GENERAL ASPECTS OF PHASE FRACTION-COMPOSITION-TEMPERATUER CHARTS AS CONSTRUCTED FROM BINARY AND TERNARY EQILIBRIUM DIAGRAMS

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Abstract:

A computer program has been written to calculate the equifraction phase lines for each of the phase present at equilibrium state of binary and ternary phase diagrams.

The computed phase fractions were used to construct the phase fraction-composition-temperature chart which may be of practical importance for alloy users.

Examples are given to show the type of phase fraction charts obtained.

Introduction:

A phase fraction-composition-temperature chart is a graphical representation of the amount of each of phases presentin equilibrium in the diagram as a function of composition and temperature. Known phase equilibrium diagrams give no straight forward information on the amount of each phase present. It would be therefore very convenient to present charts which directly show phase proportions.

Morral (1) attempted representation of phase proportions in a given equlibium diagram in the form of two dimentional charts.

This work is aimed at showing how phase fraction-composition-temperature charts may be constructed from binary and ternary diagrams. Selected examples for Cu-Mg binary phase diagram ad Cu-Mg-Ni ternary phase diagram were considered.

Results of Computations:

a) Binary Phase-Fraction-Composition-Temperature charts

Fig. (1 a) shows the copper rich side of the Cu-Mg binary phase equilibrium diagram (2), the tie lines are constructed to show the phase regions (L + α), (L + $MgCu_2$), (α + $MgCu_2$).

Fig. (1 b) represents the phase fraction-composition-temperature chart of the given diagram. The equifraction lines (f) are plotted at intervals of 0.1 (10%) in the two phase regions (L + α), (L + $MgCu_2$), (α + $MgCu_2$).

The properties of equifraction lines in binary phase equlibria are listed below:

1. The equifraction line can represent any phase amount present in the diagram. In Fig 1b equifraction lines are constructed at 0.1 (10%) intervals i.e f^{phase} = 0.0, 0.1, 0.2, 0.3, ... 1.0.
2. All phase boundary lines (i.e liquids, solidus and solivus) correspond to $f^{phase} = 0$ on a phase fraction-composition-temperature chart. For example the liquidus corresponds to $f = 0$, $f^{Mg\,Cu_2} = 0$, the solidus to $f^L = 0$ and the eutectic tie line $L \rightleftharpoons \alpha + Mg\,Cu_2$ to $f^L = 0$.
3. The equifraction lines are continuous except where invariant reactions occur. Thus in fig. 1b discontinuities in the equifraction phase lines occured when they intersect the melting point of copper at 1083°C and where they cross the $L \rightleftharpoons \alpha + Mg\,Cu_2$ tie line at 722°C.
4. The equifraction phase lines are consecutive. If the interval between lines is constant fig. 1b then any equifraction phase line on the chart can be identified by counting from $f^{phase} = 0$ line. For example the fourth equifraction phase line in the (L + α) region after liquidus $f^L = 0$ is the $f^L = 0.4$ equifraction line.
5. In two phase regions e.g (L + α), (L + $Mg\,Cu_2$), (α + $Mg\,Cu_2$) Fig. 1b, the equifraction phase lines of one phase overlap those of the other phase when the same interval is used. The $f^L = 0.8$ overlaps $f^{\alpha} = 0.2$ as is required by the relation:

$$\begin{aligned} f^L + f^{\alpha} &= 1 \\ f^L + F^{Mg}\,Cu_2 &= 1 \\ f^{\alpha} + f^{Mg}\,Cu_2 &= 1 \end{aligned} \qquad (1)$$

b) <u>Ternary phase fraction-composition-temperature charts</u>

Fig. 2-a shows isothermal section of a ternary diagram ABC. The tie lines are constructed to show the two phase regions ($\gamma + \beta$), ($\alpha + \beta$), ($\alpha + \gamma$) while Fig. 2b represents the phase fraction-composition chart at T°C. All properties of equifraction phase lines mentioned in the case of binary systems seem to apply in the case of ternary diagrams.

Because there are no invariant reactions, the equifraction phase lines of α, β, γ phases are continuous.

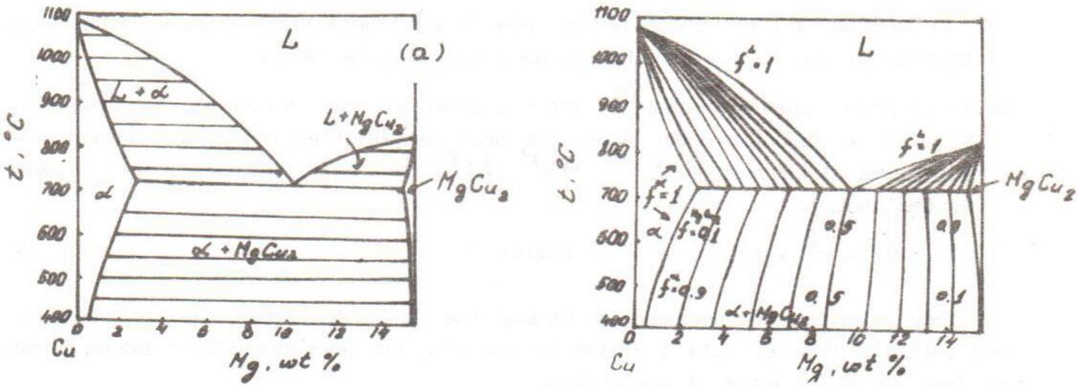

Fig. 1: a. The copper rich side of the Cu-Mg binary diagram.
b. The phase fraction-composition-temperature chart.

