A CASE FOR DIE COATINGS

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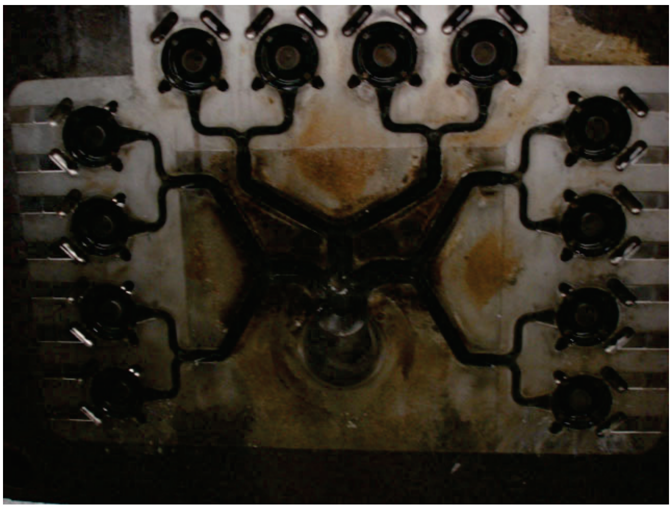
The use of die surface coatings and surface modification has been around for quite some time but the problem in the past is that they do not hold up to the aluminum die cast process so it has been money spent with very short term benefits.

So a couple of questions that comes to mind are why a die caster tries it now.

Another question that seems to come up is, “Why I (The Die Caster) should put extra costs into the Die Cast Tooling that the customer owns.” In most cases this can be a hard justification on the part of the Die Caster but let’s try and look at it from a different perspective. The die casters stake in the tooling may vary from the automotive die caster who usually is responsible for the maintenance and replacement of the die cast components by amortizing a certain amount per part to the die caster who must quote as the occurrences come up and than wait for a Purchase Order to do the work. In either case the customer is usually unwilling to pay for what they feel are extra costs that they see little or no benefit for.

So let’s make a case for the die caster with some real life examples of how it is working and where we can go with it next. Like everything else in this business nothing stands still for very long. What did not work yesterday may be worth looking at again today. Competition from overseas markets and just, in general along with current economics within the global Market are demanding that anything a domestic die caster can do to extend tool life, reduce tooling maintenance and improve productivity at the cast machine are needed in order to stay competitive with lower labor markets.

Multiple cavity tools, with 2 to 24 cavities are one way to reduce part costs to compete but this also multiples the number of problems that can develop at the cast machine.



12 Cavity Die Cast Die
(over 10 million parts produced out of this tool)

While lending help to the part price issue that has been created with lower labor foreign markets, it also creates tremendous pressure on the die cast process as to spray techniques, cooling and the ability to release parts with minimal distortion while running the fastest possible cycle time.

The opportunity that has come about with improved tool steels and better heat treatment methods has helped in general to improve the overall life (number of shots) of the die cast inserts. Soldering, heat check and die wash (erosion) can still lead to significant maintenance and core replacement issues.

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Today new opportunities exist to help these issues, especially on cores, in that some of the new die coatings actually appear to be working. As mentioned earlier Die coatings tried in the past frequently lasted only several hundred shots to maybe a few thousand before they wore off. Due to the added cost of several hundred dollars to a couple of thousand a lot of die casters gave up on die coatings. Many agreed that while it was in place it did make a difference but “it just did not last long enough”. If asked about the use of die coatings many a die caster would answer that all tool steel was oxided before seeing actual production or that no coatings were being used and than talk about the newer tool steels and heat treats.

What follows are a couple of case histories from actual production tools with both a history of uncoated and coated and the number of shots that are being realized before maintenance or replacement. At this point it needs to be stressed that there were no changes in the process, spray or cooling added to the cores or any changes to the tool steel that was used. It should also be noted that five different coatings were tried with mixed success to very good improvement in the life and maintenance of the cores. Results were compared with both uncoated and coated cores as well as the different coatings tried.

The production tools that were picked produced are high volume thick walled parts with heavily machined surfaces and the tools had a long history of uncoated tooling. In the past tooling had a very limited life before it would require modification due to soldering or ejection issues due to the buildup that affected both the die cast cycle time as well as increasing the amount of machine stock. This in turn affected machining cycle time and increase fallout with exposed porosity after machining.

