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THE PHASE DIAGRAM OF THE Al-Fe SYSTEM UP TO 45 MASS % IRON

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ABSTRACT

The phase diagram and intermetallic phases of the Al-Fe system in the range of 1.8 to 45 mass % iron concentration was investigated by DTA. After calorimetric calibration of the thermoanalyzer the heats of fusion of the θ/Al_3Fe/ and η/Al_5Fe_2/ pure intermetallic phases were also determined.

INTRODUCTION

The liquidus and solidus curves for the Al-Fe system has been determined by Lee/1/ by thermal analysis and metallographic investigations/1/ indicating a eutectic reaction of liquid + η at 26 4 at% Fe replacing the peritectic reaction suggested by Hansen /2/

The aim of the present work is to investigate the Al-side of the Al-Fe diagram in the range of 1 8 to 45 mass% iron content and to prepare and investigate pure intermetallic phases θ/Al_3Fe/ and η/Al_5Fe_2/ Using these materials as standards for X-ray diffraction and Mössbauer spectroscopy makes the phase analysis more accurate in dilute aluminium alloys

EXPERIMENTAL

The alloys investigated were prepared of high purity/99.99%/ aluminium and iron. The compositions of the alloys are summarized in Table 1.

Table 1. The compositions of the alloys investigated

Sample	1	2	3	4	5	6	7	8
Fe mass %	1.8	9.4	24.8	39.6	42.8	43.7	43.9	46.1

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The cast samples were heat treated near to their solidus temperature for 5 hours in order to attain equilibrium.

Differential thermal analysis was carried out with a Mettler TA1 thermoanalyzer using its high temperature furnace. Measurements were made in high purity argon atmosphere. Pt-PtRh10% thermocouple, Al_2O_3 microcrucible of 100 mm^3 volume and α-Al_2O_3 as reference material were used. The heating rate was 10 ^oC/min, in special cases 0.5 ^oC/min.

RESULTS AND DISCUSSION

Both the melting and solidification processes of Al-Fe alloys were investigated by DTA. As cast and heat treated samples were also measured. A difference between the as cast and heat treated samples, that is between the equilibrium and non-equilibrium state of the alloys, could only be found in the case of alloy "4" DTA melting curves of alloys "2","3","4" and "5" in as cast state are shown in Fig 1. The melting of these alloys