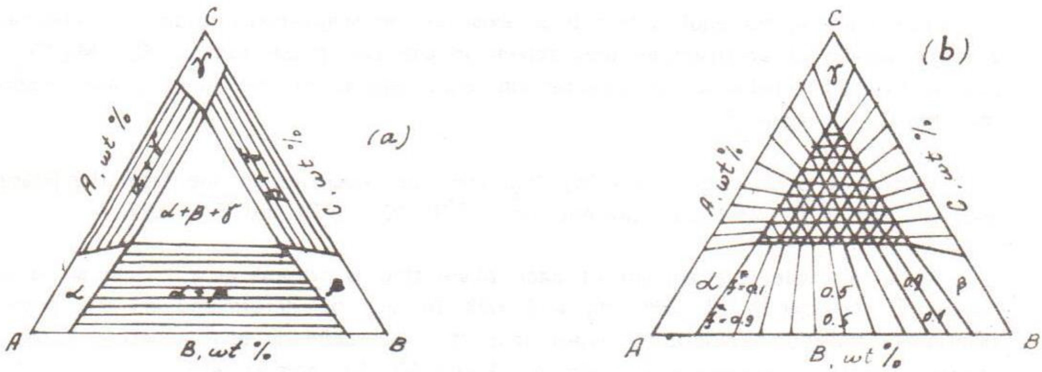

Fig. 2: a. Isothermal section of ternary diagram A-B-C at temperature T°C.
b. Phase fraction-composition chart.

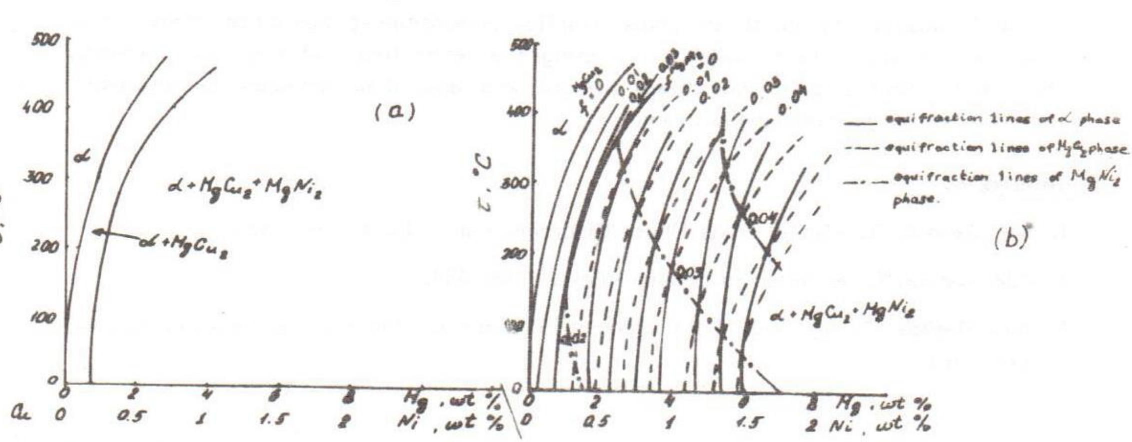

Fig. 3: a. Vertical section of Cu-Mg-Ni ternary diagram.
b. Phase fraction-composition-temperature chart.

In addition, a three phase region ($\alpha + \beta + \gamma$) appears as a triangular network of equifraction lines. All such networks have the following feature:

6. Three-phase regions consist of three bundles of equifraction phase lines. They intersect at common nodes when the lines for all three phases are incremented with constant interval (i.e $\Delta f^{\alpha} = \Delta f^{\beta} = \Delta f^{\gamma}$) the common nodes are required by the relation:

$$f^{\alpha} + f^{\beta} + f^{\gamma} = 1 \qquad (100\%) \tag{2}$$

Fig. 3a gives a vertical section through the Cu-Mg-Ni ternary diagram constructed with the help of data available in ref. (3). Tie lines are absent because non of them are in the plane of the section.

The phase Fraction-Composition-Temperature chart for the given vertical section is shown in Fig 3b. Equifraction phase lines are constructed on 1% intervals.

From Fig. 3b, no equifraction lines exist in the single-phase region , whereas a single bundle of equifraction lines appear in the two phase region (α + Mg Cu_2) and a tirangular network of equifraction lines appear in the three phase region (α + Mg Cu_2 + Mg Ni_2).

In the two phase-region (α + Mg Cu_2) the third equifraction line from the phase boundary (i.e. $f^{Mg\ Cu_2} = 0$) represents both $f^{Mg\ Cu_2} = 0.03$ and $f^{\alpha} = 0.97$.

As an example, the amount of each phase that is present at 175ºC in an alloy having a composition of 4.0% Mg and 1.0% Ni will be determined on the phase fraction-composition-temperature chart (Fig 3b), this point is approximately a node position, the alloy contains 4 wt% Mg Ni_2, 3 wt% Mg Cu_2 and 93 wt% .

Conclusion:

It is possible to construct phase fraction-composition-temperature charts from binary and ternary phase diagrams by using the lever rule and computer methods. The charts identify both the phases present and give their amounts quantitatively. They may be of practical importance.

References:

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2. **P.M. Hansen** Constitution of Binary Alloys, 1958, 638.
3. **M.E. Deritse** Binary and Multicomponent systems on the base of copper, Moscow, 1979, 162.