MOŽNOSTI ZLEPŠENIA VLASTNOSTÍ POVRCHU VSTREKOVACÍCH FORIEM

PROGRESSIVE MOLD MATERIAL SURFACE ENHANCEMENTS

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Abstract
This contribution deal about possibility of application of progressive surface enhancements for mold tool parts. Enhancement compositions and methods for its use in a molding process are described in this paper, with pros and cons of each type of coating. Due to massive abrasive wear of surface in interaction with filled thermoplastics, coating is one possible way of improving life time of tool and also extending the durability of whole mold.
Key words
Progressive surface enhancements, tool coatings, mold tools.

Introduction

Today's plastic materials can be pretty rough on injection molds. Challenges to mold maintenance extend beyond glass- and mineral-fillers to include rice hulls, wood fibers, metal powders, flame retardants, and other additives—not to mention the resins themselves. Aggressive conditions of outgassing and moisture acidity often accompany abrasive wear as potential insults to expensive tooling.

In addition, growing tool complexity involves tinier, more intricate flow passages and more frequent use of moving cores and slides. All these factors have prompted development of a wider variety of mold coatings that can keep molds operating longer between repairs.

Surface enhancement methods and processes

Surface enhancement methods and processes are utilized to impart specific properties to the mold, usually in the area of the cores and cavities. Some of the more common enhancements are mentioned in the next section, along with the advantages of each.

Before considering some of the newer, high-tech coatings, it's worth remembering that an old, reliable coating like hard chrome or electroless nickel is sometimes the way to go. One advantage of hard chrome is that it has a hardness of 72 Rockwell C (RC) and is applied at the low temperature of 55^{o}C. When applied in its purest form, it allows you to achieve any SPI finish on tooling.

Hard chrome is often a good choice for electrical circuit-breaker molds since they use materials containing as much as 40% glass. To help combat erosion and prevent severely damaging gates and surrounding mold areas, it is usually recommend a high-diamond polish on a hard-chrome coating of 7.5 microns to 12.7 microns. The downside can be cost, since chrome plating is limited to areas accessible by an anode. If mold has complex details, it could require an extra conforming anode that adds time and expense to the project. Another possible drawback is chrome's environmental impact—chromium is a carcinogen. Some companies are attempting to develop better, "cleaner" alternatives, but so far it was not aware of anything that matches hard chrome's benefits from a tooling perspective.

Tab.1 Properties of modern injection mold coatings

Injection Mold Coatings						
Coating	**Trade Name**	**Rock well Hardn ess**	**Coeffici ent of Friction Against Steel**	**Applie d Temp.**	**Benefits**	**Mold Applications**
Hard Chrome	QQ-C-320	72 HRC	0.20 or less	55 °C	Good abrasion resistance.	Glass-filled resins; not for PVC.
Electroles s Nickel	AMS-2404-C AMS-2405-B	50 HRC	0.45 or less	85 °C	Moderate abrasion & excellent corrosion resistance.	Uniform deposit needed; PVC moding.
Nickel-Cobalt	NiHard	62 HRC	0.24 or less	85 °C	Good abrasion & corosion resistance.	Uniform deposit on complex details; good chrome alternative.
Diamond-Chrome	Dia-Clust	85+ HRC	0.015 or less	55 °C	Excellent abrasion resistace.	Moving slides, rotating cores, locks.
Nickel-PTFE	Nicklon	45 HRC	0.10 or less	85 °C	Excellent corrosion resistance, high lubricity.	Eases release in deep ribs, no-draft cores, textured surfaces, hard-to-eject resins.
Nickel-Boron Nitride	NiBore	54-67 HRC	0.05	85 °C	Excellent lubricity, high wear and corrosion resistance, higher heat resistance than PTFE-based coatings, uniform deposit.	Abrasive resins, unscrewing cores, high-wear parts, fast-cycling molds.
Titanium Nitride (TiN)	Balinit A	90 HRC	0.40	480-510 °C	Abrasion & corrosion resistance, lubricity.	Ejector guides, cores, cavitites, glass-filled resins, PVC
Diamond Black (Boron Carbide)		93 HRC		95 °C	PVD deposition process	Increases tool life and eases cleaning. Good lubricity and improves corrosion resistance.

