

## Al – Mn (Aluminum – Manganese)

### Phase diagram

For a discussion of the phase diagram and the crystal structure of intermediate phases see [97 Kre], [94 Oka] and [97 Oka]. The phase diagram reassessed by Liu et al. [99 Liu] on the basis of recent experimental results is reproduced in Fig. 1.

An enlarged version of the Mn-rich part is given in Fig. 2 (see [96 Liu]).

By mechanically alloying of pure Al and Mg powders Suryanarayana et al. [91 Sur] succeeded in preparing solid solutions with up to 18.5 at% Mn. By aging at room temperature a metastable fcc phase is obtained with lattice parameter

$$a = 0.4472 \text{ nm.}$$

At temperatures  $> 623 \text{ K}$  the solid solution transforms into the equilibrium phase  $\text{Al}_6\text{Mn}$ .

Minamino et al. [91 Min] have investigated the solubility of Mn in (Al) at high pressure. The results are plotted in Fig. 3.

### Thermodynamics

Meschel et al. [93 Mes] have determined calorimetrically the standard enthalpies of formation of  $\text{Al}_2\text{Mn}_3$  and  $\text{AlMn}_4$ . The values are

$$\Delta H_{298} = -23.4 \pm 0.8 \text{ kJ g-atom}^{-1} \text{ and}$$

$$\Delta H_{298} = -15.1 \pm 1.0 \text{ kJ g-atom}^{-1},$$

respectively.

Chastel et al. [94 Cha], using the Knudsen cell mass spectrometry, have determined thermodynamic activities of liquid Al-Mn alloys in the temperature range from 1250 K to 1550 K. The results obtained at 1520 K are plotted in Fig. 4.

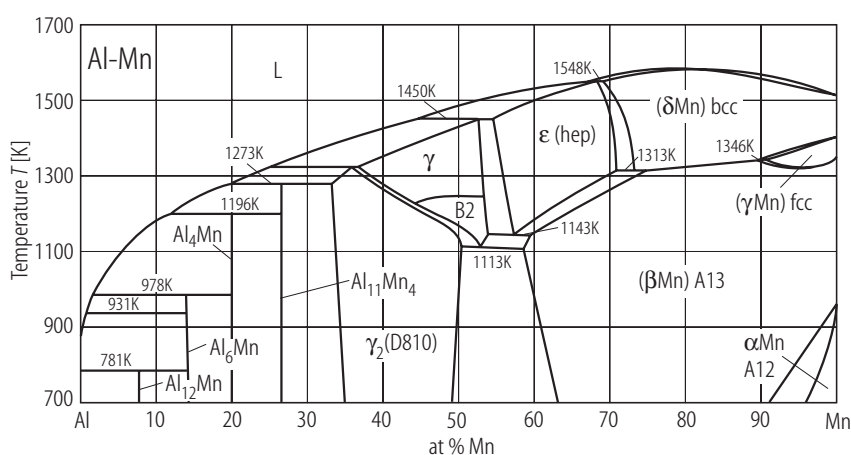
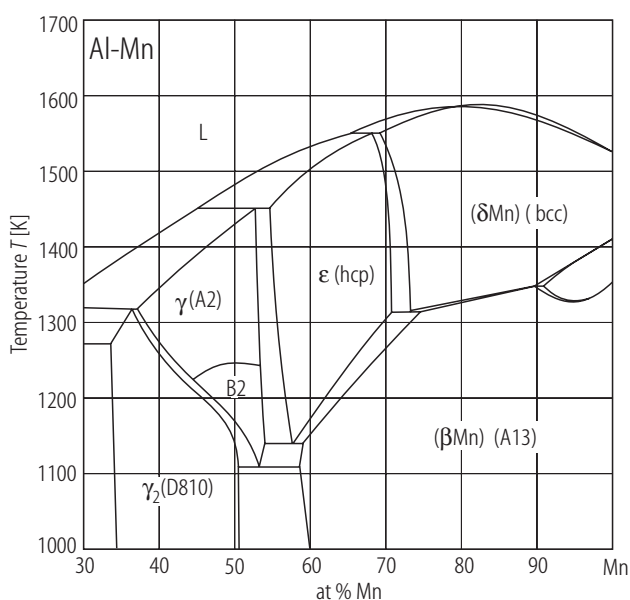
Optimizing thermodynamic data and phase equilibria of the Al-Mn system, Jansson [92 Jan] obtained the following results:

