$	βMn	$cP20$	$P4_132$	CUB_A13	$(Mn,V)_1$
σ	$D8_b$	σCrFe	$tP30$	$P4_2/mnm$	D8B_SIGMA	$(Mn,V)_{10}V_4(Mn,V)_{16}$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_V			$\Delta_r H$ / (J/mol)
fcc + bcc $\rightleftharpoons$ cub	peritectoid	1377.6	0.004	0.008	0.006	−3278
bcc $\rightleftharpoons$ σ	congruent	1343.3	0.203	0.203		−5624
bcc $\rightleftharpoons$ cub + σ	eutectoid	1277.1	0.103	0.078	0.159	−4129
cub + σ $\rightleftharpoons$ cbcc	peritectoid	1162.7	0.057	0.149	0.085	−975

Table IIIa. Integral quantities for the liquid phase at 2200 K.

x_{V}	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	−6972	−1026	2.703	−1026	0.000	0.000
0.200	−10977	−1824	4.161	−1824	0.000	0.000
0.300	−13568	−2394	5.079	−2394	0.000	0.000
0.400	−15046	−2736	5.596	−2736	0.000	0.000
0.500	−15529	−2850	5.763	−2850	0.000	0.000
0.600	−15046	−2736	5.596	−2736	0.000	0.000
0.700	−13568	−2394	5.079	−2394	0.000	0.000
0.800	−10977	−1824	4.161	−1824	0.000	0.000
0.900	−6972	−1026	2.703	−1026	0.000	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Mn(liquid), V(liquid)

Table IIIb. Partial quantities for Mn in the liquid phase at 2200 K.

x_{Mn}	ΔG_{Mn} [J/mol]	ΔH_{Mn} [J/mol]	ΔS_{Mn} [J/(mol·K)]	$G_{\mathrm{Mn}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Mn}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Mn}	γ_{Mn}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−2041	−114	0.876	−114	0.000	0.894	0.994
0.800	−4538	−456	1.855	−456	0.000	0.780	0.975
0.700	−7550	−1026	2.966	−1026	0.000	0.662	0.945
0.600	−11168	−1824	4.247	−1824	0.000	0.543	0.905
0.500	−15529	−2850	5.763	−2850	0.000	0.428	0.856
0.400	−20864	−4104	7.619	−4104	0.000	0.320	0.799
0.300	−27609	−5586	10.010	−5586	0.000	0.221	0.737
0.200	−36735	−7295	13.382	−7295	0.000	0.134	0.671
0.100	−51352	−9233	19.145	−9233	0.000	0.060	0.604
0.000	$-\infty$	−11399	∞	−11399	0.000	0.000	0.536

Reference state: Mn(liquid)

Table IIIc. Partial quantities for V in the liquid phase at 2200 K.

x_{V}	ΔG_{V} [J/mol]	ΔH_{V} [J/mol]	ΔS_{V} [J/(mol·K)]	$G_{\mathrm{V}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{V}}^{\mathrm{E}}$ [J/(mol·K)]	a_{V}	γ_{V}
0.000	$-\infty$	−11399	∞	−11399	0.000	0.000	0.536
0.100	−51352	−9233	19.145	−9233	0.000	0.060	0.604
0.200	−36735	−7295	13.382	−7295	0.000	0.134	0.671
0.300	−27609	−5586	10.010	−5586	0.000	0.221	0.737
0.400	−20864	−4104	7.619	−4104	0.000	0.320	0.799
0.500	−15529	−2850	5.763	−2850	0.000	0.428	0.856
0.600	−11168	−1824	4.247	−1824	0.000	0.543	0.905
0.700	−7550	−1026	2.966	−1026	0.000	0.662	0.945
0.800	−4538	−456	1.855	−456	0.000	0.780	0.975
0.900	−2041	−114	0.876	−114	0.000	0.894	0.994
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(liquid)

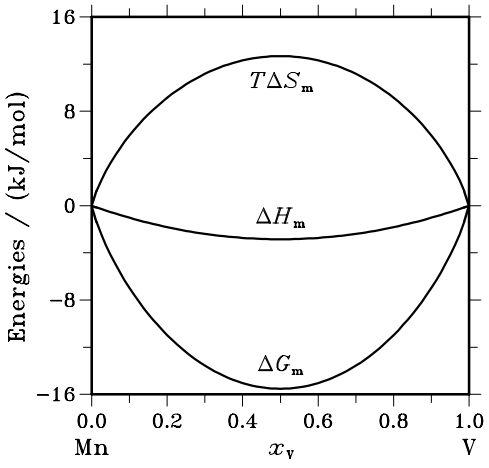

Fig. 2. Integral quantities of the liquid phase at T=2200 K.

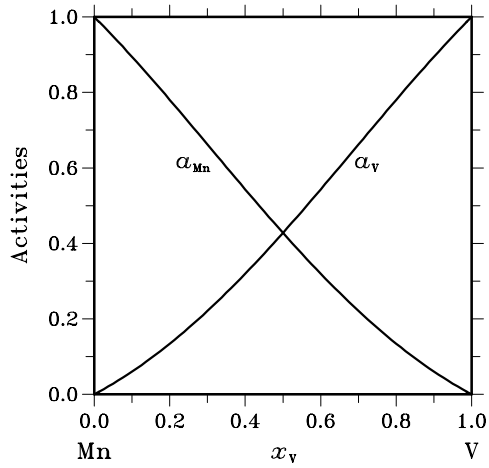

Fig. 3. Activities in the liquid phase at T=2200 K.