Tool Surface Treatments

As plastic injection molding technology pushes us into the 21st century, we find that major improvements are being made in machines and materials, but one area we are now beginning to look at closely is tooling. Greater requirements are being placed on the length of time a mold is expected to run before it is considered worn out. Some of the new resin formulations and alloys are tough on existing mold materials. Added strength from reinforcements increase property values of the plastics, but their abrasive nature can wreak havoc on the steel finishes of a mold. This section is not intended to be all-inclusive, but is written as a reference tool for those interested in knowing about, and understanding, some of the up-to-date tool steel enhancement products and how they fare concerning advertised application methods, advantages, and the mold materials on which they can be used. Many of the specific enhancements are known by various tradenames, not all of which are listed here.

We are not endorsing any of these products or methods and believe that users must make that selection for themselves.

Thin-metallic Coatings (MeC)

Dicronite DL-5™ - A modified tungsten disulfide in lamellar form, it is applied at ambient temperature by air delivery and bonds by immediately penetrating the mold steel. It is primarily used instead of mold release agents and can be used on all mold materials.

WS2™ - Also a modified tungsten disulfide in lamellar form, it is applied at ambient (room) temperature using pressurized air and can be used on all stable metal surfaces. It becomes part of the substrate, taking on the same hardness, and cannot be removed without removing part of the substrate surface.

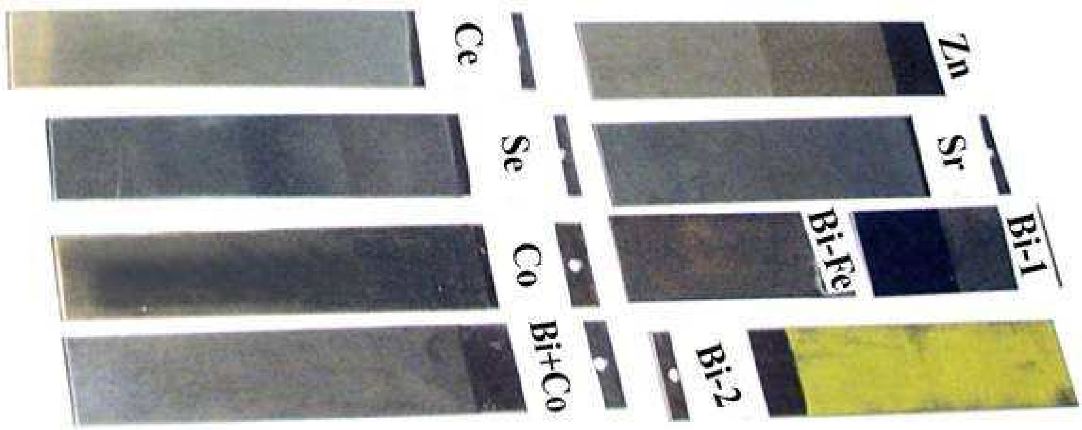

Fig. 1 MeC coated stainless steel samples - Ce and Zn (two thicknesses); Bi-1 - as deposited, Bi-2 - after heating the sample for 10 minutes at 250C, in air (the yellow color is due to bismuth oxide formation).

PTFE-metallic Fused Coatings

Poly-Ond™ - A nickel phosphorous material impregnated with fluorocarbon resins including polytetraflouroethylene, hereafter referred as PTFE (also known as Teflon™), it is applied by electroless nickel deposition, followed by a polymer bath, and then baked at 700° F (371° C) to set the polymer into the surface. It can be applied over steel, aluminum, brass, bronze, cast iron, and most other typical moldmaking materials. It is used to eliminate spray releases, prolong tool life, and increase surface hardness to 70 R_c.

TFE-Lok™ - This is a PTFE-impregnated, hard chrome material that is applied by electrodepositing the chrome, then heating the chrome to expand the pores that are then impregnated with iced TFE particles under high pressure. The process is performed at 400° F (204° C) and can be placed on any steel, stainless steel, aluminum, copper, or copper alloy mold material. It is used for its permanent release properties and increased hardness to 70 R .

