FLOWSERVE

Materials Newsletter

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Flowserve pumps, mechanical seals, quarter-turn valves, actuators and controls are the benchmarks of performance in the global industrial equipment marketplace. Key to this reputation is the unequaled materials expertise Flowserve incorporates in its products and provides to its customers.

Nondestructive Examination – Overview

Introduction:

Nondestructive examination (NDE) is a general term that includes all testing, inspection and examination activities used to find, size or determine something about an object or flaws therein, and allow the investigator to determine whether the object and/or flaws are acceptable. Various forms of nondestructive examination are used in the pump industry. This is a subject that has not previously been covered in a Materials Newsletter article. Given the widespread use of NDE in the manufacture of our products, it was thought that an overview of some of the more commonly used techniques and their primary applications would be beneficial to many of our associates.

Discussion:

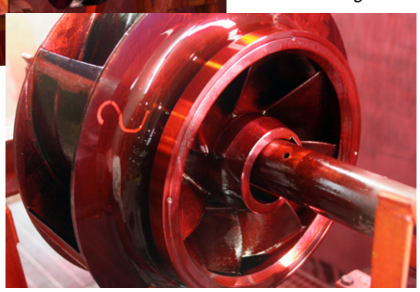
Visual Examination

Visual examination is a minimum requirement for most wrought and cast materials used in pumps. ASTM specifications for ferrous castings require compliance with one of two visual examination standards. A802 "Standard Practice for Visual Examination of Steel Castings – Surface Acceptance Standards" is a newer standard, providing several different acceptance criteria for a wide range of surface defects that can be encountered in castings. It is the responsibility of the purchaser to define the level of quality deemed necessary for the application. In the past, MSS-SP-55 was routinely used for both steels and cast irons to define minimum acceptable surface quality. This standard provided only a single level of minimum acceptable quality for various casting defects. Both standards rely on visual comparison with photos showing surface flaws or defects of various severity levels. Visual examination may be supplemented by the use of rigid or flexible borescopes to examine surfaces inside narrow passages such as impeller vanes. Defects which fail to meet the minimum acceptance criteria must be removed.

Liquid Penetrant Examination

Figure 1

Figure 2



Liquid penetrant inspection is a nondestructive method of revealing discontinuities that are open to the surfaces of solid and essentially nonporous materials. Indications of a wide spectrum of flaw sizes can be found regardless of the configuration of the work piece or orientation. Liquid penetrants seep into various types of minute surface openings by capillary action. Because of this, the process is well suited to the detection of all types of surface cracks, laps, porosity, shrinkage areas, laminations and similar discontinuities. It should be noted that surface roughness or porosity can limit the effectiveness of liquid penetrant examination. These types of surfaces produce excessive background and interfere with inspection.

There are two basic types of penetrant examination. A visible penetrant is usually red in color and produces vivid red indications in contrast to the light background of an applied developer under visible light (see Figures 1 and 2). The fluorescent penetrant, usually green in color, fluoresces

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brilliantly under ultraviolet light. The sensitivity of a fluorescent penetrant depends on its ability to form indications that appear as small sources of light in an otherwise dark area.

Liquid penetrant examination is often specified for key components of pumps intended for critical or severe service. Acceptance criteria can be found in the ASME Boiler and Pressure Vessel Code (Section VIII Division 1 Appendix 8).

Magnetic Particle Examination

Magnetic particle inspection is a method of locating surface and subsurface discontinuities in ferromagnetic materials. It depends upon the fact that, when the material or part under test is magnetized, magnetic discontinuities that lie in a direction generally transverse to the direction of the magnetic field will cause a leakage field to be formed at and above the surface of the part. The presence of this leakage field and therefore the presence of the discontinuity is detected by the use of finely divided ferromagnetic particles applied over the surface with some of the particles being gathered and held by the leakage field. This magnetically held collection of particles forms an outline of the discontinuity and generally indicates its location, size, shape and extent. Magnetic particles are applied over a surface as dry particles or as wet particles in a liquid carrier such as water or oil.

Magnetic particle inspection has the capability to detect shallow subsurface defects, although certain limitations should be recognized. If a discontinuity is fine, sharp and close to the surface, a clear indication can be produced. If the indication lies deeper, the indication will be less distinct. Skilled technicians can sometimes make a reasonable estimate of crack depth with suitable powders and proper technique. There are several disadvantages associated with magnetic particle testing. Demagnetization following testing is often necessary. Exceedingly large currents are sometimes needed for large parts. Also, while magnetic particle indications are easily seen, experience and skill are sometimes needed to judge their significance.

ASME B+PV Code Section VIII Appendix 6 covers magnetic particle testing and provides acceptance criteria. Some customers provide an option for either liquid penetrant or magnetic particle testing. Our choice should be liquid penetrant, which can be considered a less stringent method in that it does not detect subsurface defects.

Radiographic Examination

Figure 3

In our business, radiographic examination usually refers to the specific radiological method that produces a permanent image on film. Radiography is the most commonly used method to detect flaws that are completely internal, and well below the surface of the part. The method is based on differential absorption of penetrating radiation by the part being inspected. Because of differences in density, and differences in absorption characteristics caused by variations in composition, different portions of a part will absorb different amounts of radiation. These differences can be recorded on photographic film (see Figure 3). In general, radiography can detect only those features that have an appreciable thickness in a direction parallel to the radiation beam. This means that the ability of the process to detect planar discontinuities such as cracks depends on proper orientation of the part during inspection. Discontinuities such as voids and inclusions, which have measurable

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thickness in all directions, can be detected as long as they are not too small in relation to section thickness. In general, features that exhibit a 1% or more difference in absorption compared to the surrounding material can be evaluated.

