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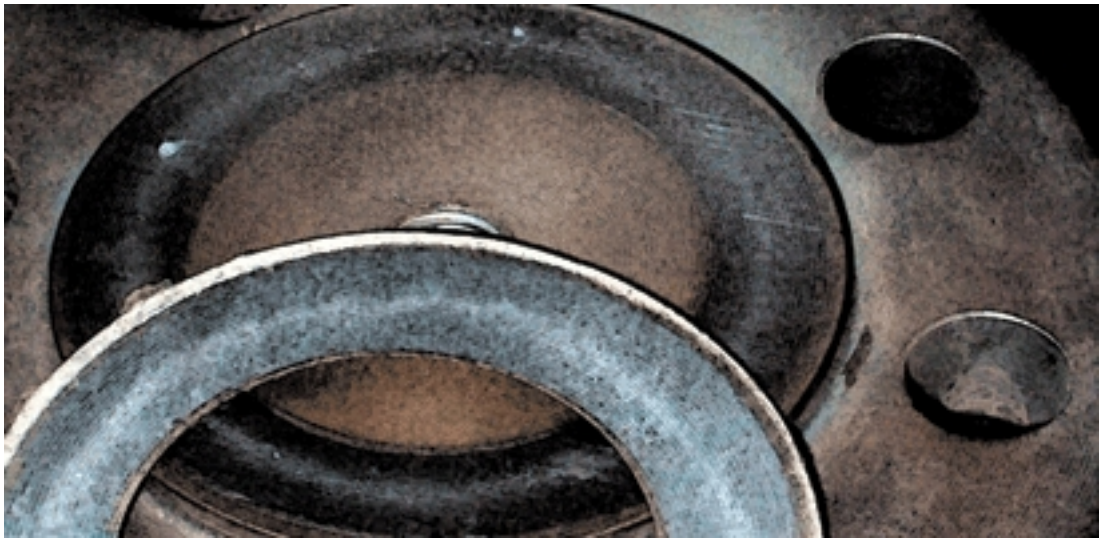

Gaskets in your piping and process-equipment systems are key factors in your plant's ability to meet production goals, ensure process safety and comply with environmental regs. How easily and quickly you install and maintain these vital components is critical both to their success and yours.

It has been one of industry's stickiest problems: Flange adhesion by many types of gaskets has posed a continual challenge for operations and maintenance personnel. The often-difficult task of separating flanges is just one part of the problem; removing their adhering gasket material without damaging the flanges is another, possibly tougher one.

While solvent-based gasket removers can be effective, they also can present health and safety issues. Thus, many plants turn to wire brushes or wheels, which, if improperly applied, can damage flanges on pipes and process equipment. Just try to imagine what could happen to your operations if particles loosened by a wire brush were to contaminate a mission-critical piping system at your facility...

The mechanism of adhesion

Many theories have been put forth to explain the mechanism of adhesion. To date, though, no single theory has been able to address the issue in a comprehensive way. What we do know for sure is that the bonding of an adhesive material to another surface is the result of a sum of mechanical, physical and chemical forces that overlap, interact and influence one another.

As detailed here, the prevailing theories include adsorption, mechanical interlocking, chemisorption and electrostatic attraction.

- The adsorption theory assumes that when an adhesive material is applied, it spreads spontaneously, "wetting" the adherent surface. For this to occur, the surface tension of the adhering material must be lower than the surface free energy of the adherent. Adhesive strength results from intimate contact between the adhesive and adherent through secondary intermolecular forces at the interface, collectively known as van der Waals forces. These include dipole-dipole forces, dispersion forces and hydrogen bonding.
- The mechanical interlocking theory is based on the fact that at the microscopic level all surfaces are rough, consisting of crevices, cracks and pores. Bonding occurs when the adhesive penetrates or surrounds these irregularities and hardens.
- The theory of chemisorption—*like that of adsorption*—is based on adhesive "wetting" of an adherent, resulting in the formation of ionic, covalent or metallic chemical bonds. These are much stronger bonds than those produced by van der Waals forces.

- The electrostatic theory posits the formation of a double electrical zone at the adhesive-adherent interface, where the transfer of electrons creates positive and negative charges that attract one another.

It has been determined empirically that minimal flange adhesion occurs with flexible graphite gaskets, since they consist of interlocked "worms" of exfoliated flakes with no organic binders. In fact, flake graphite is often used as an anti-stick coating for other types of gaskets. It has also been established that PTFE-based gasketing is subject to only minimal flange adhesion.

The well-known non-stick properties of PTFE are the result of its low surface energy. Like flexible graphite, it too is often used as an anti-stick coating for other gasketing compositions.

The problem of flange adhesion is largely associated with the use of compressed fiber gasketing. While there are many available compositions, they all contain organic rubber binders. The extent of curing and degree of cross-linking between these binders are typically lower than that of homogeneous rubber gaskets. The result is a softer, less cross-linked rubber that allows the gasket to conform to the flange and create a seal. Under heat and pressure, however, the binder flows out and wets the flange, allowing adsorption, chemisorption and mechanical interlocking to occur. These forces can be quite high, resulting in flange adhesion.

Preventing the problem

Flange adhesion can be mitigated by coating gaskets with a low-surface-tension semisolid or liquid, e.g. PTFE, silicone, a platy solid or an anti-seize compound, to prevent the binder from wetting out on the flange. Anti-seize compounds vary in composition but typically consist of metal particles in a petroleum-based carrier with other additives. These compounds are not recommended for three reasons: Under heat and pressure, the metal particles can adhere to the flange, distorting the facing, filling in the serrations and eventually rendering the gasket incapable of sealing.