Nedox-SF2™ - A modified electroless nickel infused with PTFE polymer, the nickel is modified to increase porosity, and the polymer is typically applied and set by heat at 750° F (399° C). It is used to precisely control thickness of the mold surface for close-tolerance parts, and can be used over all ferrous materials and some nonferrous, including aluminum. It imparts a hardness up to 70 R_c.

Nltuff™ - A PTFE coating applied over a hard-coat anodizing that is only used over aluminum mold surfaces. The surface is first anodized, then dipped in PTFE at approximately

200° F (93° C). It increases flow and release characteristics and increases wear resistance by imparting a hardness of up to 62 R_c.

PTFE-metallic Codepositions

Nicklon™ - A 10.5% phosphorous-nickel alloy with 25% PTFE suspended in the matrix, it is applied at 150° F [66° C) by codepositing the nickel and PTFE, and can be used on any metal substance. It is used for its mold release properties and, if heat treated, can reach a hardness level of 70 R_c.

Nicotef™ - A combination of PTFE submicron particles suspended in a nickel-phosphorous matrix, it is applied through a codeposition process at 195° F (91° C) and can be used on most metals, including aluminum. In thin coatings it is used for release, and in thicker coatings for corrosion resistance. It can attain a hardness of 35 R as applied, or 46 R_c if heat treated.

NYE-TEF™ - Also a suspension of submicron PTFE particles suspended in a nickel-phosphorous matrix, it is applied by an autocatalytic codeposition process at 95° F (35° C) over most metal surfaces, including brass and aluminum. It is used for its release properties and anticorrosion and can reach a hardness level of 48 R_c as applied and 68 R_c if heat treated.

Nutmeg Chromium-plus™ - A chrome/PTFE combination with the PTFE intermixed rather than baked on, it is applied through electrolytic deposition at 170° F (77° C) over steel, stainless steel, or brass, but not aluminum. It is used primarily to resist abrasion and can attain Taber abrasion resistance readings 24% greater than chrome alone. It has a hardness rating of 70 R_c.

Metallic Platings

Industrial hard chrome - This is considered an industry standard for adding thickness to worn surfaces by plating. It is available from many suppliers and is applied by electrodeposition of chromium plus trace amounts of oxides and hydrogen at 140° F (60° C). It has a hardness level of 70 R_c and good adhesion on most metals, but softens at 400° F (204° C).

Electrolizing - A proprietary process us ing a nonmagnetic high-chrome alloy in a deposition process at 90° F (32° C), it can be used on any tool steel, 4100 steel, stainless steel, or aluminum. It increases wear resistance, reduces friction, aids mold release, and can be used for repair. It has a hardness level of 72 R_c.

Armoloy™ - A dense chrome alloy that is applied to ferrous and nonferrous metals, except for aluminum, in an electrocoating process at 140° F (60° C), it has good release and wear properties, and is excellent for use with glass-filled materials, with a hardness rating of 72 R_c .

Electroless nickel - This is the most popular deposited surface enhancement for molds. It is a nickel alloy combined with varying phosphorous content to provide specific properties. Applied through electroless deposition at 180° F (82° C) and up to 400° F (204° C) in postbake, it attains a hardness rating of 48R_c as applied, and 70 R_c when heat treated.

Nutmeg tungsten nickel – A solution alloy of tungsten and nickel, it is applied using electrolytic deposition on any metallic surface at 150° F (66° C) and attains a hardness rating of up to 65 R_c, if baked. It is excellent for corrosion resistance and polishes well.

Fig.2 Electroless Nickel Phosphorous Plating

Fig.3 Hard Chrome & Chrome Plating

Surface Hardening Treatments

Melonite™ - A thermomechanical, salt-bath nitriding process that reacts to any ferrous based metal substrate to create nitrides, it is performed at 1,075° F (579° C) and achieves up to a 70 R_c hardness. It is extremely resistant to wear and improves fatigue properties by 20 to 100%.

