

Carbon and graphite packings

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It is easy to confuse graphite fibre packings with carbon fibre packings. In fact, the terms carbon fibre and graphite fibre are often used interchangeably, even by packing manufacturers. Both products are used to manufacture braided packings, and they both have relatively good chemical and temperature resistant properties. But there are differences, and each has its advantages and disadvantages.



Figure 1. Graphite.

Carbon and graphite fibres

Typically, carbon fibres have excellent strength and toughness and are considerably less expensive to manufacture in comparison to graphite fibres. Since carbon fibre based packings are generally tougher than graphite, they are more resistant to abrasive media. They also have the ability to handle the higher compressive loads that are required for high pressure services. Graphite fibres may approach the strength of carbon, but have improved lubricity and, as such, are not so abrasive. Graphite fibre packings also have better thermal conductivity than carbon fibres, meaning they can better dissipate any frictional heat that is generated. Carbon

and graphite fibres are both composed of elemental carbon, but with distinct characteristic differences. These property differences are primarily created by the raw materials from which the fibres are made, and the type and extent of thermal processing. Historically, one major distinction is that graphite fibre typically has carbon content greater than 95 percent.

Graphite fibres more closely approach the purity and properties of crystalline graphite, while carbon is far less crystalline, so is often called "amorphous." Both graphite and carbon fibres are made from one of three precursors or raw materials: polyacrylonitrile (PAN), rayon, or petroleum pitch fibres. All three of these materials are organic polymers in fibre-form that are heated, initially in air in certain cases, then ultimately to high temperatures in furnaces without air to prevent oxidation during processing. This process is called "carbonization." After carbonization, the graphite fibres are heated again to much higher temperatures to enhance crystallinity, carbon content, and purity. These fibres, in yarn form, are then subjected to various treatments such as "sizing" or coating.

Some packings are carbonized after braiding.

Fibre packing fabrication

When large numbers of fibres are combined (typically by twisting them together), they form yarns. The yarns are then braided into various types and sizes of packing after coating with specific agents, such as PTFE, that serve to aid braiding as well as enhance ultimate sealability. A disadvantage of any fibrous yarn packing is that fibres do not totally seal fluids – they restrict flow. To provide a more effective seal, the braided carbon or graphite fibre packings are impregnated with "blocking agents," which are compatible viscous lubricants that can be used to fill the voids and effect a seal between the fibres.

Blocking agents

Historically, typical blocking agents were greases, oils and waxes. They were used to provide the necessary sealing characteristics in asbestos, cotton and flax fibre packings. Today, the most common blocking agent for carbon or graphite fibre packings is a colloidal form of PTFE. The fibres are treated with the PTFE dispersant which effectively seals the voids



Figure 2. Typical carbon and graphite braided packings.

between the fibres. It is typical to find up to 25 percent PTFE in some carbon and graphite fibre packings. PTFE is an effective blocking agent, however it does present two pitfalls. Firstly, when used on high-speed rotating shafts, the PTFE tends to sinter or form a hard plastic-like inner region of the packing ring where it makes contact with the shaft. This makes gland adjustments extremely difficult, thereby requiring eventual replacement.

Secondly, it can be responsible for acceleration of serious pitting-corrosion in valve stems. When temperatures exceed 370°C (700 °F) decomposition of PTFE generates hydrogen fluoride (HF) gas which when exposed to moisture, forms very corrosive hydrofluoric acid.

To offset the problems caused by PTFE blocking agents other materials, such as colloidal graphite, have been developed and used. Most of these do not contain any significant quantities of halogen compounds so have a lower tendency to cause pitting or stress corrosion cracking.

Expanded graphite

Expanded or Flexible Graphite is made by treating graphite flake with very strong oxidizing agents, such as sulphuric and nitric acids. After the acids weaken the bonds between the layers, the flakes are rinsed, dried, and exposed to high temperature which causes the layers to separate and expand dramatically taking the appearance of wormlike shapes and giving rise to an often used description for expanded graphite: "vermiculated (worm-like) graphite."

Unfortunately, after compressing the expanded 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 carrier fibres into flexible graphite sheet for tensile reinforcement, and the sheet is then slit into braiding strands.

Another method is to knit metal wire netting around strands of flexible graphite and use them as braiding yarns. 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 fibre and flexible graphite. Since flexible graphite is an excellent sealing material itself, blocking agents are typically not required and, since blocking agents are normally the limiting factor for higher temperature use, flexible graphite packings without added lubricants are typically rated for temperatures in excess of 540°C. Some high purity die-formed graphite rings can handle even higher temperatures in a non-oxidizing atmosphere. However, if the flexible graphite packing has a high level of fibre reinforcement the optimum qualities of flexible graphite will be compromised, and this may then require blocking agents to effect a seal. Since flexible graphite can form a homogeneous mass without the need for blocking agents or added lubricants, it is a very effective material in sealing fugitive emissions of "volatile organic compounds" (VOCs). As environmental legislation becomes more stringent braided flexible graphite has become recognised as an excellent sealing material for valves and flanges in the chemical process industries, limiting such fugitive emissions. However modern emission standards are now so strict that they tend to force manufacturers to add blocking agents to their packing to achieve the extremely low required leak rates. 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 sulphuric acid over

98 percent concentration. Some packing compositions include oxidation inhibitors or are physically structured to extend temperature capability when exposed to oxidizing gases.

Flexible graphite packings are not very extrusion resistant therefore needing end rings or a reinforcement to avoid them being squeezed out of stuffing box clearances.

Graphite is a nobler compound on the galvanic scale than stainless steel. Under certain circumstances graphite can cause galvanic corrosion (pitting corrosion) on valve stems. Therefore corrosion inhibitors, either sacrificial or ideally passive, are often added to packing materials.

Summary

Graphite and carbon fibre braided packings have proven to be effective solutions to many common sealing applications.

Flexible graphite packing appears to have become the packing of choice when sealing fugitive emissions, high temperature 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.

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