

## **Preparation of molds for rubber molding to ensure smooth start-up in production**

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This paper aims to take a brief look at the reasons why molds need to be cleaned and illustrates some of the processes through which molds become so unclean that they need to be given attention in order to produce good moldings once again. It further explores the area of mold cleaning followed by a study of some surface treatments that can be applied to metal surfaces to ensure that molds can be re-introduced into production in good condition, recommencing the production of good quality molded parts. A comparison between the molding of two different rubber stocks in this study revealed that halogenated compounds need some extra-special measures regarding post-cleaning mold protection.

### **Mold Fouling**

This phenomenon is the reason most molds need to be taken from production, eventually, and cleaned back to the bare substrate. No matter which mold release system is used, a mold will eventually become so dirty that molded part quality will be affected. Some mold release agents actually contribute to mold fouling, accelerating the need to remove the mold for cleaning. Mold fouling can imprint a very poor appearance on molded components due to mold surface build-up. It can also be the prime cause of rubber compound sticking, or even dimensionally interfere with the molded component release process

Mold fouling has several sources. There is what can be regarded as the conventional type, documented by van Barle<sup>1</sup>, whereby the presence of zinc oxide in many rubber compounds, reacts with sulfur to form zinc sulfide crystals, which in turn encourages organic fouling deposition on the mold surface. The van Barle<sup>1</sup> paper also documents other factors such as mold temperature and rubber compound injection pressure that have a profound effect on the rate of mold fouling. So, any compound that is being molded with a sulfur cure system is likely to lead to this type of mold fouling with the eventual need to remove the mold from production for cleaning purposes

Two major sectors in the rubber industry where mold fouling is encountered on a large scale, and for very different reasons, are in rubber-to-metal bonding and the production of high quality gaskets and shaft seals that operate in hot, fluidic environments.

To illustrate the situation in rubber-to-metal bonding, here is a photo, (below left), of a mold that has been in contact with an adhesive-treated curved metal, followed by hot bonding to the compound. In this case, it is a typical natural rubber formulation used in the production of motor mounts for vibration isolation or noise, vibration, harshness (NVH) reduction in a motor vehicle suspension system. The actual molded part is on the right.



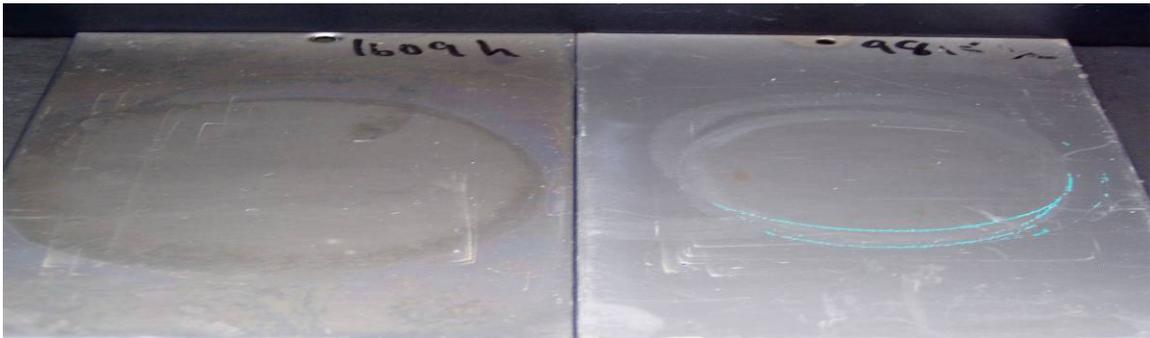
This amount of fouling was produced within 30 heats of the mold being cleaned. In order to cause this accelerated fouling, for test illustration purposes, a mold release having very poor barrier properties was selected and the adhesive-treated metal was loaded into the mold about ten minutes prior to commencement of the molding cycle. Although there is likely to be a contribution to the mold fouling from the rubber compound, the bulk of this mold contamination probably originated in the adhesive. In a regular production environment, one would attempt to encapsulate the coated metal in the rubber compound as soon after loading into the mold as possible, to minimize the effects of bonding agent sublimation and re-deposition on the mold surface.

This kind of mold fouling can be greatly reduced by employing a good quality semi-permanent release system. Compare the photo below with the previous one.



The degree of fouling is much less extreme, mainly because the release system employed has enough barrier property to prevent large-scale re-deposition of the bonding agent on the mold surface.

As an illustration of the type of fouling seen in the production of gaskets and shaft seals, here is a photo, of two test panels that have been used in the molding of a very high quality peroxide-cured FKM compound, designed to work in a hot, gasoline vapor environment. This is a sulfur-free compound. The mold fouling takes on a very different appearance here.



