The erosion resistance of tool alloys in foundry melt the Zamak 4 – 1

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Abstract.
The paper considers the resistance against erosion dissolution in the melt of foundry Zamak 4 – 1 die steels used for press machine parts manufacturing for injection molding, and hard alloys system WC – Co. It is established that the solubility in the melt Zamak – 4 – 1 steel of 4H5MFS and DI – 22 are promising for the parts fabrication of metal-wire casting machines of CLT and IDRA types. A significant reserve to increase the resistance of metal wires is the use of cast steel, as well as in electroslag and electro-beam remelting options. Metal-ceramic alloy doped with chromium VK25H may be recommended for reinforcement of heavily loaded parts of the press-nodes of hot casting machines under pressure.

The main cause of failure of parts of metal-wire and press-nodes components (mouthpieces, adapters, diffusers, liners, press-pistons, compression rings) of hot casting machines under pressure types CLT and IDRA experiencing hydrodynamic effects of zinc alloys, is erosive wear (feathering) of working surfaces, due to high physic-chemical activity of zinc interaction of melts with alloys based on iron, accompanied by the dissolution of iron and formation in the diffusion layer of aluminum and zinc intermetallic compounds of the Fe2Al5, Fe2Zn13, Fe2Zn7, etc., as well as solid solutions of η and α – phases [1, 2, 3, 4, 5].

This paper presents a comparative study of resistance to dissolution (erosive wear) in a zinc melt of foundry, Zamak 4 – 1 die steels: 4H5MFS, 3H2V8F, 5H4SCV4MF, 4H3VMF, 4H4VMFS (DI – 22), 5H3V3MFS (DI – 23), DI – 22 in electroslag (DI – 22 ESR) and electro-beam remelting (DI – 22EBR) variants, DI – 22 in a molten state, and sintered alloy of WC – Co with different content of cobalt: VK10, VK20, VK25, VK30; the size of carbide particles:(≈ 10 μm) – VK10S, VK20S; (≈ 30MKM) – VK20K; and doped(≈ 1%) with chromium VK25H, and molybdenum, VK25MO.

All-steel were thermally processed: after quenching from temperatures 1313 – 1393K and tempering 853 – 993K on the hardness of 44 – 46 HRC.

Hard alloys after sintering had hardness in the range 1750HV for VK10 and 1570HV for alloy VK30.

Material tests on the solubility in the melts were carried out in conditions of continuous change of the contacting fluid volumes and its flow impact on the sample typical for operational details loading.
of metal-wire. Main dimensions: length, $l = 30$ mm; diameter, $d = 4$ mm; taper, $\Delta 15^0$; the radius of curvature of the tops of the stake-owls, $r = 0.02$ mm. Investigated surface-cone of samples was processed to a purity of $R_a = 0.8–0.64$ microns and was controlled by the profilograph – profilometer – CALIBR. Model mode samples load: amplitude, 10.0 mm; the frequency, $100c^{-1}$. The maximum speed of the movement of the studied plots in the melt is 2.0 m/sec. As criterion of solubility evaluation a change in the length of the sample, $\Delta l$, mm was adopted.

The study of kinetics solubility of steels and hard alloys in the melt Zamak – 4 – 1 was done under the duration of the interaction in the range of 12 – 90 min. at a constant temperature of melt, equal 743K (Fig. 1).

Fig.1 – Influence of duration of interaction ($\tau$, min) on the solubility of $\Delta l$, mm tool materials in the melt Zamak – 4 – 1: 1 – 3H2V8F; 2 – 4X3VMF; 3 – 5H4SV4MF; 4 DI 23; 5 DI 22; 6 – 4H5MFS; 7 DI 22ESR; 8 DI 22E prophecy; 9 – VK30; 10 – VK25; 11 – VK20; 12 – VK10S; 13 – VK20S; 14 – VK20K; 15 – VK25M; 16 – VK10; 17 – VK25H; 18 – DI 22L.

Analysis of these data has confirmed that the solubility of the investigated materials in the melt Zamak – 4 – 1 varies considerably. For example, when the temperature is 743K and $\tau = 45$ min, it changes from $\Delta l = 0.012$ mm (steel DI – 22 EBR) to $\Delta l = 0.14$ mm (steel 3H2V8F, curves 8 and 1 Fig. 1). A positive effect on the increase in the resistance of the solubility investigated steels has their alloying with chromium in combination with molybdenum and silicon (curves 3, 4, 5, 6, Fig. 1).

Reserve for increasing the resistance against dissolution is manifested in the use of material metal purity, i.e. after the ESR and EBR, as well as in molten state (DI – 22L, curves 7, 8, 18, Fig. 1).

Study of the effect of temperature on the solubility of materials in the melt Zamak – 4 – 1 was carried out in the range 723 – 873K if the duration of the interaction 12 min., is represented on Fig. 2.
Fig. 2 – The effect of testing temperature on the solubility of tool materials in Zamak melt – 4 – 1: 1 – 3H2V8F; 2 – 4H3VMF; 3 – 5H4SV4MF; 4 – DI 23; 5 – DI 22; 6 – 4H5MFS; 7 – DI 22 ESR; 8 – DI 22EBR; 9 – VK30; 10 – VK25; 11 – VK20; 12 – VK10S; 13 – VK20S; 14 – VK20K; 15 – VK25M; 16 – VK10; 17 – VK25H; 18 – DI 22L.

At lower temperatures (723 – 773К) fine-grained ceramic materials VK10S, VK20S, (curves 12, 13, Fig. 2), and also alloyed with molybdenum, chromium and VK25M, VK25H (curves 15, 17, Fig. 2) in comparison with the steels have almost the same resistance, and with increasing testing temperature in Zamak melt – 4 – 1 they are worse than steel. In this case a clear trend to decrease resistance of WC – Co composites at cobalt increasing in the bundle (curves 9, 10, 11, 16, Fig. 2). So at lower testing temperatures (Tr = 773K) alloys VK20S and VK20K have almost the same resistance superior to that of the 1.5 times for alloy VK20. At higher testing temperature (Tr = 823K) solubility of alloy VK20K increases dramatically in comparison with VK20S (curves 13, 14, Fig. 2).

Alloying VK25H with chromium increases the resistance of solubility in the melt Zamak – 4 – 1 in the whole test interval temperature (curves 10, 17, Fig. 2). Effect of alloying with molybdenum at elevated temperatures of the melt leads to a reduced resistance of alloy VK25M (curve 15, Fig. 2).

Thus, in terms of solubility in the melt Zamak – 4 – 1 the promising for of manufacturing of details of metal-wire foundry cars CLT and IDRA types are steels 4H5MFS and DI – 22. Considerable reserve for increasing the life of metalwire is the use of cast steels, as well as options of ESR and EBR.
Metal-ceramic alloy doped with chromium VK25H may be recommended for reinforcement of heavily loaded parts of the press-nodes of hot chamber machines under pressure (press – pistons, cylinder liners).

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