FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

Benefits and Pitfalls of Graphite Packing (Part Two)

The conclusion of our two-part series that analyzes the pros and cons of flexible graphite packing.

Last month, "carbon/graphite fiber" braided packings were shown to be effective solutions to many common sealing applications. But the questions remain: Are there packing materials that can more effectively seal at high temperatures? If so, do they require blocking agents?

Do Packing Materials Exist that Seal More Effectively at High Temperatures?

The answer is yes, in the form of "flexible graphite" packings. *Flexible graphite*, also referred to as *expanded graphite*, begins with natural mineral flake graphite, found and mined in various parts of the world.

The "flakes" form a laminated or layered structure of completely crystalline graphite, which is essentially elemental carbon. This may be compared to a new deck of playing cards that has all its individual cards cemented together. In this unexpanded form, flake graphite is used for such products as dry powder lubricant, and the "lead" in pencils. It has excellent lubricity in this form, but poor sealing attributes.

However, when expanded and recompressed, it is transformed into a soft, flexible material (hence the term "flexible" graphite). It is resistant to strong chemicals and high heat, has a very low coefficient of friction, and has the wonderful advantage over braided carbon/graphite fiber packings of being an even superior conductor of heat – a real plus on rotating shaft/sleeves – with limited cooling water.

Flexible graphite has good corrosion resistance and will take the geometry of any vessel into which it is compressed, forming a homogeneous mass that makes it an excellent sealing material.

Expanding Graphite Flake for Flexible Graphite

Expanding graphite flake is accomplished with the use of very strong oxidizing agents, such as sulfuric and nitric acids. After the acids weaken the bonds between the layers, the flakes are rinsed, dried, and exposed to high heat. The heat causes the layers to separate and form wormlike shapes.

Imagine our previously mentioned deck of cards where all of the individual cards have been misshapen and then put back into the deck, giving the impression that the deck has expanded. When flake graphite goes through this process, it expands dramatically, now taking the appearance of worm-like shapes and giving cause to an often used description for expanded graphite: "vermiculated (worm-like) graphite."

Turning Flexible Graphite into Braided Packings

Unfortunately, after compressing the worm-like graphite into flexible graphite it has very little tensile strength, so making it into yarns strong enough to be braided requires creativity. Since the flexible graphite is usually processed into sheets, typically a meter wide, some yarn manufacturers have simply embossed a variety of fibers into flexible graphite sheet for tensile reinforcement, and the sheet is then slit into braiding strands.

Another method is to knit Inconel® wire netting around strands of flexible graphite and use them as braiding yarns (this braided product is typically used for valve applications, rather than high speed rotating equipment).

A third yarn-making method is to pultrude flexible graphite around a tiny bundle of carbon reinforcement yarns, which benefits from the properties of both carbon/graphite fiber and flexible graphite.

Do Flexible Graphite Packings Require Blocking Agents?

Since flexible graphite is an excellent sealing material, blocking agents are typically not required, depending on the ratio of flexible graphite to its reinforcement. Too much fiber reinforcement may defeat the optimum qualities of flexible graphite, and this may then require blocking agents to affect a seal.

In addition, too high a ratio of reinforcement to flexible graphite may inhibit the braided packings' ability to transfer heat on rotating applications. Some flexible packing manufacturers do add lubricant to their flexible graphite yarns in the braiding process to assist in the break-in period on high-speed rotating shaft/sleeves, but high quality flexible graphite, made into yarns and then braided, typically does not require added lubricants.

Temperature Limits

As we discussed last month, carbon/graphite fiber packings

are limited to the maximum temperature of their blocking agents, such as PTFE. Flexible graphite packings without added lubricants can exceed these temperatures and are typically rated well over 1,000-deg F. Some high purity die-formed graphite rings can handle even higher temperatures in a non-oxidizing atmosphere.

Applications

Since flexible graphite can form a homogeneous mass without the need for blocking agents or added lubricants (which could be "washed out" by chemically corrosive media, or "cooked out" in extremely high temperature), it is a very effective material in sealing fugitive emissions of "volatile organic compounds" (VOCs).

VOCs have been targeted by a number of government environmental agencies as being responsible for air pollution. As such, braided flexible graphite has become an excellent sealing material for valves and flanges in the chemical process industries, limiting such fugitive emissions.

Braided flexible graphite packing is also finding greater acceptance in sealing rotating equipment (pumps, mixers, agitators, etc.) requiring near leak-free and flush-free service.

Some Pitfalls

Flexible graphite may be susceptible to chemical attack in the presence of strong oxidizing fluids, including air at extremely high temperatures. These include liquids such as nitric acid, especially over 20 percent concentration, and sulfuric acid, especially over 98 percent concentration. Some compositions include oxidation inhibitors or are physically structured to extend temperature capability when exposed to oxidizing gases. Excessive shaft run-out in pumps and mixers also can adversely affect sealing performance of some flexible graphite packings just as they might with some fibrous packings. Because the material is not very abrasion resistant, pump applications with abrasive slurries or dissolved solids that can form abrasive precipitates also can cause sealing problems and may require a flush, reinforcement with fibers or foils, or corner yarns of a more abrasion resistant yarn.

Summary

As we learned last month, carbon/graphite fiber packings have proven to be effective solutions to many common sealing applications. This time, we have learned that flexible graphite packings appear to have become the packings of choice when sealing fugitive emissions, high heat media, and rotating equipment with limited cooling or flush available.

Which graphite packing is right for you? Consult your packing manufacturer for proper selection and installation assistance.

Next Month: *What are the considerations in applying mechanical seals to abrasive slurry applications?*

We invite your questions on sealing issues and will provide best efforts answers based on FSA publications. Please direct your questions to: sealingquestions@fluidsealing.com.

P & S

Fluid Sealing Association

Sealing Sense is produced by the **Fluid Sealing Association** as part of our commitment to industry consensus technical education for pump users, contractors, distributors, OEMs, and reps. *This month's Sealing Sense was prepared by FSA Members Greg Raty and Ward Crosier.* As a source of technical information on sealing systems and devices, and in cooperation with the **European Sealing Association**, the FSA also supports development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump technology issues on rational Total Life Cycle Cost (LCC) principles.

The **Compression Packing Division** of the FSA is one of five with a specific product technology focus. As part of their mission they develop publications such as the joint *FSA/ESA Guidelines for the Use of Compression Packings* and *Pump & the Valve Packing Installation Procedures* pamphlet. These are primers intended to complement the more detailed manufacturer's documents produced by the member companies. In addition to English, they are available in a number of other languages, including Spanish and German.

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