

Study of the solubility of die-cast steels in silumin AK12 (AL2)

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Abstract. The results of the research of solubility of die-cast steels in silumin AK12 (AL2), depending on the chemical composition, method of refining, thermal and chemical-thermal treatment. Perspective marks of steels for the manufacturing molds pressure die-casting aluminum alloys are established. The expediency of application for the press- tools of cast alloys, nitriding and methods of arc-plasmous and electroslag remelting on the example of steel DI – 22 is shown.

The processes of die-casting, solid-liquid stamping are characterized by high parameters of the cyclic temperature and force loading of the press-tool and are accompanied by active interaction of press-tools with melts in liquid or solid-liquid states. For the aluminum alloy die-casting press-tool (ALDC) the high physical and chemical activity of aluminum melts with iron-carbon alloys leads to dissolution of the surfaces of the elements of the press-tool, reducing the resistance of the central inserts, splitters, bushes, pressing chamber working surfaces to 3000 – 5000 cycles. The maximum temperature at pressing aluminum alloys can reach 700°C at a technological temperature of the filled alloy of 640 – 680°C. The material of ALDC molds also undergoes a significant force action resulting from the pressure of the pressed alloy up to and above 500 MPa [1].

The purpose of this work is to select the die-steels, methods of remelting and hardening for molds of aluminum die-casting under pressure on the solubility index in silumin.

To perform the study we selected the following die-steels: 3H2V8F, 10H4SM4N4TYU, 10H6M5N9YU2, 5HNM, 4H8V2, 35H3V3MF, 28H5M2F, 25H3V3F, 4H2SVMFYU, 4H5M2FS, 5H2MFSD, Kh12M, 3H2V5F, 25H10V7M2K10, 4H3VMF, 4H5V2FS, 5H4SV4MF, 20H12N20F2MT3YUB, 4H4VMFS (DI - 22). Steel 4X4BMΦC (DI – 22) was tested in cast and hammered state after electric arc melting (DI – 22EM), and also after electroslag (DI – 22ESR) and plasma arc remelting (DI – 22PAR). The quenching temperature (T_{harding}) of the samples was assigned from the conditions of obtaining the maximum hardness while retaining fine grains of austenite (8 – 10 points in accordance with GOST 5639 – 82). The tempering temperature (T_{leave}) was determined experimentally to provide a hardness of 44 – 46HRC. During the tests the temperature of the melt (600 - 700°C) and the duration of the interaction of the stamping steels with the melt (up to 12 minutes) varied.

Studies of the solubility of steels in silumin, AK12 (AL2) were carried out by immersing specimens of die- steels in the melt and providing hydrodynamic interaction due to cyclic oscillation of samples with a frequency of 100 s⁻¹ and an amplitude of 10 mm. For the tests we used cone samples with the following dimensions: length, $l = 30$ mm; diameter, $d = 4$ mm; taper, $\angle 15^\circ$, radius of curvature of cone tops, $r = 0,02$ mm. During the tests the maximum speed of sample movement in silumin was about 2,0 m/s, which corresponds to the contact conditions of the silumin melt on the surface of



ALDC molds. As a criterion for estimating the solubility, a change in the sample length, Δl , mm, is accepted.

The results of the experiments are shown in Fig. 1 and 2. Analysis of the data presented indicates a significantly different resistance to dissolution of the investigated die-cast steels in the melt AK12 (AL2). The dissolution rate interval at the melt temperature of 640°C ranges from 1,0 mm/min (steel 10H4SM4N4TYU, Fig.1, a, curve 2) to 0,09 mm/min (steel 25H10V7M2K10, Fig.1, b, curve 14). The increase in the melt temperature of AK12 (AL2) causes the increase in the solubility of all the steels studied. The greatest resistance to solubility is noted in steels with the increased chromium content (Figure 2, b, curves 10, 14) and wolframite (Fig. 2, b, curve 14). Molybdenum and silicon also have a positive effect. The influence of nickel does not play any positive role (Fig. 2, a, curves 2, 4).

The effect of nitriding of die-steels on the solubility index in the melt of AK12 (AL2) has been studied using the example of steels 3H2V8F and 4H3VMF. Nitriding was carried out according to the $T_{\text{nitriding}} = 540^{\circ}\text{C}$, medium - dissociated ammonia (40% dissociation degree), duration – 20 hours, layer depth – 0,18 - 0,22mm, layer hardness – 880 - 900HV. The results of this series are shown in Fig. 1, d and Fig. 2, d. As it follows from the comparison of options 1 and 15, the average rate of dissolution of nitrided steels is characterized by record low values of $\sim 0,04 - 0,06$ mm/min and is practically independent of the chemical composition of the steels studied.

Influence of methods of smelting, plasma arc and electroslag remelting of die-steels on the solubility in the melt of AK12 (AL2) was investigated for steel 4H4VMFS (DI – 22). The solubility of steels after electroslag remelting (ESR) and after plasma-arc remelting (PAR) is 2-3 times lower than after arc melting.