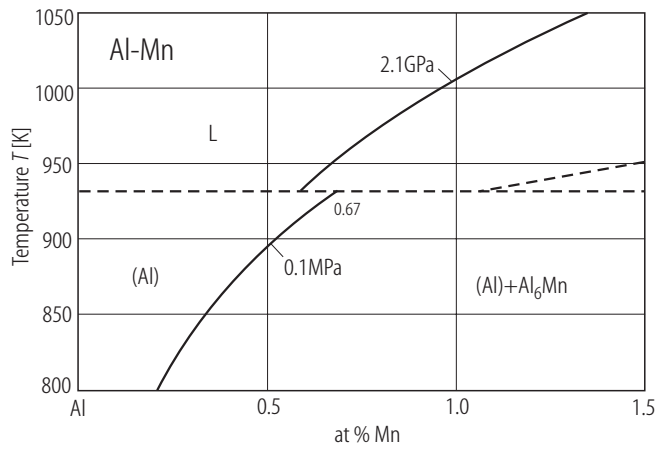
- 1) Calculated enthalpies of mixing of liquid alloys at 1626 K, which are in very good agreement with experimental  $\Delta H^L$ -values found by [73 Esi] (see Fig. 5).
- 2) Thermodynamic activities of Al in liquid Al-Mn alloys at 1570 K. The calculated data are in good agreement with experimental  $a_{\text{Al}}^L$  values published by Batalin et al. [72 Bat] (see Fig. 6).
- 3) Solubility of Mn in fcc-Al (see Fig. 7). There is good agreement with data from different authors.
- 4) Calculated parts of the phase diagram (see Fig. 8 and Fig. 9). These calculated results are in agreement with experimental data, too [71 Göd], [60 Kös], [87 Mur].

At least [92 Jan] has calculated enthalpies of formation of intermediate phases. In Table 1 the results are compared with experimental data published by [60 Kub].

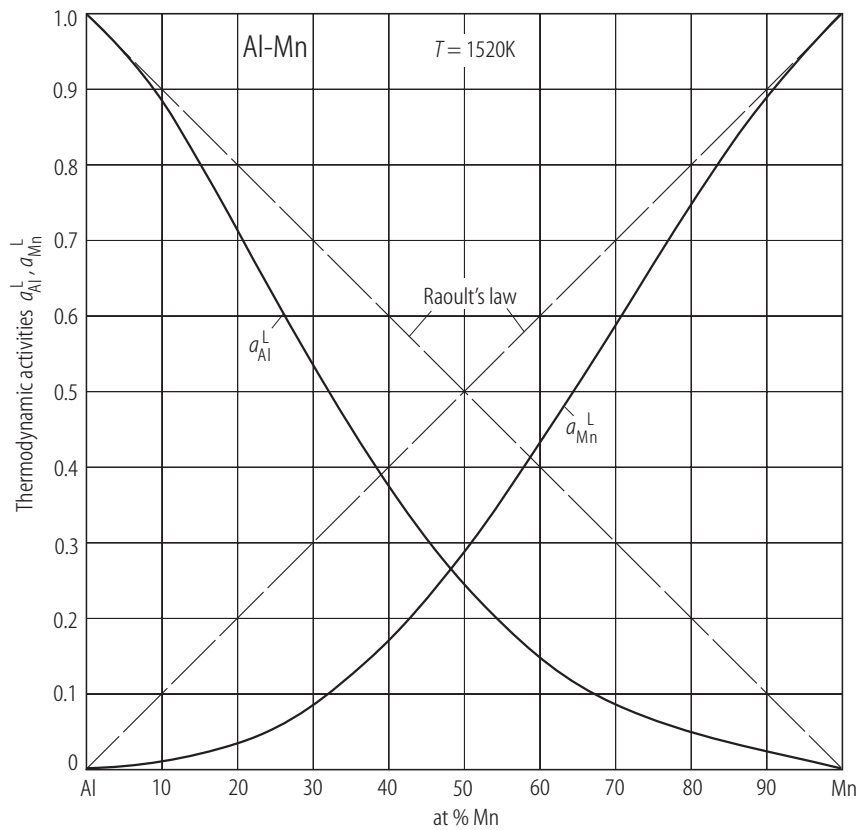
**Table 1. Al–Mn.** Calculated enthalpies of formation of intermediate phases compared with experimental  $\Delta H^S$ -values in kJ g-atom<sup>-1</sup> Experimental data taken from [60 Kub].

