Biofilms: How They Impact the Die Casting Process

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Introduction

Within the die casting process, where molten metal is injected into a steel die, a release/lubricant agent is applied to the die to allow for proper release. These release agents are often referred to as die lubricants.

Die Lubricants provide three major functions that are vital to the die casting process.

- Release of the Casting
- Lubrication of the moving parts of the Die
- Surface cooling of the Die

Most of these products are water dilutable. Typically, they are diluted between the range of 50:1 to 100:1 in a central mixing system. The die lubricant is delivered through a network of piping connected to the die cast machines and ultimately to the die surface through spray nozzles. Below is a simple diagram of this type of set up.

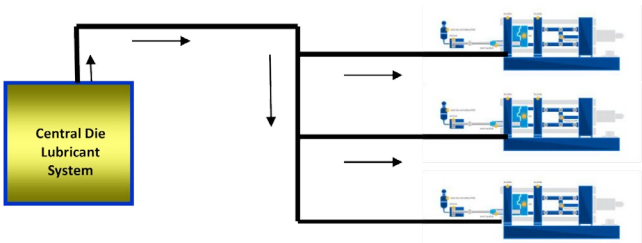

***Figure 1** – Die lube delivered through a network of piping.*

An important key to assuring that the die is evenly coated with the die lubricant is to make sure that all spray nozzles are working and there is nothing that would obstruct the flow to and from these nozzles.

To insure this, a series of filters are placed at various locations in the die lubricant supply system.

***Figure 2** – An example of a steel reinforced wire mesh filter used in Die Lubrication supply systems. Often steel reinforced filters are used to keep the filters from collapsing.*

The purpose of these filters is to keep the fluid clean so that foreign materials will not plug up the spray nozzles. However, these filters often become contaminated with a slime (biofilms) resulting in a reduction of die lubricant flow to the spray nozzles and sometimes completely shut off. Following are pictures taken of steel mesh filter exhibiting this scenario.

Biofilms not only impact the filters but the supply lines and the holding tanks for the diluted die lubricant as well as seen in the following photos.

As one can see by the examples shown, Biofilms are a real problem in maintaining a clean die lubricant system. In addressing this problem, the following questions need to be answered:

- What are Biofilms?
- How do Biofilms Form and Reproduce?
- What can be done to remove Biofilms?
- What can be done to prevent Biofilms?

***Figure 3** – Wire mesh filter pulled out of system for replacement.*

A magnification of the filter shows the fine mesh.

Further magnification shows the biofilm covering the wire mesh reducing spray flow.

Figure 4 *- A biofilm located on top of the die lubricant diluted tank (left); Biofilm build up in a pipe line supply die lubricant to the Die Cast Machines. Notice the that the pipe diameter is almost reduced by 50% (right).*

What are Biofilms?

Biofilms are collections of microorganisms and the extracellular polymers they secrete, attached to either inert or living substrata.

All water dilutable die lubricants share the common problem of susceptibility to microbial degradation. This is not all bad news, since we need the die lubricant to be biodegradable for disposal purposes. However, the challenge for both the formulators and die casters using water based products, is to minimize the adverse effect of uncontrolled microbial growth.

The chemical composition of Die Lubricants is a combination of ethoxylated polymers, amines, a blend of other surfactants, high temperature polymers, oxidized waxes, etc..... It is these components that provide a nutrient rich environment to support microbiological growth.

In the concentrate (before the die lubricant is diluted for end use), the product is formulated with biocides and a high pH (9.0-9.6) to prevent microbial attack. However, once the product is diluted 50 – 100:1, the biocide package is too diluted to be effective and the pH is lowered to 7.8-8.8 and the microbes begin to metabolize (feed) on the chemical components.

This microbiological growth, if left without treatment, will increase dramatically and form biofilms.

Biofilms

There are two types of microorganisms that feed on die lubricants, bacteria, and fungi.

A. Bacteria

Bacteria are single cell organisms that are either aerobic (grow in oxygen rich environments) or anaerobic (grow in oxygen depleted environments). It is the anaerobic that often create the foul odors. With die release agents, you will get a rotten or pungent odor after the system has been shut down for a couple of days.