It has been established that the 4H3VMF, 5H4SV4MF, 4H5V2FS and 4H4VMFS (DI – 22) die-steels are promising for the manufacture of the press- tools of cast alloys for high resistance to dissolution in the melt of silumin; nitriding of die-cast steels increases the resistance to dissolution in the melt of silumin, that is the advantage of die-steels in comparison with the deformed ones.

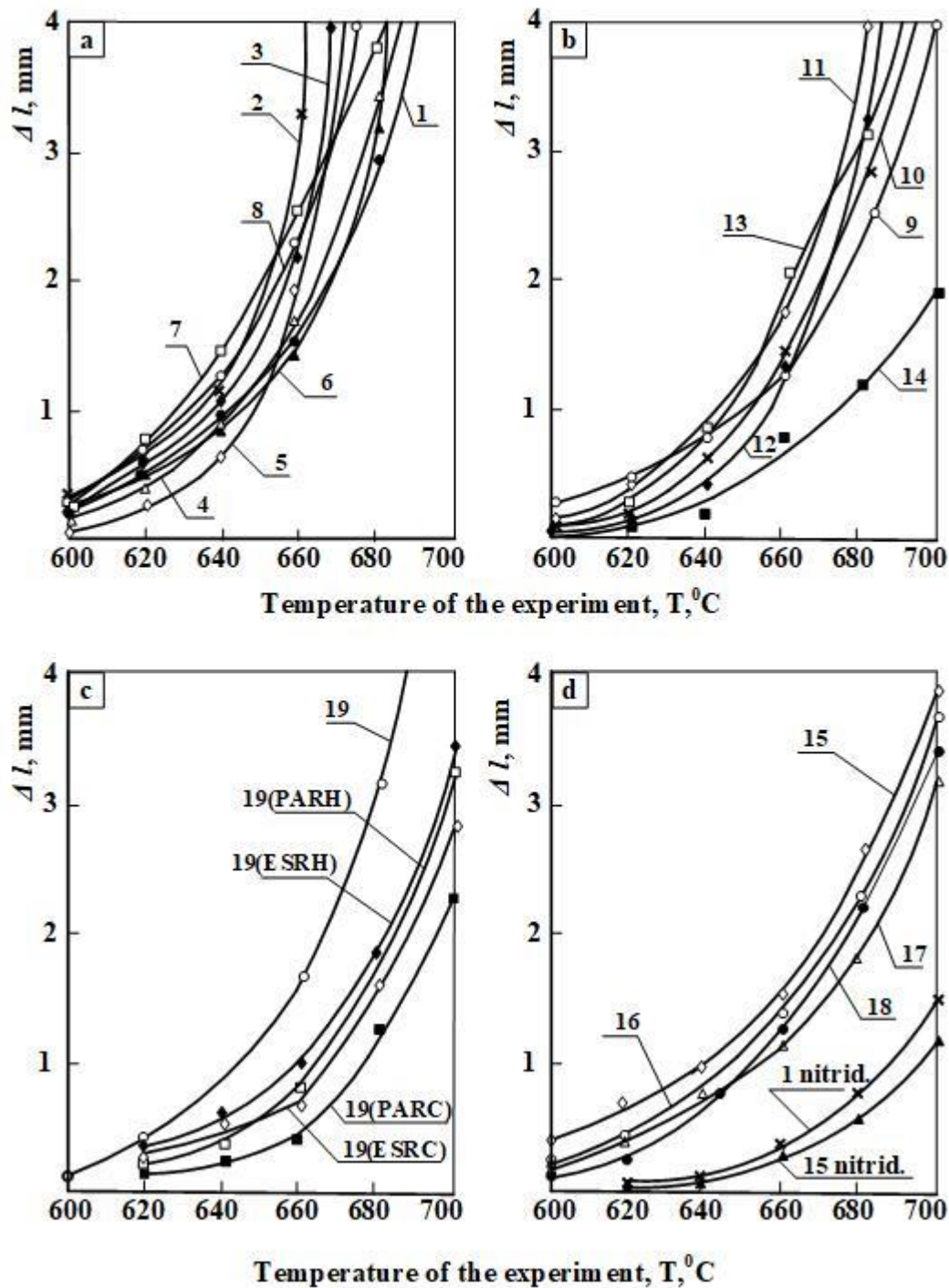


Fig. 1 – Influence of the chemical composition, the method of remelting and nitriding on the solubility (Δl , mm) of steels in the melt of AK12 (AL2) depending on the temperature of the melt. The duration of the interaction, $\tau = 3$ min. 1 – 3H2V8F, 2 – 10H4SM4N4TYu, 3 – 10H6M5N9Yu2, 4 – 5HNM, 5 – 4H8V2, 6 – 35H3V3MF, 7 – 28H5M2F, 8 – 25H3V3F, 9 – 4H2SVMFYu, 10 – 4H5M2FS, 11 – 5H2MFSD, 12 – H12M, 13 – 3H2V5F, 14 – 25H10V7M2K10, 15 – 4H3VMF, 16 – 4H5V2FS, 17 – 5H4SV4MF, 18 – 20H12N20F2MT3YuB, 19 – 4H4VMFS (DI – 22, ESRH – hammered after electroslog remelting, ESRC – cast after electroslog remelting, PARH – hammered after plasma-arc remelting, PARC – cast after plasma-arc remelting).