The photo on the right shows a light blue ring that is actually uncured compound, brought about through the presence of oxygen at the air/compound interface as the compound, under molding pressure, moves across the test panel surface during the molding operation. Oxygen restricts the cure process at this interface and de-molding leaves behind an uncured ring every molding cycle, leading to rapid in mold build-up and subsequent reject parts. Although this uncured ring is very sticky, the molded disc within its perimeter could be removed quite easily from the test panel. This serves to illustrate that the adhesive forces of the uncured ring on the treated panel surface are greater than the cohesive forces within the uncured rubber compound itself. The photo on the left is of a panel coated in a superior mold release that prevents the uncured ring sticking to it, illustrating that the release ease is lower than the cohesive forces within the rubber compound, a truly great situation to prevent uncured rubber build-up on the mold surface.

### **Mold Cleaning**

Clearly, it can quite easily be seen that molds will get dirty through a variety mold fouling mechanisms. Cleaning, although the interval between the need to do it can be greatly elongated through the choice of an excellent semi-permanent system, is an inevitable event in order to bring molds back to their best condition.

Molding companies adopt various practices depending upon whatever suits their own particular system.

Molds are often taken out of production, remain contaminated to various levels and then, just prior to being needed in production once more, are cleaned and prepared for the press, either with or without some subsequent pre-treatment medium. On the other hand, some companies adopt a more rigid discipline of cleaning molds directly after removal from the press, followed by application of some sort of protectant, in the hope that the mold surface remains clean until the day it is needed once again to produce parts.

Mold cleaning methods include in-press methods at such extremes as simple wire brushing by hand or dry ice blasting, using sophisticated machinery. On the other hand, out of press methods include strong alkali soaking followed by wet blasting, dry bead blasting or immersion in a detergent medium, assisted by ultrasound.

In-press cleaning methods allow application of the regular mold treatment directly after the cleaning process. Should an out of press method be used, the opportunity can be taken to fully clean complicated mold cavities, clean and lubricate mating faces, clear out drillings and dowels and then apply some surface treatment.

When a mold surface is thoroughly cleaned, the metal surface is at its most vulnerable to attack from its immediate environment. Freshly cleaned metal, unless the environment is at zero humidity, will develop an oxide layer within just a few minutes. This oxide layer, which is a conglomerate of reactive sites, combines with atmospheric moisture to form hydroxyl groups on the metal surface. Protection from continued exposure to a moist environment is required in order to prevent the onset of heavy corrosion.

It would be quite easy to guess that a heavily oxidized mold surface would not produce good quality molded parts.

## **Surface Protection**

The choice of surface treatment, in order to isolate the oxide layer referred to above, can have a major influence on the mold performance when it is re-introduced into the production cycle. Mold treatments include: -

- Mineral and synthetic oils
- Corrosion inhibitors
- Semi-permanent mold release agents
- Anti-moisture barriers

Usually, the mold will be cool or even cold when it has been removed from the cleaning apparatus. This generally makes the application of water-borne treatments quite difficult, due to the slow evaporation rate of the carrier. At very best, a water-borne treatment will require the inclusion of a corrosion inhibitor and need to be dried with the assistance of compressed air. This can be a very messy, even quite a dangerous process.

In this particular study, the use of a solvent-based semi-permanent mold release and an anti-moisture barrier have been compared for their effectiveness in resisting the development of the heavy type of corrosion that can lead to rapid mold re-fouling.

A semi-permanent mold release coating of the polysiloxane type was one choice, since it potentially can provide the mold with an ideal start-up treatment, (otherwise known as a base-coat), for the mold release agent of choice that would be used during regular molded part production. Application and choice of product is key in the potential success of this option.

An anti-moisture barrier coating was the other choice since it offers the potential to provide superb metal corrosion protection whilst being very easy and simple to apply.

## **Methodology**

- Run some test moldings using pairs of cleaned cold-rolled mild steel press panels,
- Blast clean the panels,
- Apply some of the designated protectant
- Expose the panel surfaces to high humidity
- Monitor the surface appearance change with time

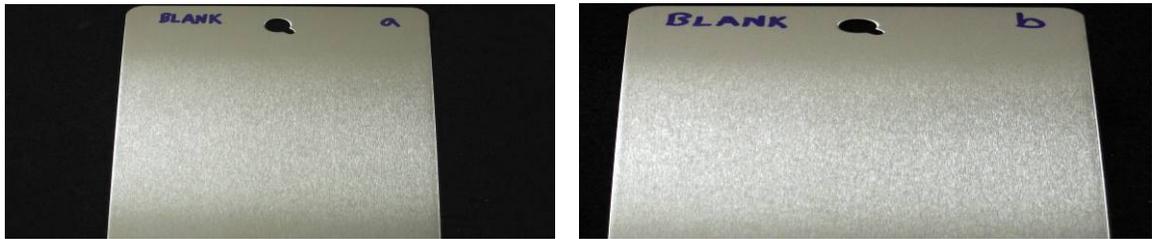
Two different molding compounds were chosen, one of which was a natural rubber compound, typical of that used in an NVH application. The other was a bromobutyl, chosen because halogenated compounds can bring about rapid oxidation of mold surfaces due to the formation of a strong acid during the curing cycle. Observations have also been made that show molds to be pitted after lengthy periods of time in molding halogenated compounds.