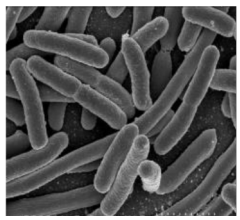

Figure 5 *- An example of simple bacteria found in die lubricant systems.*

B. Fungi

Fungi are classified as either yeasts or molds. Yeasts, like bacteria are unicellular and are spherical in shape. Molds are composed of more than one cell and form complex mazes of filaments giving it a mat like appearance.

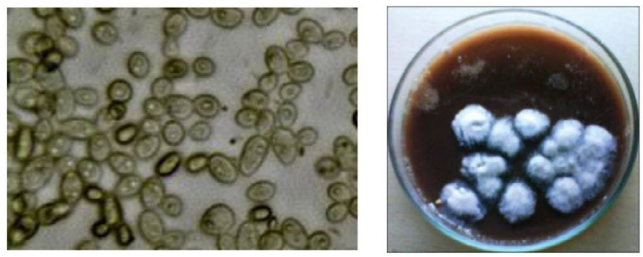

Figure 6 *- Example of yeast (left), and an example of mold (right).*

How Do Biofilms Form and Reproduce?

Although, these microorganisms can exist in bulk free-flowing fluid of die lubricant, a large part of the population exists in biofilms. Biofilms create a layer of protection from the bulk fluid environment, which may contain chemicals that are adverse.

Biofilm formation begins with **planktonic**, or free-swimming, bacteria, which land on a surface. Bacteria can attach to a variety of surfaces. The cells can attach to the surface by excreting a sugary molecule that holds the cells together and attaches them to the surface. This sugary substance is called extracellular **polymeric substance**, or EPS, and has a strand-like structure that allows it to bind to the surface and to other cells, creating a matrix.

This matrix of cells and strands can be quite complex: the cells may even share genetic material and have organized structure. A biofilm can be as thin as a single cell or as thick as several inches, depending on conditions in the environment. As a biofilm grows and develops, it thickens and becomes mature. If there are sufficient water and nutrients, the biofilm will develop until small portions detach and float to another surface and colonize. (See diagram).

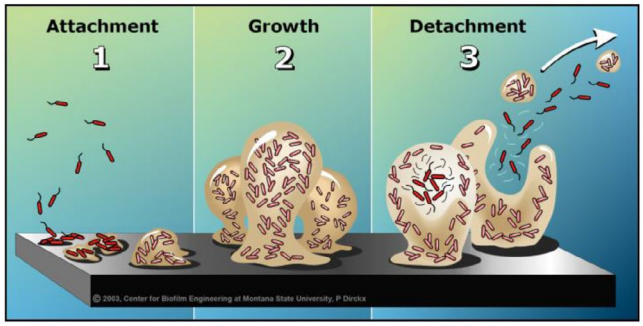

***Figure 7** – This diagram illustrates the three Step process that the biofilms under go.*

Initial phases of the formation of a biofilm. Single cell bacteria attaching themselves to the surface.

An example of part of the biofilm breaking off and start the colonization process elsewhere.

Because the microorganisms are growing within a biofilm are protected from the conditions that maybe affecting the bulk fluid, the ability of chemical microbiological agents to effectively control their growth is limited.

What Can Be Done to Remove Biofilms?

Biofilms are difficult to remove, especially the mature colonies. Typically, removal involves a two-step process.

A. Chemical Treatment

A residual level of biocide is essential to help control biofilms, but biocide alone cannot penetrate or dissolve a biofilm mass. Incorporating the use of specially formulated cleaners/disinfectants assist in dissolving the EPS allowing the biocide to effective kill the microbes. It also removes by-products, such as Nitrogen (Ammonia) that promote the growth of the bacteria in the biofilm.

Normally, the system being cleaned is filled with the cleaner/disinfectant and allowed to sit for a period of 8 to 24 hours before being flushed with water (preferably hot). This allows for plenty of contact time for the surfactants of the cleaner to break down the EPS and allow the disinfectant to do its work.

