Pyrotek

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Improving Quality of Molten Aluminium
With Pyrotek's SIVEX LP Low-Phos CFF

Ceramic foam filters (CFF) have been widely used for filtering impurities out of molten aluminium in cast houses since the 1990s. The first CFFs were developed in 1970s and today are used in more than 50 percent of the aluminium cast globally.

Filtration is a necessary step to optimize metal quality and downstream finished products. Inclusions can originate from a variety of sources during the production process, including surface oxide films, eroded furnace refractories and insoluble impurities like carbides.

If not filtered, impurities can become trapped in solidified metal. Filtering with CFF is a supplement to metal treatment within the furnace, such as fluxing and degassing or inline filtration.

"The presence of inclusions in aluminum alloys adversely affects the quality and properties of aluminum products in many different ways. This is detrimental to the fatigue strength of aluminium alloys used specifically in the automotive and aeronautic industry" (Duval et. al., 2009).

A wide variety of non-metallic inclusions can exist in aluminium as a result of its melting, alloying and processing steps. Inclusions can be a major source of defects in the final product. They can include:

- Poor machinability
- Reduced brightness in anodized products
- Pinholes in light-gauge foil
- Reduced mechanical strength, ductility and fatigue resistance
- Flange cracks in beverage cans
- Poor surface finish
- Surface streaks in bright automotive trim
- Reduced extrusion die life

Demand

With the demand for high quality aluminium products increasing, filtration has proved an optimum method for improving metal quality.

Pyrotek's low-phosphorous ceramic foam filter, SIVEX LP.

"In the can industry, the constraints imposed with respect to the inclusion content are drastic: the inclusion concentration must be less than 10 4 parts per million (weight), to meet can producer requirements; this typically corresponds to much less than 20 defects per million cans produced (Duval et. al., 2009).

Ceramic Foam Filter Overview

Technical advances in CFF, such as fine pore filters and improved filtration systems better suited to the stringent operating conditions of the casthouse have offered an efficient method of removing inclusions from liquid aluminium in a wide range of critical applications.

Ceramic foam filters offer a simple, reliable and cost-effective method to remove inclusions. Filtering with CFF is a supplement to metal treatment within the furnace, such as fluxing and degassing or inline filtration.

They "have an open pore reticulated structure with very high porosity and very high surface area to trap inclusions. The open foam structures are composed of ceramic material, such as alumina, mullite or silica. Alumina is the most common filter material. Ceramic foam filters operate in a deep bed filtration mode where inclusions smaller than the pore openings are retained throughout the cross-section of the filter" (Bao, et. al., 2013).

CFFs typically are a polyurethane foam coated with a ceramic slurry then dried and fired. During firing, the polyurethane foam dissipates leaving behind a porous ceramic structure. The ceramic can be a phosphate-bonded alumina.

Pore sizes and thicknesses can vary.

Pyrotek Ceramic Foam Filters

Pyrotek has been supplying CFF to aluminium cast houses for almost 20 years. Since 1999, Pyrotek has been producing and supplying filters under the SIVEX® brand. The primary components of ceramic foam filters for this first generation are aluminium oxide, (Al_2O_3) ≈ 88%, and phosphorus pentoxide as a binder (P_2O_5) ≈ 10%.

Low-phosphate CFF

Pyrotek's low-phos SIVEX LP, is the next generation CFF. The main change from the standard SIVEX is a lower amount of phosphate binder (P_2O_5).

It is available in sizes from 17.8–66 centimetres (7–26 inches) and in filter grades of 10–80.

SIVEX LP has a gasket on the edges to help seat the filter in the filter bowl and ensure no metal bypasses the filter. Two types of gaskets are available: a standard fibre gasket that is 48 millimetres (1.89 inches) wide and 6 millimetres (0.24 inches) thick and an expandable gasket that is 38 millimetres (1.50 inches) wide and 3.5 millimetres (0.14 inches) thick.

There are a number of differences between standard SIVEX filters and the low-phos version.

- Flexural strength is higher than that of standard SIVEX filters.
- Compressive strength for SIVEX LP filters is higher than that of standard SIVEX filters.
- Snowing is much lower.
- Thermal expansion of LP is lower than in standard SIVEX filters.
- Thermal shock for LP is significantly higher compared to the original SIVEX filter. It displays increased crack resistance, which is most important during the filter preheating process.
- SIVEX LP has a lower ΔT than standard SIVEX. ΔT is the difference between temperature above and under the filter.