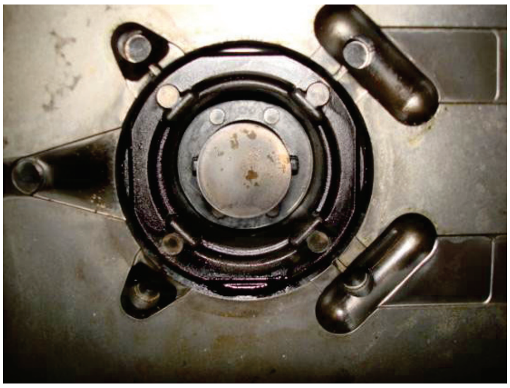
While there are several different producers of die coatings but the basic application process are limited to a couple primarily CVD or PVD.

What is CVD?

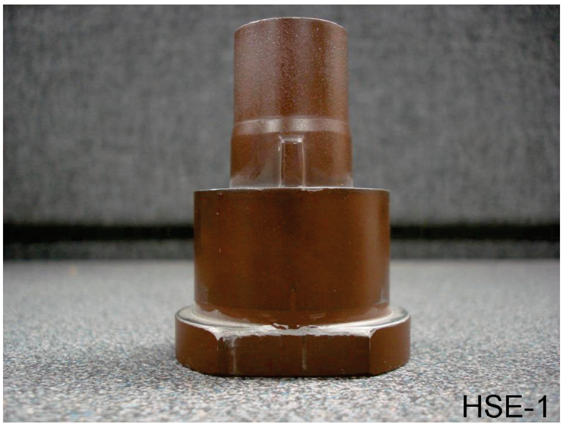
Chemical vapor deposition (CVD) is a chemical process used to produce high purity, high performance solid materials. In a typical CVD process the substrate is exposed to one or more volatile precursors, which react with and/or decompose on the substrate surface to produce the desired deposit. Some of these materials include tungsten, silicon carbide, silicon nitride and titanium nitride to name a few. The CVD process is a versatile one for depositing coatings on various substrates. It can be described as a process in which a mixture of gases interacts with the substrate surface at a relatively high temperature, resulting in the decomposition of some of the constituents of the gas mixture and the formation of a solid film coating on the substrate. Typical coating temperatures are on the order of 1000 Centigrade (1800 degrees F). The gaseous nature of the CVD process results in all surfaces of the tool being coated. The high temperature necessitates re-hardening and tempering of the tool steel materials in order to restore the desired mechanical properties. The high temperature and re-heat treatment also raises concerns over material distortion, so careful consideration of dimensional tolerances must be given before choosing a CVD coating.

What is PVD?

Physical vapor deposition (PVD) is a variety of vacuum deposition and is a general term used to describe any of a variety of methods to deposit thin films by the condensation of a vaporized form of material onto various surfaces. The PVD process is defined as the creation of vapors in a vacuum from solid material sources and their subsequent condensation onto a substrate. Unlike the CVD process, the PVD process is a line of sight process conducted at lower temperatures (180-500 degrees C or 400 to 932 degrees F) and a physical bond is created the coating and substrate rather than a chemical bond. Line-of-sight means that only those areas exposed to the plasma will be coated. The low temperature of the PVD process allows for nearly a tool materials can be coated without concern for softening or distortion.



Cavity showing core



Actual core

The study we will look at was performed on a 12 cavity die (shown above) (Insert #2 cavity showing core) and center ejector core inserts. The inserts are about 1 1/2 inch in diameter (Insert #3 Actual Core) and see very high metal temperatures in that the cast area around them is very thick. In consideration of the fact that the diameters to be machined are very close tolerances there is not a lot that cam be done to reduce machine stock. In the series of pictures below shows several cores from different coating processes and also an uncoated core along with the number of shots that the cores had seen.

In this study uncoated cores began to break-down at approximately 10,000 cycles and required modification to the size at approximately 50,000 cycles.

