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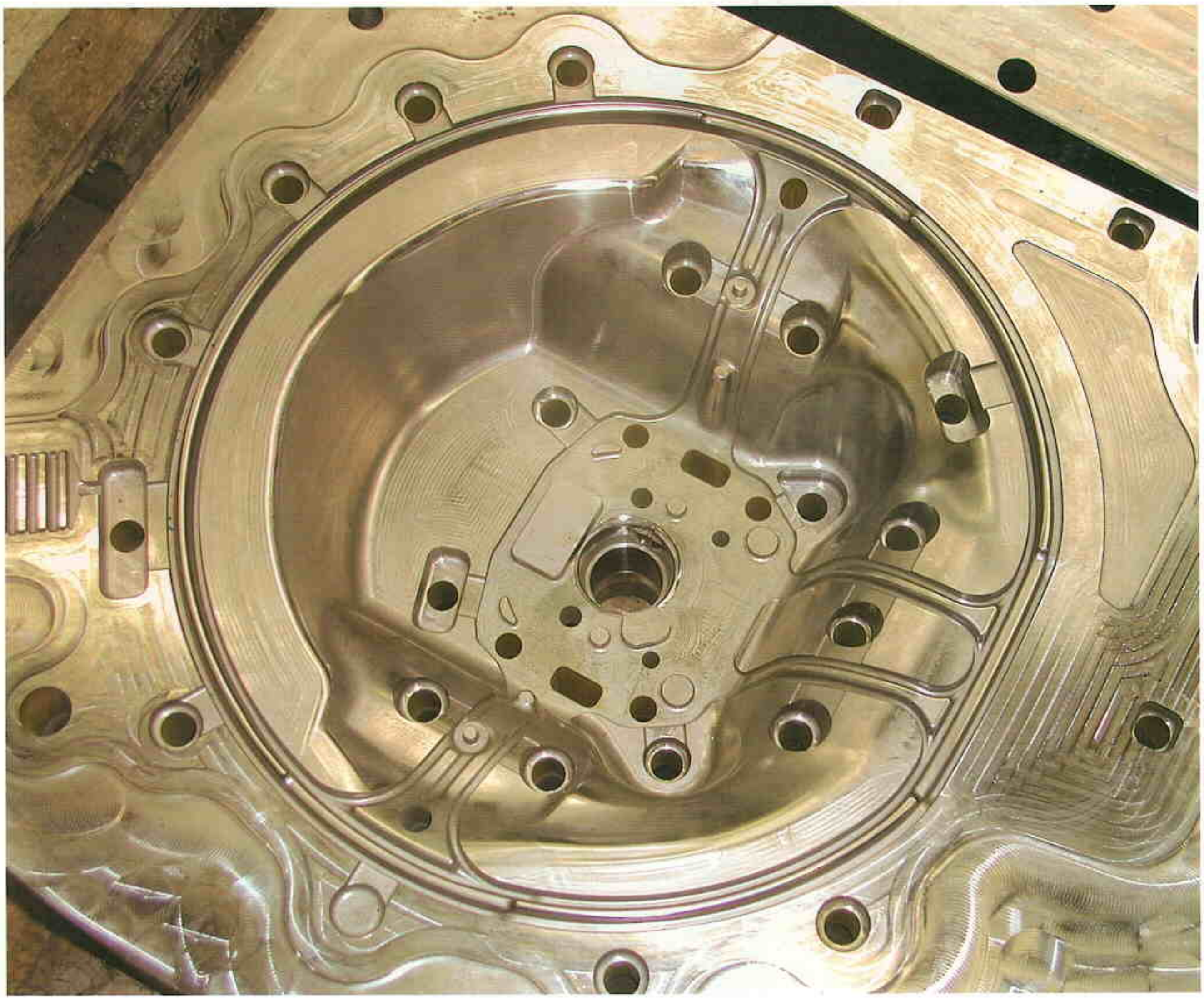

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Low-wear ejectors make for a longer service-life of dies

Ejectors reduce wear and tear of die-casting dies

Ejectors are amongst most intensely moved parts in die-casting tools. Therefore they largely influence die service lives and maintenance intervals

by PIUS EICHINGER, NEUENDETTELSAU

Both the composition and structure of the nitriding layer are of major influence on the service life of an ejector pin and on die-casting dies for that matter. Contemporary long-term tests raise questions regarding nitriding processes used even today, although they no longer represent the state of the art.