Table IVa. Integral quantities for the stable phases at 1500 K.

Phase	x_{V}	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)]
bcc	0.000	0	0	0.000	0	0.000	0.000
	0.100	−4954	−897	2.705	−899	0.002	−0.008
	0.200	−7840	−1596	4.163	−1599	0.002	−0.012
	0.300	−9718	−2095	5.082	−2099	0.003	−0.013
	0.400	−10793	−2395	5.598	−2399	0.002	−0.012
	0.500	−11144	−2496	5.765	−2499	0.002	−0.011
	0.600	−10793	−2397	5.598	−2399	0.002	−0.009
	0.700	−9718	−2098	5.080	−2100	0.001	−0.007
	0.800	−7841	−1598	4.161	−1600	0.001	−0.004
	0.900	−4954	−899	2.703	−900	0.000	−0.002
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Mn(bcc), V(bcc)

Table IVb. Partial quantities for Mn in the stable phases at 1500 K.

Phase	x_{Mn}	ΔG_{Mn} [J/mol]	ΔH_{Mn} [J/mol]	ΔS_{Mn} [J/(mol·K)]	$G_{\mathrm{Mn}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Mn}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Mn}	γ_{Mn}
bcc	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1414	−99	0.877	−100	0.000	0.893	0.992
	0.800	−3182	−397	1.857	−399	0.001	0.775	0.968
	0.700	−5347	−895	2.968	−899	0.003	0.651	0.930
	0.600	−7970	−1594	4.251	−1599	0.003	0.528	0.880
	0.500	−11143	−2493	5.767	−2499	0.004	0.409	0.818
	0.400	−15026	−3592	7.623	−3598	0.004	0.300	0.749
	0.300	−19914	−4892	10.015	−4898	0.004	0.203	0.675
	0.200	−26471	−6392	13.386	−6398	0.004	0.120	0.599
	0.100	−36816	−8092	19.149	−8098	0.004	0.052	0.522
	0.000	$-\infty$	−9992	∞	−9998	0.004	0.000	0.449

Reference state: Mn(bcc)

Table IVc. Partial quantities for V in the stable phases at 1500 K.

Phase	x_V	ΔG_V [J/mol]	ΔH_V [J/mol]	ΔS_V [J/(mol·K)]	G_V^E [J/mol]	S_V^E [J/(mol·K)]	a_V	γ_V
bcc	0.000	$-\infty$	−9960	∞	−9992	0.022	0.000	0.449
	0.100	−36813	−8078	19.157	−8096	0.012	0.052	0.523
	0.200	−26470	−6389	13.387	−6398	0.006	0.120	0.599
	0.300	−19915	−4895	10.013	−4899	0.003	0.203	0.675
	0.400	−15027	−3598	7.620	−3600	0.001	0.300	0.749
	0.500	−11145	−2499	5.764	−2500	0.000	0.409	0.818
	0.600	−7971	−1600	4.247	−1600	0.000	0.528	0.880
	0.700	−5348	−900	2.966	−900	0.000	0.651	0.930
	0.800	−3183	−400	1.855	−400	0.000	0.775	0.968
	0.900	−1414	−100	0.876	−100	0.000	0.893	0.992
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(bcc)

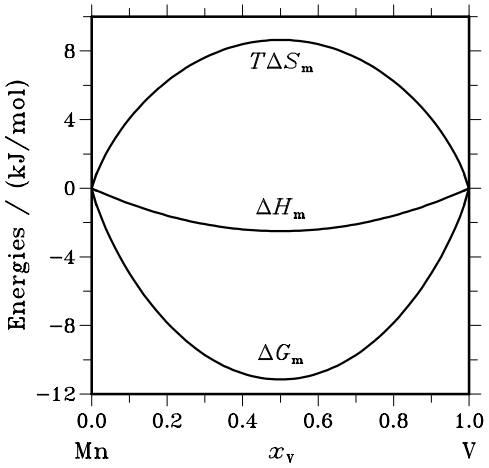

Fig. 4. Integral quantities of the stable phases at T=1500 K.

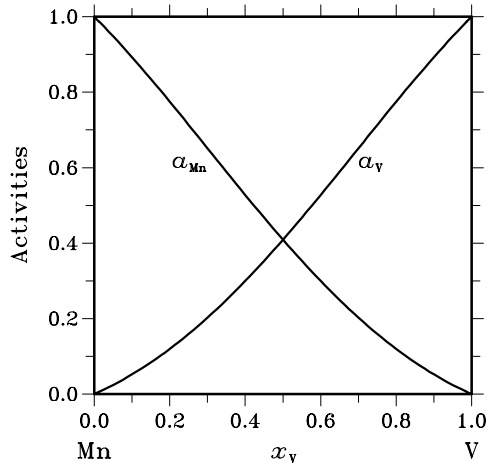

Fig. 5. Activities in the stable phases at T=1500 K.

References

[91Hua] W. Huang: Calphad **15** (1991) 195–208.