Uncoated core after 10,000 shots

Uncoated core after 50,000 shots

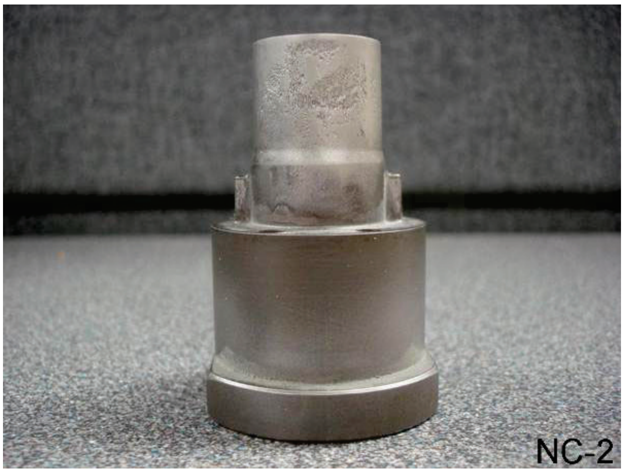
PVD Coated cores provided some improvement early on to help reduce soldering but started to show some deterioration at 20,000 cycles and still required modification at 50,000 cycles.

Side by side
HSE CVD @ 50,000 &
3HC-1 PVD @50,000

Side by side
HSE CVD @ 50,000 &
3HC-1 PVD @50,000

Side by side
HSE CVD @ 50,000 &
3HC Different PVD @ 50,000

NC-1 PVD @ 20,000 shots

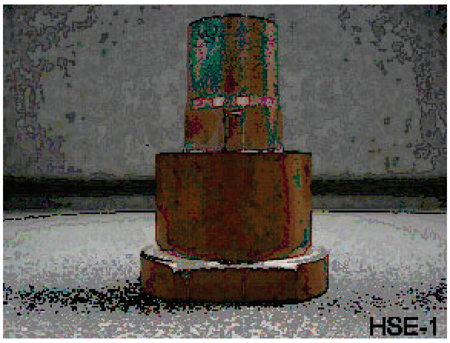


NC-2 PVD 2 50,000 shots

TD+ High Temperature Coating @ 50,000 shots

TD+ High Temperature Coating @ 20,000 shots

CVD coated cores did much better and showed little or no breakdown at 50,000 cycles. The cores showed no heat checking or wear and maintained surface properties that still resisted soldering and good release. At 80,000 cycles the CVD coated cores were just starting to show signs of breaking down.



HSE-1 CVD has seen 50,000 shots

HSE-2 CVD Has seen 80,000 shots

The improved surface quality of the cores reduced maintenance required and downtime associated with it. Overall, all coated cores showed an improvement but the CVD cores showed outstanding improvement in shot life.

Another way to improve wear and also improve shot life is to nitride cores.

What is Nitriding?

Nitriding is a surface-hardening heat treatment that introduces nitrogen into the surface of steel at a temperature range (500 to 550 degrees C or 930 to 1020 degrees F) while in a ferrite condition. Thus, Nitriding is similar to carburizing in that the surface composition is altered, but different in that nitrogen is added into ferrite instead of austenite.

Because Nitriding does not involve heating into the austenite phase and a subsequent quench to form martensite, Nitriding can be accomplished with a minimum of distortion and with excellent dimensional control.

Reasons for Nitriding:

To obtain high surface hardness

To increase wear resistance

To improve fatigue life

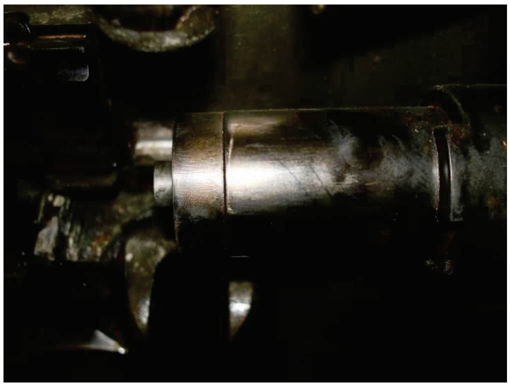
To improve corrosion resistance

To obtain a surface that is more resistance to surface softening at high temperatures.

Medium-Sized Non-Nitrided core after 35,000 shots

Medium-Sized Non-Nitrided Core after 55000 shots

Large Nitrided Core after 30,000 shots



Large Nitdided core after 50,000 shots

Large Nitrided core after 80,000 shots

In the pictures below the core that was not nitrided needed some maintenance after 35,000 shots and replacement after 55,000, while a Nitrided core in a similar application need only some maintenance at 80,000 shots.

In conclusion we have determined that some of the coatings or surface modifiers that are available are proving to be very useful in extending the life and decreasing the maintenance on cores. Especially the CVD coatings have shown to double or more the life. The next step to follow on this is inserts in the gate areas and what can be done to improve the life in direct metal flow by the use of die coatings.

Acknowledgements: To the people of IonBond, Phygen and Philos for information and comments that helped with this study.