Natural rubber compound cured for 245 seconds at 350F  
Bromobutyl rubber compound cured for 420 seconds at 375F

Mild steel test panels were chosen as mold faces since they are very easy to handle and oxidize readily, which means they provide a quick indication of the degree of protection offered, in experimental situations. In all molding situations, the test panel was solvent-washed and a three-layer base coat of a good quality polysiloxane water-based release agent was applied at the compound vulcanization temperature, allowed to cure for the recommended amount of time and ten de-moldings run off. All panels were then bead-blasted for a similar amount of time to provide a consistent surface finish on which to apply the test protectant. Blank panels were blasted in a similar way in order to provide background “control” data.

### Reporting of Results

Here are two photos, one taken of a blank panel and one of a blank panel treated with mold release agent, prior to the molding of a test compound.



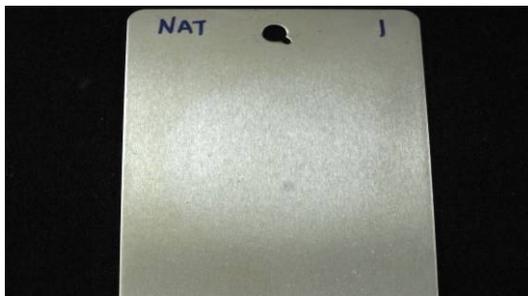
There is no discernable difference in appearance

The bead-blasted panels were then given one coat of the designated protectant, followed by exposure for several days in a humidity cabinet controlled at 80% RH at 30 Celsius. Photographs of the panel surfaces were taken at regular intervals for visual comparison purposes.

### Natural Rubber Molding

Here are photos of the panels used for natural rubber molding, coated with the anti-moisture barrier

Immediately after coating



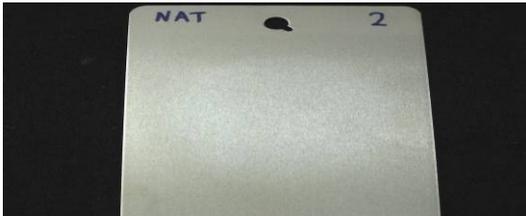
After 5 days exposure at high humidity



Although one can quite clearly see the disc where the molded rubber has been in contact with the panel, there is no visible difference in the surface appearance of the two panels. The anti-moisture barrier has, indeed, been very effective in preventing the two things that cause corrosion, oxygen and moisture, from attacking the metal surface.

Here is a photo of the panels used in natural rubber molding, coated with a state-of-the-art semi-permanent mold release product

Immediately after coating



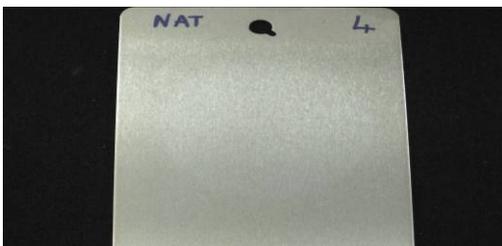
After 5 days exposure at high humidity



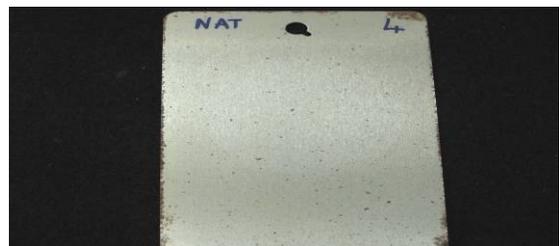
It is quite clear that the panel surface has changed. Exposure to humidity has penetrated the micro-thin film of the semi-permanent mold release system and brought about some corrosion of the panel, albeit quite minimal. It is reasonable to conclude that the metal surface has not been fully isolated from the factors that cause oxidation i.e. air and moisture.

Now, look at a pair of panels that molded the same natural stock and were not given any surface treatment

Immediately after blasting



After 5 days exposure at high humidity



The exposed panel has suffered noticeable corrosion over its whole surface. It is reasonable to assume that the effect of having molded some natural rubber on this panel (the circle where the molding took place is still evident) has not resulted in any additional corrosion in the contact area.