Property Comparison *SIVEX LP vs Standard SIVEX Filters*	
Flexural Strength	34%
Compressive Strength	35%
Snow	-70%
Thermal Expansion	-10%
Thermal Shock Resistance	345%

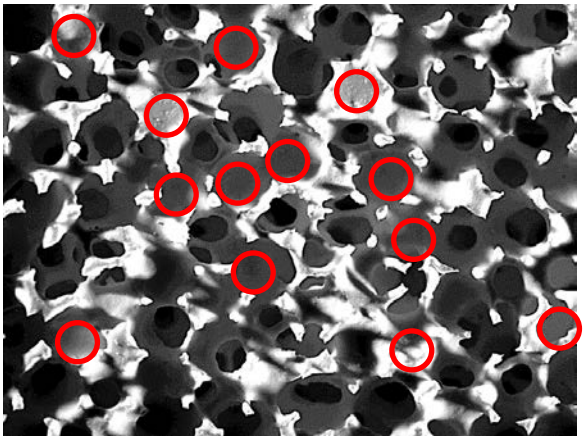
Internal Structure

The internal structure of SIVEX LP, compared to standard SIVEX filters, is much more open. This means that SIVEX LP filters have fewer closed pores than standard SIVEX filters and that the effective area of filtration (effective area of contact with molten aluminium) will be increased.

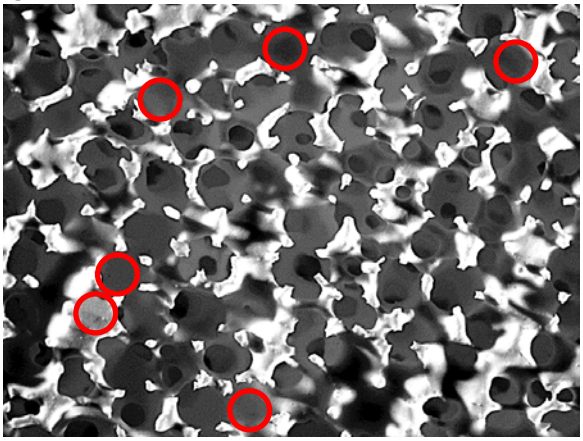
Usually for standard SIVEX, the higher the grade, the more closed pores will be found.

Images below show a comparison of filter surface between LP and standard SIVEX—with closed pores marked in red.

Standard SIVEX



SIVEX LP



Permeability

"Permeability is an important parameter for the characterization of CFFs, since it is required to predict the flow rate obtainable for an imposed pressure gradient (e.g. the casting rate for a given metal head and filter area) or to be able to predict the pressure drop (and therefore the required head or elevation change) necessary to achieve a specific flow rate for a fixed filter area (as in the design of a casting line and filter bowl)" (Kennedy, et. al., 2013).

Pyrotek test results for permeability confirmed that the more open structure of SIVEX LP has an impact on permeability. This can impact the height of metal in a filter box during priming of SIVEX LP (allows lower priming height) and preheating time before casting (smaller differences of temperatures above and under the filter).

Preheating

The preheating tests also confirmed that, for SIVEX LP, with increasing filter grade (decreasing filter permeability vs. standard SIVEX), the temperatures under the filter are higher.

Temperatures under the filter for 30 grade and 40 grade are almost the same. For 50 and 65 grades the differences are higher due to the higher permeability of SIVEX LP (lower pressure drop).

Results indicate that SIVEX LP can better achieve higher temperatures under the filter for higher grades under the same heating conditions as standard SIVEX filters.

Expandable Gasket

For SIVEX LP filters ordered with an expandable gasket, the gasket width is 38 millimeters.

The main reason for this improvement is the reduction in downforce and to make it easier to remove after casting than standard SIVEX. If the downforce is lower, the tension in the filter during preheating is lower, especially in the corners. Cracking during preheating is significantly reduced. Another factor in the cracking reduction is the thermal expansion of SIVEX LP, which is 15 percent lower than standard SIVEX. During all testing and industrial trials, no edge crushing was observed.

Filter gaskets with a width of 38 millimeters were tested at a number of customer facilities. Final results showed that the 38-millimeter gasket works correctly and doesn't display any edge cracking, flotation or bypassing effect. It was also confirmed that the filter removal is easier after casting.

Laboratory examinations and industrial tests of standard SIVEX and SIVEX LP showed that reducing the phosphorus binder level has had a positive influence on the mechanical properties and structure of LP filters:

- Better flexural strength
- Compressive strength maintained at standard SIVEX levels
- Reduced snowing
- Three times better thermal shock resistance
- Lower permeability
- Much more open internal structure
- Much more open surface pores
- Lower thermal expansion
- Faster preheating

Pyrotek's global network of application engineers works with aluminium operations to determine the best filtration methods and products for their needs.

About Pyrotek

Pyrotek® is a global engineering leader and innovator of performance-improving technical solutions, integrated systems design and consulting services for customers in the energy, metals, glass and other high-temperature materials industries.

With global resources and dependable local support in more than 35 countries, Pyrotek products are in use around the world in automotive, aerospace, rail transportation and high-tech manufacturing.

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