Coating gaskets with anti-seize compounds can cause problems as the gaskets are compressed. A lubricated gasket not only has a tendency to extrude and split, but also can be forced out of the flange by internal pressures and lack of friction. In addition, the petroleum in anti-seize compounds can attack and soften some gasketing.

Although the use of silicone anti-stick agents can be effective, they can contaminate system media. If they come into contact with paint or photographic chemicals, for example, these agents can cause a lack of adhesion. For this reason, the use of silicone is excluded from many gasketing applications.

PTFE-based anti-stick agents can be effective, but lack thermal stability. PTFE begins to decompose above 500 F—*well below the maximum service temperatures of most compressed fiber gasketing* . In addition, hazardous and corrosive halogenated byproducts can be formed during decomposition.

A better solution is to use an inorganic material, such as talc, mica, vermiculite or graphite, to prevent the binder from wetting out on the flange. Due to their layered crystal structure, these materials are effective as anti-stick agents, cleaving to form thin sheets which, when milled, result in flat, plate-like structures. These structures allow the particles to form a laminar barrier on the surface of the gasket.

However, these naturally occurring substances vary in their morphology, degrees of purity and levels of undesirables. Graphite is also an electrical conductor that can result in severe galvanic corrosion in wet or humid environments. Wetted by seawater, graphite gaskets can cause rapid localized attack of most stainless-steel alloys, and at elevated temperatures they can carburize some stainless and nickel alloys, making them more susceptible to intergranular corrosion.

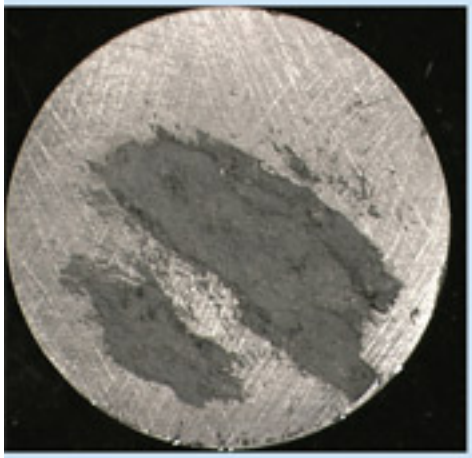

Fig. 1. Residual deposits of the gasket after testing without the new anti-stick coating

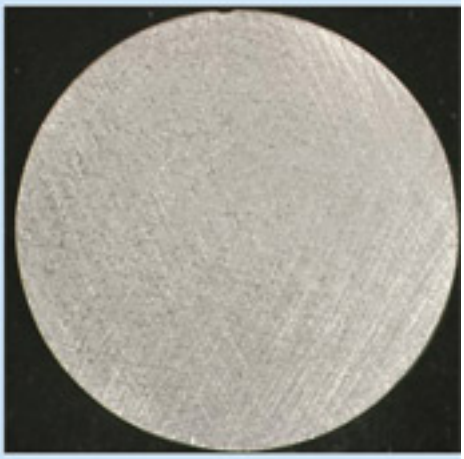

Fig. 1a. Post-test disk surface after removal of a coated gasket

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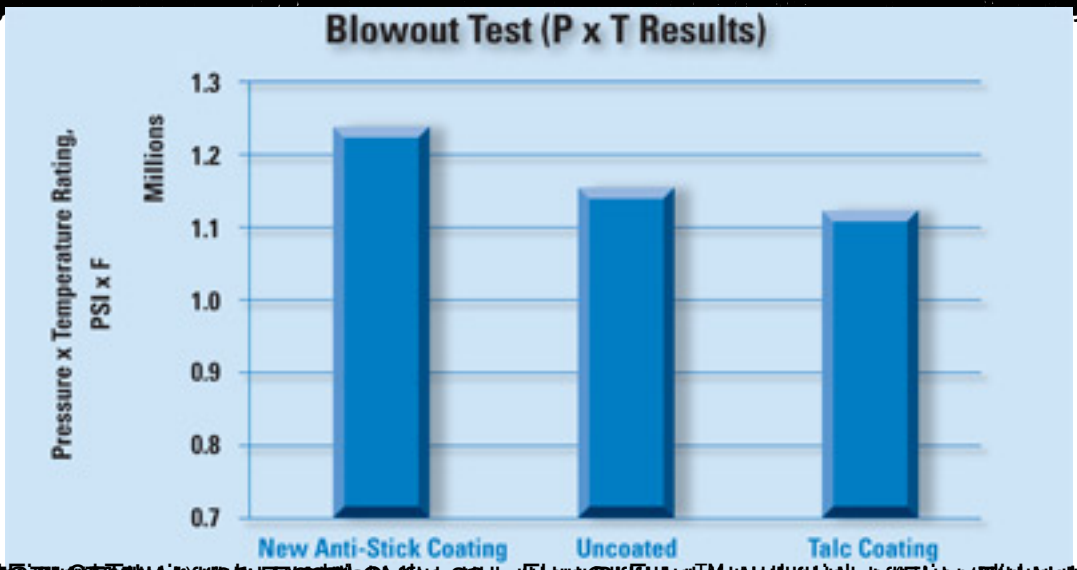

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