

THE STUDY OF THE CRYSTALLINE STRUCTURE OF THE PHASES IN THE AL-NI ALLOYS ULTRARAPID SOLIDIFICATION BY THE METHOD OF X RAY DIFFRACTION

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Abstract: Melt –spinning and melt extraction methods of rapid solidification have been applied on Al-Ni alloys in the lower and higher composition.

For orientate appreciations of the peripheric speed of the cooling disk it is used the dependence between the thickness of the solidified fibers and the peripheric speed of the extraction disk.

The cooling speed calculated on the basis of the thermic transfer coefficient in accordance with the thickness of the fibers has lead to values of the cooling speed of the one million C/sec for fibres of 100 micrometers.

Alloys with 1,86 % Ni content in pouring status and ultra-rapid solidificated have been analysed from the point of crystalline structure.

The paper it's a short analysis of the use of the X-ray diffraction techniques for observing the effects of ultra-rapid solidification in Al-Ni alloys. This technique permit to observe highlighting the imperfections in the crystal pattern.

Research upon the Al-Ni alloys with low content of Ni by X ray diffraction

Within slow solidification conditions it is expected that in the alloys rich in aluminium the following phases should be present according to the aphasic equilibrium diagram (Fig. 1) of the Al-Ni binary system [1].

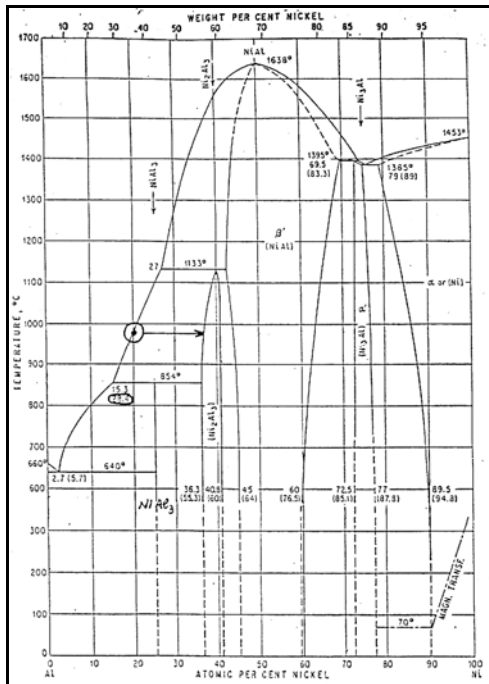


Figure 1. Equilibrium diagram Al-Ni

- phase Al. with cubical pattern of centred faces (CFC) with extremely little Ni in substitution solid solution according to the data [2,3] regarding the solubility in solid state of the Nickel in Aluminium: 0.05 % gr., (0.023% at) Ni at 640 °C (temperature for the formation of the eutectic Al-Al₃ Ni); 0.028 % gr. (0.013 % at.) Ni at 600 °C; 0.01 gr. (0.0045 - 0.009 % at.) Ni at 540 °C; 0.006 % gr. (0.003 % at.) Ni at 500 °C.

- phase Al₂ Ni (42.03% gr. Ni) with singular composition .The crystalline structure of the phase Al₃ Ni is diamond shaped of the DO₂₀ type with the pattern parameters a = 6.611Å, b = 7.366 Å and c = 4.812 Å

Within the very fast cooling conditions it is expected to appear phases outside the equilibrium such as the solid solution with oversaturated aluminium base in Ni (CFC) according to the data of solubility extension in solid base from table no. 1 [4].

The use of the techniques of studying by the diffraction of X rays for observing the effects of ultra rapid solidification in Al-Ni alloys

The main problem we tried to provide an answer for by applying the diffraction technique was connected to the extension of Ni solubility in Al by the utilisation of ultra rapid solidification. The alloy Al - 1.86% gr. Ni was chosen for highlighting this phenomenon, common to all the studied Al-Ni

alloys.

This alloy, by its position in the aphase equilibrium diagram is a hypo-eutectic one with a microstructure made of Al dendrites and eutectic (Al + Al₃Ni). So, if the ultra rapid solidification really produces the extension of Nickel solubility in Al it is to be expected that the whole quantity of Ni from this alloy composition should be dissolved in Al and the secondary phase Al₃Ni should disappear completely from the alloy composition.

Table 1.

The chemical element		Solubility in solid state in % at		
Atomic no.	Symbol	Maximum solubility at equilibrium C_{ech}	Extended solubility by applying ultra rapid solidification	The degree of solubility extension in solid state induced by ultra rapid solidification C_{ext} / C_{ech}
1	2	3	4	5
12	Mg	18,9 at 723 K	36,8 ÷	2,11 times
13	Si	*1,59 at 850 K	10 ÷ 16	10 times
21	Sc	*0,25 at 928 K	3,2	12,8 times
22	Ti	*0,15 at 938 K	0,22	13,3 times

The studying technique capable of proving this phenomenon in the most convincing way is the diffraction analysis, because within it the presence of phases in the alloy microstructure is rigorously certified by the ensemble of the diffraction lines which compose "the diffraction model" of each phase.