B. Physical Removal

Physical methods can be effective, especially in addressing "mature," well-developed biofilms. Flushing hot water through pipes at high velocities, for example, can help remove biofilms from smooth pipe interiors, such as PVC.

Biofilms may be more difficult to address in pipes with rough interior surfaces. In those cases more aggressive physical methods are used to scour pipe interiors. Pushing a flexible swab with an abrasive outer coating through a pipe by means of hydraulic pressure is one of the most common methods employed to physically remove scale and biofilm.

If the buildup is too much, then the pipe should be replaced with PVC if possible.

What Can Be Done to Prevent Biofilms?

Biofilms are heterogeneous, inherently patchy, and colonized with diverse microbial communities—qualities that make biofilm control challenging for any die lubricant supply system. The keys are a monitoring system, a treatment system, and a preventative maintenance program.

A. Monitor the Microbes within the System

With the understanding that the microbes (bacteria and fungi) are present where water and food sources are present, it is unrealistic to think that the microbes can be eradicated. However, monitoring the number of microbes within the bulk fluid allows for a die caster / fluid manager to determine when to hit the system with a kill dosage of biocide / fungicide.

The simplest way of monitoring them is by bio dip slides.

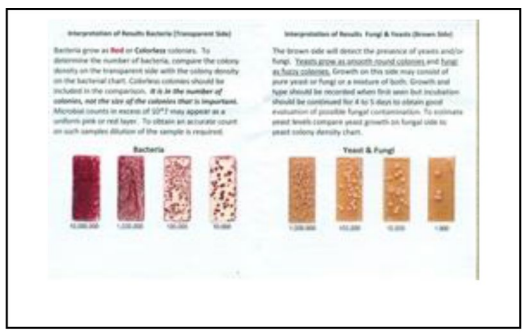

***Figure 8** – Monitoring microbes with bio dip slides.*

Each side of the dip slide is coated with a different medium, one side being selective for fungi and the other for bacteria. Almost all aerobic bacteria will grow on the side designated for those organisms. Their growth will be in the form of red dots, also known as colonies, on the surface of the agar. The dip slide is compared to a chart to get a quantitative interpretation of the results.

Most fungi (yeast and mold) that contaminate aqueous industrial systems will grow on the dip slide. On the side designated for fungi, growth of yeast and mold will generally appear as cottony, filamentous structures. The reacted dip slide is compared to a color chart from which an estimated fungal count can be made.

These slides allow for the both the die caster / fluid manager to determine the concentration of microbes present in the bulk fluid. If the bacteria are greater than 104 in the bulk fluid then the system should be treated with a dose of biocide. If fungus shows up in greater amounts in two colonies, then a fungicide should be added. These are typically added to the diluted die lubricant reservoir.

B. Reduce the free number of bacteria by using small dosages of biocide/fungicide

There are products that keep the number of both bacteria and fungi minimal by introducing low maintenance dosages into the system throughout the week. The focus is keeping the number of microbes minimal before they begin to create biofilms.

This type of technology has been implemented in the treatment of cooling tower systems.

***Figure 9** – Biocide Feed pump set up on a timer to control the amount and when to add.*

C. Perform preventative maintenance every six months

Every six months, the system should be shut down and cleaned using the specially formulated cleaner / disinfectant. This will keep the bacteria and biofilms to a minimum before they create problems for production.

Summary

Die lubricant spray is vital to the successful production of castings within the die casting industry. Biofilms, without the proper treatment program can create a real problem in this area. Die casters must have a monitoring system and a scheduled preventative program in place to assure a clean and consistent source of die lubricant supply to the die.

About the Author

Tim Cowell is the Technical Director for The Hill and Griffith Company. He has over 29 years of experience in the Metalworking Industry. He is responsible for new product development, working with die casting and machining manufacturers on special projects and providing technical support to the technical and sales teams.

Tim has a BS degree in Chemistry from Cedarville University. He has authored several articles on paint adhesion problems, die casting continuous improvement initiatives and scrap reduction projects. Tim also assists as an instructor for several North American Die Casting Association courses.