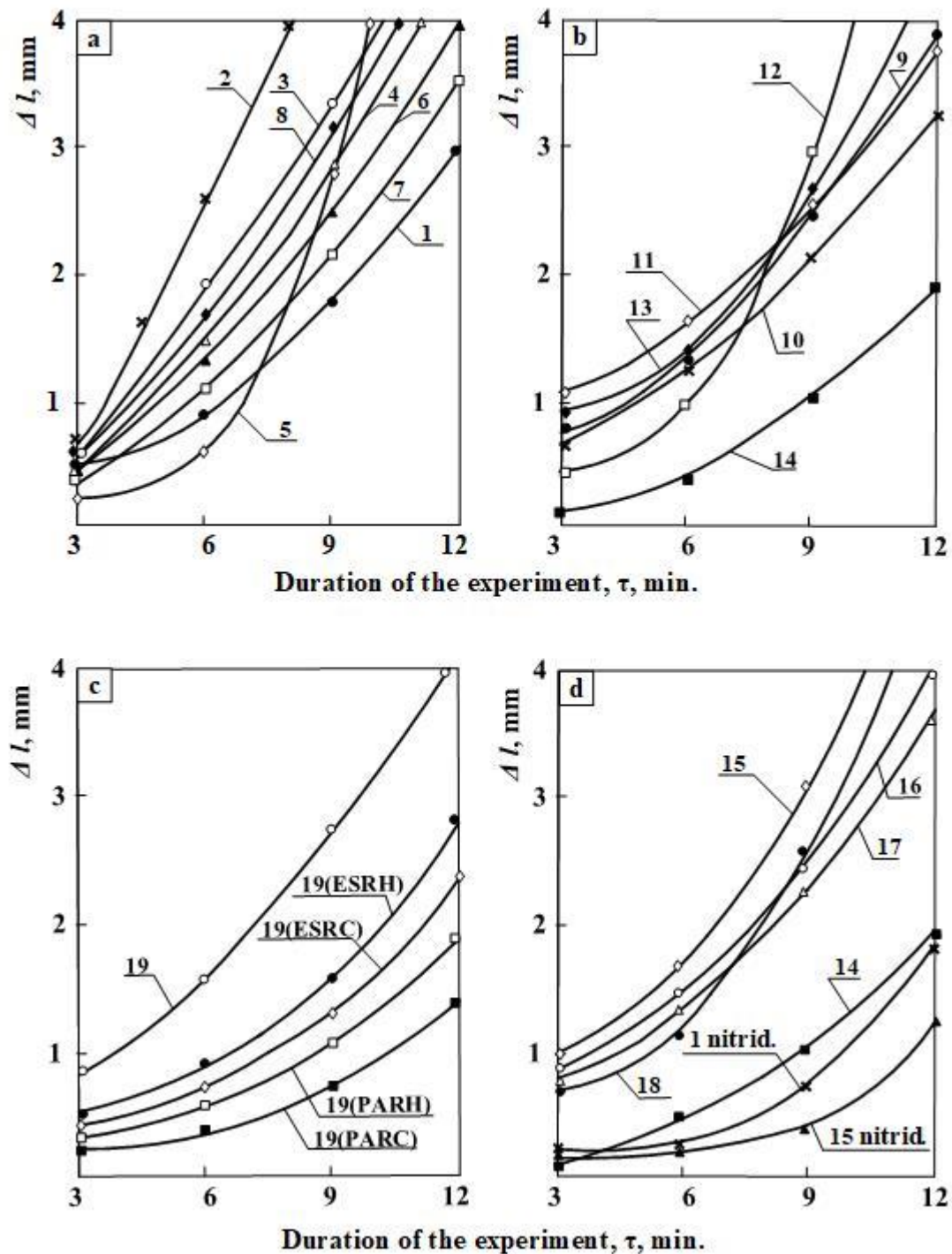


Fig. 2 – Influence of the chemical composition, the method of remelting and nitriding on the solubility (Δl , mm) of steels in the melt of AK12 (AL2) depending on the duration of the interaction, $T_{\text{melt}} = 640^{\circ}\text{C}$: 1 – 3H2V8F, 2 – 10H4SM4N4TYu, 3 – 10H6M5N9Yu2, 4 – 5HNM, 5 – 4H8V2, 6 – 35H3V3MF, 7 – 28H5M2F, 8 – 25H3V3F, 9 – 4H2SVMFYu, 10 – 4H5M2FS, 11 – 5H2MFSD, 12 – H12M, 13 – 3H2V5F, 14 – 25H10V7M2K10, 15 – 4H3VMF, 16 – 4H5V2FS, 17 – 5H4SV4MF, 18 – 20H12N20F2MT3YuB, 19 – 4H4VMFS (DI – 22, ESRH – hammered after electroslag remelting, ESRC – cast after electroslag remelting, PARH – hammered after plasma-arc remelting, PARC – cast after plasma-arc remelting).

References:

- [1] Goryunov I I 1973 Die-casting molds Reference manual L: Mashinostroyeniye 256 p