The diffraction technique

Instead of the usual X ray diffraction, the diffraction technique adopted for the purpose of obtaining clear and convincing results was the high resolution diffraction with synchrotron radiation

For a limited number of samples which came to be studied by this technique the measurements could be made by the

synchrotron radiation using the facilities offered by the Hasylab within the DESY system of Hamburg Germany [5].

The synchrotron radiation is obtained as shown in figure 2 as a consequence of the acceleration of a fascicle of electrons (produced by the help of linear accelerators)

The acceleration is made by applying large magnetic fields and the accelerating rings are a few km long.

The fascicle of accelerated electrons sends photonic radiation with angstrom length of waves within the same spectral range as the one of X radiation.

Figure 2 presents a comparison between a conventional X source radiation and a synchrotron source.

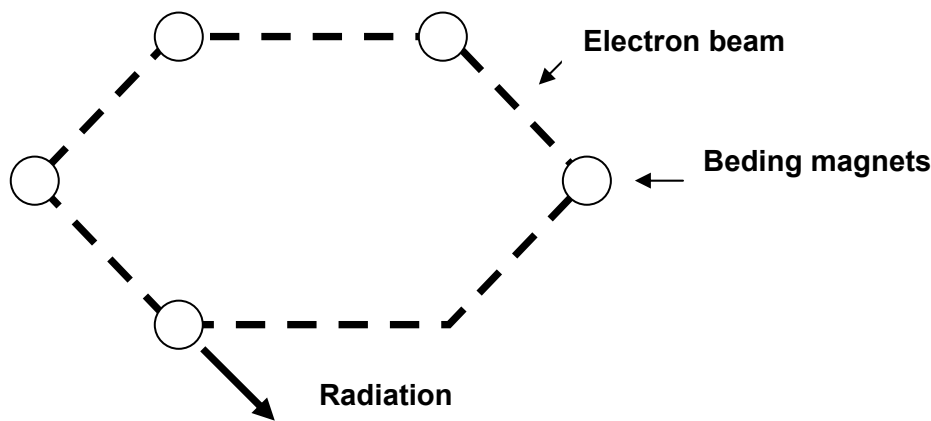


Figure 2.

Highlighting the imperfections in the crystal pattern

The imperfections in the crystalline pattern may be dotted (vacancies), one-dimensional (dislocations) or bi-dimensional (packaging defects)

They are produced by the ultra rapid solidification in the solid solution as a consequence of the solubility extension and can have an important role in the precipitation reactions which are to be expected at the decomposition during heating of these solid solutions obtained by hardening from liquid state. The concentration of the vacancy type of defects may have an important role in the diffusion processes which take place at the decomposition of the supra saturated solid solution.

The packaging defects of another physical nature represent interfaces within the inside of crystalline seeds where there is an alteration in the sequence of maximum atomic density planes from the one specific to the cubic network with centred faces (CFC) to the sequence specific for the compact hexagonal network (HC).

These imperfections can be pointed out by another experimental technique than the one of the vacancies, namely by X ray diffraction.

A few attempts made on Al Ni alloys solidified ultra rapidly with various contents of Ni, have shown that the X rays diffraction proves the changes of planes from CFC to HC in these alloys and it also highlights the fact that the frequency of these changes increases together

with the increase of Ni content in the alloy.

This aspect may be interpreted as generating an increase of the concentration in the packaging defects from the Al base supra saturated solid solution owing to the fact that these imperfections in the network, experimentally shown in Al-Ni alloys ultra rapidly solidified play an interesting part in the hardening by aging of the Al alloys.

CONCLUSIONS

In some Al alloys the packaging imperfections as well as dislocations may be places of germination for the precipitation especially when the crystalline pattern of the precipitate is of HC type.

In Al-Ag alloys the helicoidally dislocations introduced at the solid state hardening absorb the silver atoms and can degenerate in low and narrow packaging imperfections on the crystallographic planes.

These packaging defects act as germs for the formation of γ' precipitates with the hexagonal crystalline network.

Normally in Al the packaging imperfections are absent owing to the very high rate of their superficial energy. But during the formation of supersaturated solid solutions by the hardening of certain Al alloys it is possible to appear clusters of foreign atoms which produce a decrease of the superficial energy of the packaging imperfections and consequently make their appearance possible as it is shown in the determinations of the X ray diffraction.

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