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Abstract

Full Text

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On the Construction of Phase Diagrams of Multicomponent Metallic Systems

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In constructing phase diagrams, along with microstructural, X-ray structural, thermal, and other methods, geometrical methods of investigation can also be of great practical importance. A geometrical investigation of, for example, a t-dimensional section of a $(t+1)$-dimensional diagram makes it possible to propose the existence of regions of phase states and their approximate location by constructing a theoretical section on the basis of known one-dimensional, two-dimensional, ···, $(t-1)$-dimensional sections. On the basis of such a theoretical section it is possible to choose the most rational directions for carrying out the experiment, with the aim of reducing the volume of work. Owing to the fact that the geometrical structure of such a section often has several variants, the geometrical investigation should be carried out in parallel with the experimental one. We shall show, using as an example the investigation of a region of an isothermal section of the seven-component system Ni–Cr–W–Mo–Nb–Ti–Al, the application of one of the methods of geometrical investigation ([1]).

Fig. 1. Section of the six-dimensional simplex $ABCDEFG$ by the three-dimensional plane $MLKN$

A seven-component system can be represented by a six-dimensional phase diagram. An isothermal section of such a diagram is located inside the six-dimensional simplex $ABCDEFG$ (Fig. 1). The simplex itself defines the composition diagram of the system. Let us place the component Ni at vertex A and consider this vertex as the origin for measuring the remaining components. Then the vertices B, C, D, E, F, G will represent, respectively, the remaining components: Cr, W, Mo, Nb, Ti, Al.

Inside the simplex $ABCDEFG$ a tetrahedron $MNLK$ was selected in the following way. Point M was chosen inside the tetrahedron $ABCD$ of the following composition: Ni–81.0%, Cr–10.0%, W–6.0%, and Mo–3.0%. Points N, L, K are the first chemical compounds formed by nickel with the components Al,

Fig. 2. Phase diagram of the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb at 1100°

Figure 2: Fig. 2. Phase diagram of the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb at 1100°

Fig. 3. Cutaway model of the diagram γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb

Figure 3: Fig. 3. Cutaway model of the diagram γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb

Nb, and Ti: L—Ni_3Al, N—Ni_3Nb, K—Ni_3Ti. In constructing the diagram under experimental conditions, alloy M was conventionally taken as 100% of the initial component and was designated γ_4. Since all the compounds listed are single-phase alloys, they may be taken as pure components of the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb ([2,3]). Let us carry out a geometrical investigation of the quasi-quaternary system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb, represented by the tetrahedron $MNLK$.

Starting from the studied faces of the tetrahedron ([1]), all possible phase regions of the diagram under investigation were revealed geometrically. It was found that the regions β and η, present separately on the faces MLN and MLK, form inside the tetrahedron a single region $\beta(\eta)$, since they possess unlimited solubility in one another, which follows from consideration of the faces

MNK and LNK (Fig. 2). This region is located in the tetrahedron along the edge NK. Fig. 3 shows a cutaway model of the diagram for the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb. The regions $\gamma' + \beta$ in the face MLN and $\gamma' + \eta$ in the face MLK border, along lines 6-7 and 5-9, respectively, the regions β and η. It has been established that within them they also form a single region $\gamma' + \beta(\eta)$, which can border the region $\beta(\eta)$ only along the surface 6-7-9-5, which is defined by the lines 6-7, 5-9, and 7-9 of the faces of the tetrahedron. In an entirely analogous way, a region $\gamma + \beta(\eta)$ is formed, which borders the region $\beta(\eta)$ along the surface 6-5-10-8. Between the latter two regions there is located the region $\gamma + \gamma' + \beta(\eta)$, which is defined by the regions $\gamma + \gamma' + \beta$ and $\gamma + \gamma' + \eta$ of the faces MLN and MLK. This region borders along the surfaces 1-2-5-6 and 4-3-5-6 with the regions $\gamma' + \beta(\eta)$ and $\gamma + \beta(\eta)$, respectively. The four surfaces considered can intersect along the line 5-6, which is the boundary between the pairs of regions $\beta(\eta)$—$\gamma + \gamma' + \beta(\eta)$ and $\gamma' + \beta(\eta)$—$\gamma + \beta(\eta)$,

Fig. 2. Phase diagram of the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb at 1100°

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which also corresponds to the rule of contact of phase-state regions ([4]). Further, at the vertex M there is located the region of the γ solid solution, which can border the region $\gamma + \beta(\eta)$ along the surface 3-4-11-12, as follows from the faces of the tetrahedron having the common vertex M. At the vertex

L there is the region of the γ' solid solution; it may border the region $\gamma' + \beta(\eta)$ along the surface 1—2—16—15. Between the regions γ and γ' there is the region

$\gamma + \gamma'$, which is separated from the three adjacent regions γ, γ', $\gamma + \gamma' + \beta(\eta)$ by the surfaces 4—3—13, 1—2—14, 1—2—3—4, respectively, and from the regions $\gamma + \beta(\eta)$ and $\gamma' + \beta(\eta)$ by the lines 3—4 and 1—2, which likewise does not contradict the rule of contact of phase-state regions (4).

Thus, on the basis of the geometrical analysis carried out for the tetrahedron, when its faces are known, we conclude that within it there must be a total of seven (single-phase, two-phase, and three-phase) regions: γ, γ', $\beta(\eta)$, $\gamma + \gamma'$, $\gamma + \beta(\eta)$, $\gamma' + \beta(\eta)$, $\gamma + \gamma' + \beta(\eta)$. However, the exact location of the boundaries remains undetermined. Such a theoretically constructed three-dimensional section makes it possible to choose two-dimensional sections for experimental investigation that are most convenient for the purpose of accurately identifying the boundaries and confirming the correctness of the geometrical analysis of the existence of the regions.

In the system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb, two sections, MPN and MRN (1), shown in Fig. 2, were constructed experimentally; they confirmed the general arrangement of the phase regions and showed that the third proposed section, MTN, need not be investigated. As a result of the geometrical investigation, the necessity of an experiment at the boundary of the regions γ and $\gamma + \beta(\eta)$ was clarified; for this purpose only a small portion of the section MQN was constructed. As a result, a phase diagram at 1100° was constructed for the quasiternary system γ_4—Ni_3Al—Ni_3Ti—Ni_3Nb, which is a three-dimensional section of the seven-component system Ni—Cr—W—Mo—Nb—Ti—Al.

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1. L. I. Pryakhina, DAN, **139**, No. 3 (1961).
2. Van' t-Hoff, *Zs. phys. Chem.*, **5**, 322 (1890).
3. H. W. Roozeboom, *Zs. phys. Chem.*, **8**, 504 (1891).
4. L. S. Palatnik, A. I. Landau, *Phase Equilibria in Multicomponent Systems*, 1961.

Note: Figure translations are in progress. See original paper for figures.