Phase	$\Delta H^S$	
	Calculated [92 Jan]	Calculated [60 Kub]
Al <sub>6</sub> Mn	- 15.00	- 12.38
Al <sub>4</sub> Mn	- 21.13	- 21.67
Al <sub>11</sub> Mn <sub>4</sub>	- 23.65	- 21.21
Al <sub>8</sub> Mn <sub>5</sub>	- 23.74	- 20.71; - 22.01

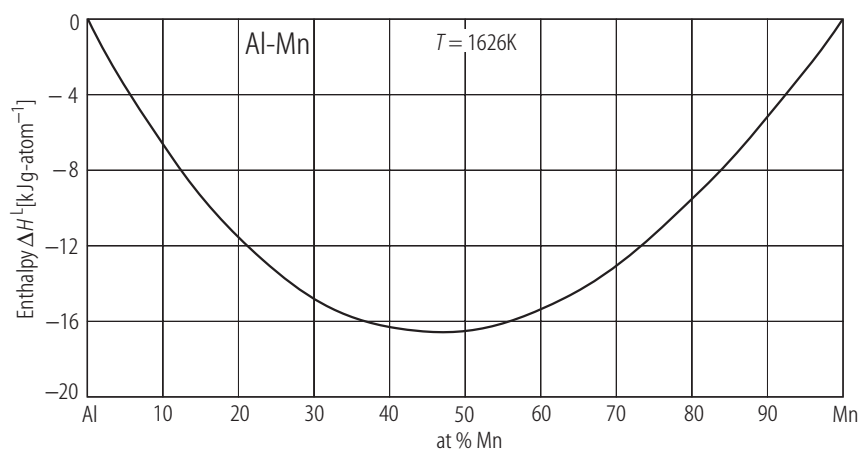
**Figures****Fig. 1. Al–Mn.** Phase equilibria Al–Mn reassessed by Liu et al. [99 Liu].**Fig. 2. Al–Mn.** The Mn-rich part of the phase diagram in an enlarged version [96 Liu].



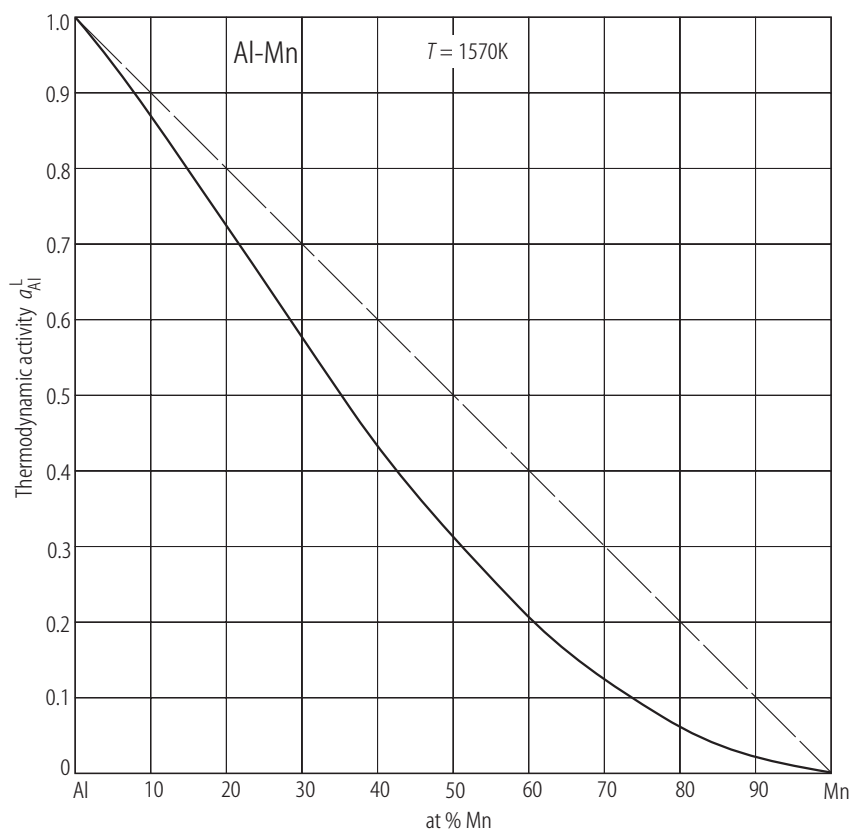
**Fig. 3. Al–Mn.** Solubility of Mn in (Al) at 0.1 MPa and 2.1 GPa [91 Min].



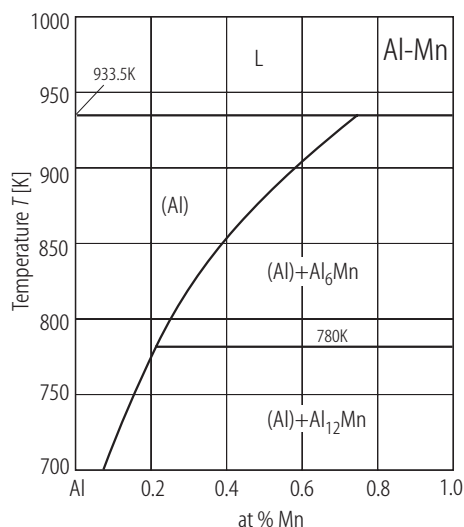
**Fig. 4. Al–Mn.** Thermodynamic activities of the components in liquid Al-Mn alloys at  $T = 1520$  K [94 Cha].