Dies serve longer and maintenance intervals go up, if ejectors resist wear for longer. Although they are included among what are called standard parts, there are considerable differences between makers and versions on offer.

Following a general dividing line, there are nitrided and hardened ejector pins. Nitrided versions are used at high temperatures, when operating with very hot molten mass.

An ejector made of hot forming tool steel remains stable up to temperatures of 600 °C. Nitriding achieves a surface hardness of up to 70 HRC (up to 1,100 VH 0.3). At this point the tough core material still scores at about 44 HRC, thus retaining sufficient elasticity to cope with lateral and longitudinal forces. Thus, the stability of the ejector mainly depends on its basic material. Service life, however, is essentially defined by the nitriding layer.

Old and new nitriding methods

The oldest method is salt bath nitriding. But considerable environmental and safety problems already meant that this process almost disappeared. But the process also scored low as for reproducibility. Inherent process conditions have never made for reliably-reproducible outcomes. Impurities largely affected bath concentration, so that the end result of the nitriding process could not be controlled. A number of very deep pores were formed in the external session layer during salt bath nitriding, resulting in a very rough surface.

As we understand it now, these pores represent interruptions of the material's bonded grid, clearly reducing material strength on the surface.
Years ago already studies had proved that even at low surface loads and after relatively short periods of wear, particles will break off or be shorn off from the porous section of the session layer, producing - together with the lubricant employed - an abrasive mixture [Hoffmann and Mayr - AWT Seminar, Berlin 1984).
So these pores result in micro notch effects, weakening the ejector. Short lifting movements and abrasive environments result in early extensions of the bore hole and ejector wear. Molten mass can thus penetrate the opening between ejector and pin bore, leading to time lost for production.
Gas nitriding produces fewer pores than the salt bath, so - to some extent - the layer composition may be controlled a bit better. Problems do come up, however, with uniform layer density and layer structure. Gaseous nitrogen is introduced between parts to be nitrided. Pieces produced in wholesale manufacture very often show largely different nitrogen concentrations. Nitriding errors, such as excessive nitrogen concentrations, produce an abrasive porous edge, which has the effect of sand in the guiding.

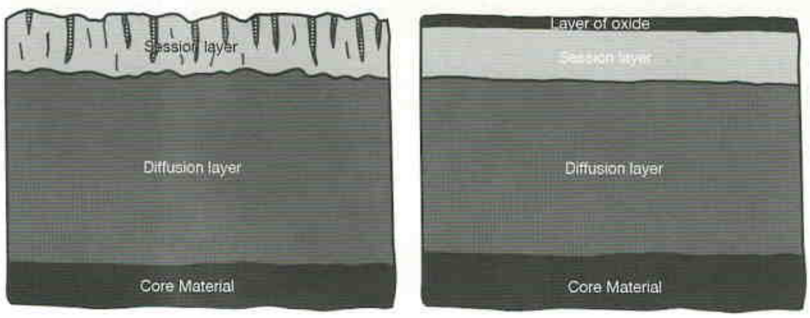

Fig. 1: **Structure diagram of nitriding layers**

Why plasma-nitriding and oxidising?

Exact and uniform layer composition is required for exploiting maximum wear resistance [Fig. 1]. In plasma-nitriding, electrical charges are uniformly discharged on the surface of the work piece.

This produces a small electric arc, as in welding. This so-called luminous edge is needed to make sure that nitrogen gas penetrates the steel surface. Thus, a thin nitride layer will be formed on the work piece. This is called a session layer. It is followed by a layer of a nitrogen-enriched isomorphous mixture plus eliminated nitrides, called a diffusion layer. Ideally, this session layer is very thin; it does not crack, is not porous and solidly sticks to the diffusion layer. This session layer can be made thin and with a few pores only by pulsed-mode plasma operations. Electronic equipment may be used for precise control of this process. Given sufficient experience, required layer depth may be manufactured reproducibly and to very exact specifications.

Salt-bath and gas nitriding were the main processes used for a long time. The downside processes of ejector making were adapted to this process. As surfaces manufactured by such operations, (Fig. 2) could not be used, ejectors were polished after nitriding. This meant, however, that part of the nitriding layer was removed again. Cracked session layers produced by salt bath and gas nitriding were polished off, either unequally or completely. The ejector then had a polished surface but the wear-resistant protective session layer had disappeared.