### **Bromobutyl Rubber Molding**

This part of the study is quite difficult to report since all panels that had molded any rubber were badly attacked in the disc contact area.

The mold release functioned well in terms of releasing the disc, but was not effective in preventing the heavy staining, which is probably the result of the formation of hydrobromic acid and subsequent attack on the mild steel panel surface.

However, the point of the exercise was to study how effective the post-cleaning treatments could be, especially as it is commonly thought that residual halides could possibly remain on a mold surface, even after bead blasting.

Here are the photos of panels used in molding the bromobutyl compound, coated with the anti-moisture barrier.

Immediately after coating



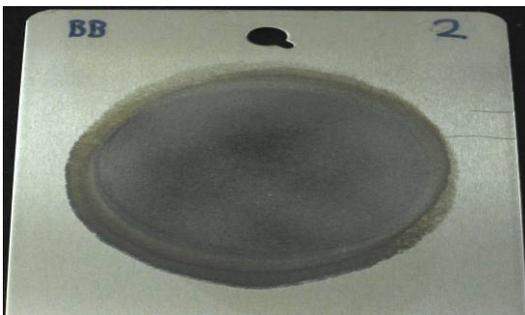
After 5 days exposure at high humidity



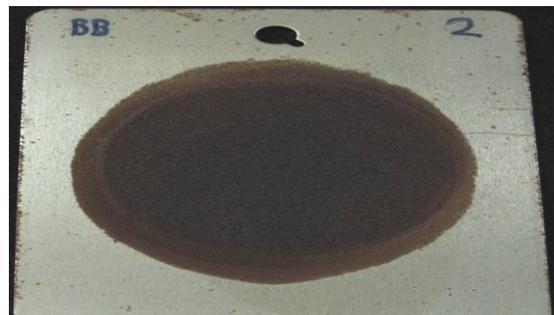
After exposure, there is only minor corrosion in the land areas of the panel, but most noticeably, the area where the disc has been molded has turned a rusty red color. This is a clear indication that even an anti-moisture barrier cannot totally isolate the metal from atmospheric oxygen and moisture

Now, look at the panels that have been coated in the solvent-based semi-permanent release agent

Immediately after coating



After 5 days exposure at high humidity



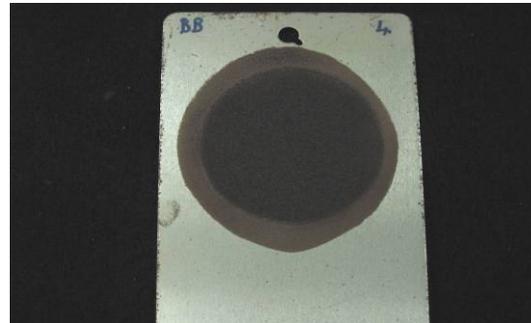
After exposure, corrosion of the panel areas is evident. Whilst not heavy, it is quite advanced. The area where the rubber disc has been molded is a very rusty red, indicating that the metal has not been fully protected from oxygen and moisture.

To complete the sequence, here are photos of the two panels given no surface protection after molding with bromobutyl compound.

Immediately after blasting



After 5 days exposure at high humidity



After exposure, the land areas of the panel were quite heavily corroded. The disc that had been in contact with molded rubber was red rusty, once again indicting the profound effect of the halogenated compound at the mold surface.

## Conclusions

Blast-cleaned mild steel metal panels that have produced moldings in a natural rubber stock can be adequately protected from atmospheric moisture by means of an anti-moisture barrier coating. A state-of the art solvent-based semi-permanent will provide some protection from moisture and oxygen.

It is reasonable to assume that since the study was made with mild steel substrates, under accelerated exposure conditions, that actual tool steel under ambient conditions would be more resistant to corrosion using either of these metal treatments and that the anti-moisture barrier coating would offer better longer-term protection.

Blast-cleaned mild steel panels that have produced moldings in a bromobutyl rubber stock do not show good resistance to corrosion with either of the surface treatments in the contact areas with the compound. It is reasonable to assume that although tool steel would fare much better, attack on mold cavities would be a possibility. Land areas of molds, outside of mold cavities would be expected to suffer minimal corrosion.

## Further Work

There is adequate evidence that some measure of protection can be afforded by means of a semi-permanent release agent, applied to a mold surface, directly after blast cleaning. The author is aware of many molding situations where this process is in use and regarded as an ideal mold start up measure, since a semi-permanent release system can then be used from thereon.

A useful piece of work would be to study the effect on molding both with and without the underlying protective coating

***Reference***

1. Ben van Barle, "Mold fouling during rubber vulcanization" Rubber World, December 2001.