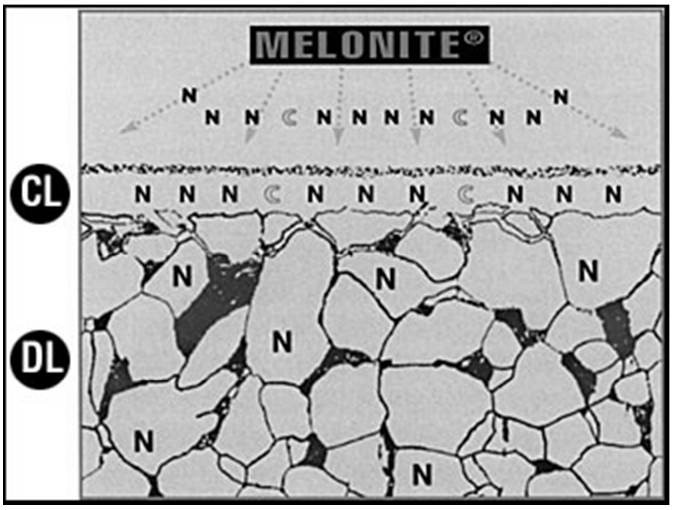

Fig.4 Structure of Melonite coating used for mold tools

Compound Layer (CL) - Consists of epsilon iron nitride with about 6-9% nitrogen and 1% carbon. The thickness for most applications is around 0.01016mm - 0.02032mm. It improves:

- Corrosion Resistance
- Scuffing Resistance
- Hot Strength
- Wear Resistance
- Running Behavior

Diffusion Layer (DL) - Contains nitrogen, either dissolved in the iron lattice and/or precipitated as very fine nitrides. Low alloy steels give thicker layers with lower hardness. Higher alloys give greater hardness with thinner layers. It improves:

- Rotating Fatigue Strength

- Pressure Loadability
- Rolling Fatigue Strength

Ion nitriding - A plasma glow surface hardness treatment process in which ionized nitrogen electrons form nitride compound and diffusion zones in most ferrous substrates, it is performed at 950° F (510° C) and achieves a typical hardness rating of 65 R . This is a very low cost process used to improve fatigue resistance, wear resistance, and lubricity.

Thin Film, Hi-hard Coatings

Titanium nitriding - This is a common high temperature coating applied through a negative ionization, vapor deposition process at 950° F (510° C). It is applied to most steels, stainless steel, and beryllium copper, and is used primarily to reduce friction. It can achieve a hardness rating of 85 R .

Diamond Black™ - Reported to attain the highest hardness rating available at 95 R., it is a thin boron carbide film combined with tungsten disulfide applied in a low temperature (250° F [121° C]) magnetron sputtering process. It is used to increase hardness for extended tool life and also provides good lubricity and corrosion resistance.

Impregnated Polymer

Micro-tuff™ - This is a process consisting of impregnating two long-chain polymers into a preplated surface of chrome over most metals, at a temperature that is only referred to as being above ambient (room temperature). It attains the same hardness of the substrate, and is used primarily to improve mold release properties, but can increase wear resistance by 10 times more than that of chrome.

Conclusion

Advanced plastic compounds present special challenges to the mold designer. New formulations include caustic precipitates, acidic gas that eats away at mold vents, and highly abrasive additives that increase mold wear and prevent smooth part release. Thinner profit margins necessitate that production lines be run at high output rates — often around the clock. Setup and tool changes can eat up the better part of a day, reducing output to zero. Therefore, tool failure is costly in both dollars and lost time.

Uncoated injection mold components can fail after only a short run. Ordinary injection mold coating can help, but sometimes don't make the grade. Fibrous additives add significant strength to finished products, but are abrasive and very hard on molds, thus shortening productive life. In addition, any deterioration in surface finish can have a devastating effect on release characteristics, causing slowdowns.

The moldmaker's challenge is to maintain the quality of precise, well-finished, and uniform parts throughout a production run. Progressive mold surface enhancements and coatings significantly increases corrosion and wear resistance to ensure maximum life, and reduces friction to keep high-output injection molds running smoothly at peak production rates.

Key words
progressive surface enhancements, tool coatings, mold tools

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