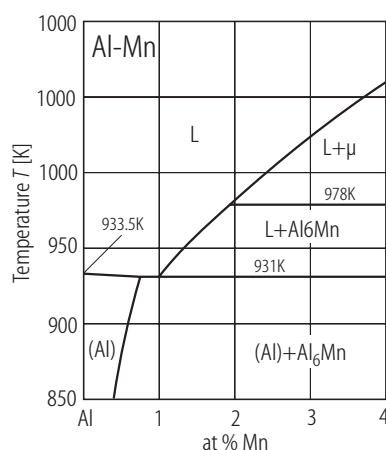
**Fig. 5. Al-Mn.** Calculated enthalpies of mixing of liquid alloys at 1626 K [92 Jan] [73 Esi].



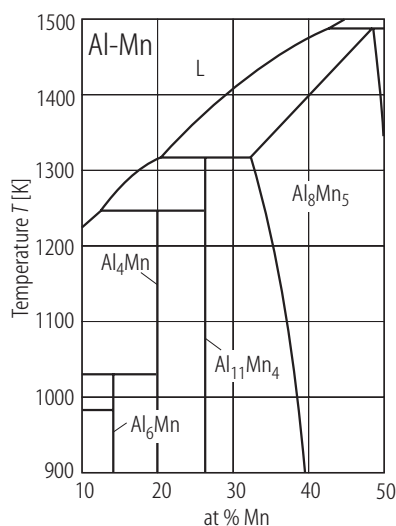
**Fig. 6. Al-Mn.** Calculated thermodynamic activities of Al at 1570 K [72 Bat] [92 Jan].



**Fig. 7. Al-Mn.** Solubility of Mn in fcc-Al [92 Jan].



**Fig. 8. Al-Mn.** Calculated Al-rich part of the phase diagram [92 Jan].



**Fig. 9. Al-Mn.** Calculated part of the phase diagram [92 Jan].

## References

- [60 Kös] Köster, W., Wachtel, E.: Z. Metallkde. **51** (1960) 271
- [60 Kub] Kubaschewski, O., Heymer, G.: Trans. Faraday Soc. **56** (1960) 473
- [71 Göd] Gödecke, T., Köster, W.: Z. Metallkde. **62** (1971) 727
- [72 Bat] Batalin, G.J., Beloborodova, E.A., Stukalo, B.A., Tshechowsky, A.A.: Ukr. Khim Zh. **38** (1972) 825
- [73 Esi] Esin, Y.O., Bobrov, N.T., Petrushevskii, M.S., Gold, P.V.: Russ. J. Phys. Chem. **47** (1973) 1103
- [87 Mur] Murray, J.L., McAlister, A.J., Schaefer, R.J., Bendersky, L.A., Biancaniella, F.S., Moffatt, D.L.: Metall. Trans. A **18A** (1987) 385
- [91 Min] Minamino, Y., Yamane, T., Araki, H., Takeuchi, N., Kang, Y., Miyamoto, Y., Okamoto, T.: Metallurg. Trans. A **22A** (1991) 783
- [91 Sur] Suryanarayana, C., Sundaresan, R.: Materials Science and Engineering **A131** (1991) 237

- 
- [92 Jan] Jansson, A., Metallurg. Trans. A **23A** (1992) 2953  
[93 Mes] Meschel, S.V., and O.J. Kleppa, "Metallic Alloys", edited by J.S. Faulkner, and R.G. Jordan, NATO Serie e **256** (1993) 103  
[94 Cha] Chastel, R., M. Saito, and C. Bergman, J. Alloys and Comp. **205** (1994) 30  
[94 Oka] Okamoto, H., J. Phase Equilibria **15** (1994) 123  
[96 Liu] Liu, X.J., R. Kainuma, H. Ohtani, and K. Ishida, J. Alloys and Comp. **235** (1996) 256  
[97 Kre] Kreiner, G., H.F. Franzen, J. Alloys and Comp. **261** (1997) 83  
[97 Oka] Okamoto, H., J. Phase Equilibria **18** (1997) 398  
[99 Liu] Liu, X.J., I. Ohnuma, R. Kainuma, and K. Ishida, J. Phase Equilibria **20** (1999) 45