Therefore, Drei-S-Werk developed the smooth-surface plasma-nitrided ejector (A004). This version no longer needs additional polishing. It now has a smooth pin with a light-grey, mat surface with an appropriately optimised session layer.

Ejector durability can be improved even further, if an additional oxidised layer is added on top of the session layer. Drei-S-Werk, together with well-known nitriding facilities, further improved this new process for ejector pins. It now markets a new generation of ejectors, called AV03 (Fig. 3). In principle, the new black oxidised layer may be applied as a part of various processes. But most technical advantages result from a combination with plasma nitriding:

- > improved wear-resistance of pin bore and ejector,
- > the oxide layer functions as a non-stick layer for molten mass,
- > improved corrosion resistance, and
- > safe to run dry.

In principle, dry surfaces wear off more rapidly than those with lubrication. To resolve that problem, Drei-S developed the AWF 1,400 high-performance lubricating grease. That was because MoS2, used before, turns crystalline at temperatures of about 300 to 350 °C, resulting in additional abrasion. AWF 1,400 may be used safely up to 1,400 °C. It is also effective at lower temperatures and may be used sparingly.

Comparative wear tests

A comparative wear test was carried out to find out which type of surface treatment results in longer service-life for ejectors. To find results as closely related to service conditions as possible, an office of independent engineers working for Drei-S simulated standard operating conditions.

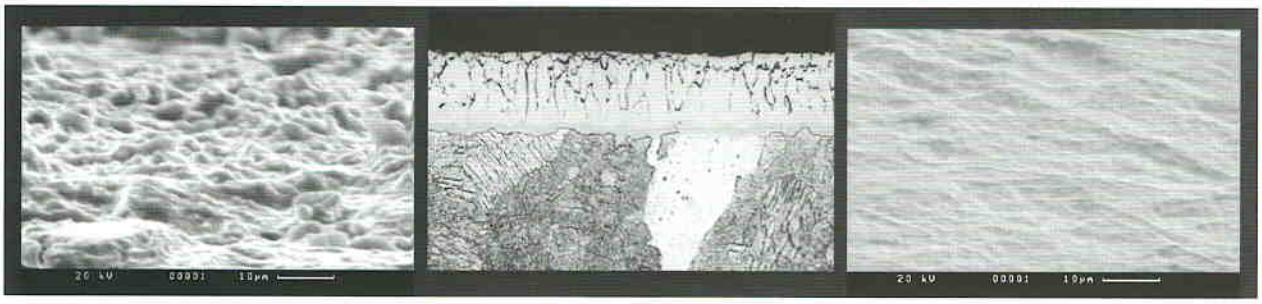
Surface after salt-bath nitriding — Gas-nitriding, material section — Plasma-nitrided and oxidised surface

Fig. 2: **A comparison of surfaces after salt-bath nitridung and plasma-nitriding**

FOTOS: DREI-S-WERK

Fig. 3: The AVO3, a plasma-nitided and oxidised ejector

The results were as follows:

1. Black nitrided ejector with MoS2 (outdated use in die-casting):

MoS2-coating with anti-friction coating (ca. 15 µm) led to essentially higher friction between ejector and bore, resulting in an additional heating up of the die and in much larger wear of ejector and bush.

2. Plasma-nitrided bright ejector with lubricant:

The short lifting movement produced a collection of rubbed-off parts. Some of these ended up relatively solidly linked to the ground, leading to considerable roughness. Equal distribution of bright areas over and beyond the edges of the bush leads one to assume that crushed material, together with the lubricant, acted like abrasive paste.

3. Plasma-nitrided and oxidised black ejector with lubricant (new version for die-casting):

Though after 100,000 lifting movements no more residual oxidised layer remains to be seen at the friction mark, there is only minimum wear and tear. Die contours remained almost unchanged.

Based on what we know today and considering the state of the art, the plasma-nitrided and oxidised ejector pin (AV03) may be called a die-protecting device. It may either be employed in its long-time stability lubrication version (AWF 1,400) or in a dry operation.

From a tribological point of view no two equal friction partners should ever be used together. This would entail uncontrolled wear and might result in parts adhering very closely, and eventually jamming. As part of this central statement, it was also found by tests that application of an Fe304 layer generally improved sliding qualities and emergency running properties. Similar versions of this method are also being used by other sectors. The automobile branch also oxidises the camshafts of engines built today. Both corrosion resistance and dry-running behaviour have been employed for years in manufacturing pistons of lifting cylinders.

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