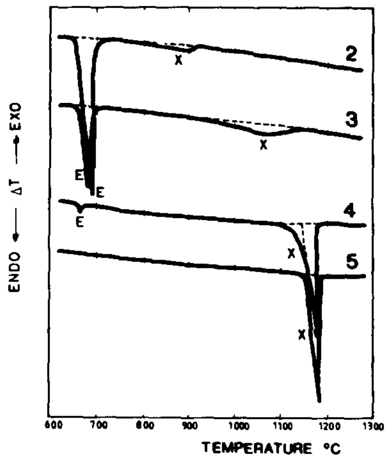

Figure 1. DTA melting curves of the alloys "2", "3", "4" and "5"; v=10 ^oC/min

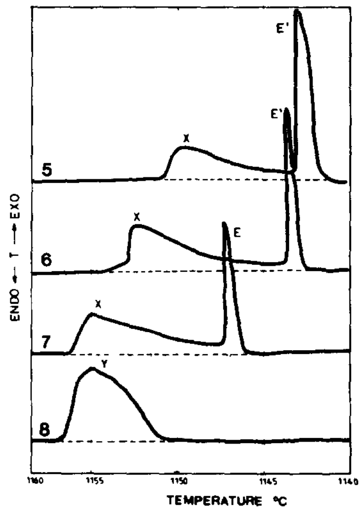

Figure 2. DTA freezing curves of the alloys "5","6", "7" and "8"; v=0.5 ^oC/min

starts with that of the Al-Θ eutectic /E peaks/, after which the melting of the primary solidified Θ phase /X peaks/ takes place. It can be seen that the amount of Al-Θ eutectic decreases as the iron content of the alloy increases. The E peak corresponding to the melting of the Al-Θ eutectic disappears in the case of alloy "4" if it is heat treated. This means that in this alloy the Al-Θ eutectic forms only in course of non-equilibrium crystallization. The alloy with 39.6 mass% Fe /alloy "4"/ in its equilibrium state is single phase of Θ. The melting curve of the alloy "5" shown in Fig. 1. exhibits only one peak. It also melts in one peak if the heating rate is as small as 0.5 °C/min. This result would suggest that it would also be an alloy with only one phase. But in its freezing curve /Fig 2 / an other reaction could also be observed beside the formation of Θ, which is the Θ-η eutectic reaction In Fig. 2. the freezing curves of alloys "6" and "7" are very similar to that of alloy "5" in spite of the fact that their melting curves consist of only one peak. The reason for this is that the temperature difference between congruent melting point of η an Θ-η eutectic temperature is only 10 °C, and that of between Θ and Θ-η eutectic is only 4 °C /1/. Therefore DTA melting curves of the alloys in this concentration range exhibit only one peak, the thermoanalyzer cannot resolve the two processes. On the freezing curves, however, the two processes are clearly distinguished in consequence of the fact that the eutectic undercools stronger than the other phase. On the freezing curve of sample "8" there is no E' peak corresponding to the melting of the Θ-η eutectic. This alloy consists of single phase of η/ Al_5Fe_2/.

In order to determine the heats of fusion of the Θ and η phases a calorimetric calibration of the thermoanalyzer was carried out in the temperature range of 1000-1600 °C. For calibration high purity metals /Ag,Cu,Mn,Fe,Ni/ were used. The heats of fusion of the Θ/Al_3Fe/ and η/Al_5Fe_2/ are the following:

$$H_\Theta = 31 \pm 15 \text{ \% kJ/mol}$$

$$H_\eta = 78 \pm 15 \text{ \% kJ/mol}$$

The heat of fusion of the Θ phase is in good agreement with previously reported values /3/. There are no data in the literature as to the heat of fusion of the η phase.

CONCLUSIONS

According to the above described results the phase diagram of the Al-Fe system can be constructed /Fig. 3./. A non-equilibrium phase boundary for the Θ intermetallic phase /dashed line/ is also suggested in the diagram. The range of homogeneity of the Θ phase was also determinded as $39.6 \leq c_{\Theta} < 42.8$ mass% iron.

In the concentration range between Θ and η only the solidus line could be determined from the melting curves of the alloys. Liguidus temperature are generally determined from the freezing curves The freezing curves of the alloys in this range of concentration, however, are not suitable for determination of liquidus temperature because of the great tendency for undercooling in these alloys From the melting curves the temperature of the $\Theta - \eta$ eutectic reaction was determined as $1148\,^{o}C$, which is in good agreement with that of Lee.

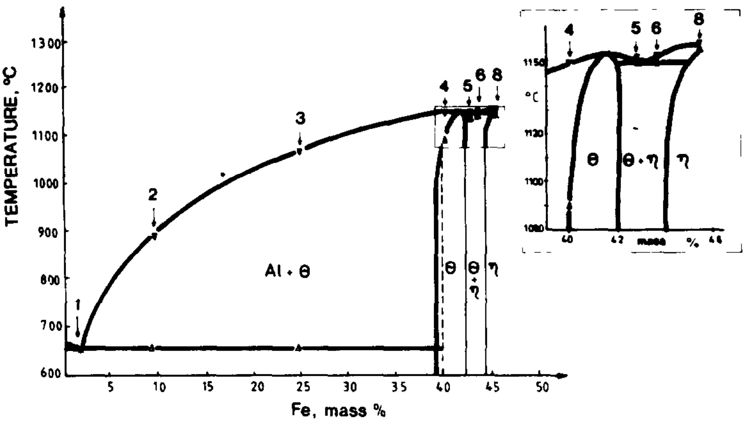

Figure 3. The phase diagram of the Al-Fe system

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