Radiographic inspection is commonly used on castings and weldments, particularly where there is a critical need to ensure freedom from internal flaws. For example, radiography is often specified for the inspection of thick wall castings for steam power equipment and other high pressure applications. Castings will always have internal defects to some degree. This is well known and a primary reason why allowable stresses for cast materials are lower than for their wrought analogs. Hence, the choice of reasonable and appropriate acceptance criteria is particularly important for radiographic inspection of castings. Both ASTM and ASME have standards covering methods for radiographic examination and acceptance criteria.

It should be noted that most pressure castings receive only visual examination. After a pump has been in service for some length of time, customers may decide to perform additional nondestructive examination, possibly including radiography on pressure retaining castings. Flowserve generally opposes this inspection, because it is almost certain to detect flaws that were present in the existing casting that are not harmful, but may raise a concern with the customer.

Hydrostatic Testing

Hydrostatic testing is commonly used to verify the pressure tightness of pump casings. The test involves filling the casing with water and pressurizing it to a specified level, usually 150% of the design pressure. The pressure is held for a specified length of time and the casting is inspected for leaks. A hydrostatic test can be made more effective by adding a surfactant (trade name Tergitol®) to the hydrotest water. This chemical additive lowers the surface tension of the water and allows it to penetrate very small defects, thereby identifying areas of leakage that might otherwise not be found until the pump is in service. The use of a surfactant in hydrotest water and other methods of enhancing the severity of a hydrotest (i.e., longer time at pressure, cycling) have been found to be more effective than radiography in finding leaks in casings in some severe applications, such as heat transfer oils.

Another type of pressure test, known as a helium leak test, is occasionally used for pressure casings intended for very severe applications, such as HF alkylation pumps in refinery service where no trace of leakage is permissible. The casing is pressurized with helium gas, immersed in a tank of water and inspected for bubbles on the surface.

Conclusions:

This article has touched very briefly on the more commonly used methods of nondestructive examination used in the pump business. There are several other methods such as ultrasonic examination that are occasionally used but not mentioned in this article. The proper use of nondestructive examination can be a very effective tool in assuring quality and preventing a host of material problems once a pump is placed in service. There is a wealth of information available on each of the nondestructive inspection methods covered in this article. Flowserve materials engineers are thoroughly familiar with the selection and use of the various NDE methods and can provide guidance on all aspects of this subject, including the very important but often overlooked matter of selecting acceptance criteria that are suited to the material and the application.

Tantalum Surface Alloys: New Extremely Corrosion-Resistant Materials

Tantalum Surface Alloys: New Extremely Corrosion-Resistant Materials

By Dean Gambale, Tantaline Inc.

The need for corrosion-resistant materials is continuing to grow as engineers push their existing processes harder to gain more efficient production and as new next-generation processes, which are far more demanding, come online. These processes push conventional materials and specialty alloys beyond their limits, creating a strong need for new material solutions.

Recently, Tantaline Inc., based in Waltham, Massachusetts, and the Flowserve Flow Control Division have teamed up to offer the most acid-resistant valves commercially available. Taking advantage of its tantalum surface alloy technology, Tantaline grows an extremely corrosion-resistant surface into and on top of Flowserve standard stainless steel valves. The result is a valve product with the corrosion resistance of tantalum metal, at costs competitive with specialty alloys like Hastelloy® C276 and with the commercial availability of stainless steel.

How it Works

Tantaline Inc. produces its Tantaline® surface alloy by first heating a furnace to 700-900°C, where the tantalum metal is chemically reacted and vaporized. The high temperature fosters conditions suitable for solid state diffusion and alloy bonding at an atomic level. A gaseous atmosphere of tantalum is created and individual tantalum atoms diffuse into the substrate, typically stainless steel, creating a metallurgical alloy (See Figure 1). Once the alloy is formed, the process continues until a dense layer of pure tantalum metal grows on all surfaces of the part, both internal and external. The final pure tantalum surface layer is about 50 microns thick (max 200 µm) (see Figure 2).

Figure 1

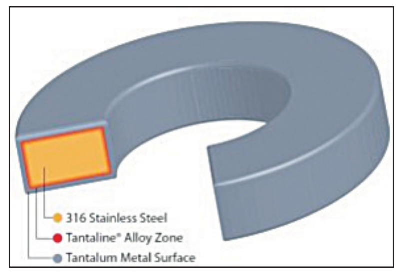
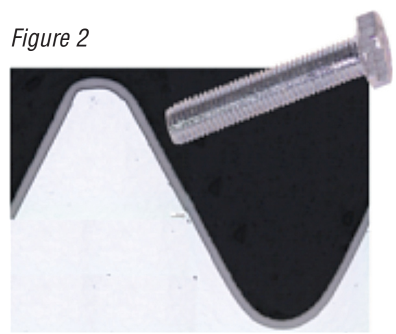


Figure 2



If needed, prior to processing, all parts could be chemically etched to maintain the original dimensions of the part. As a result, the Tantaline-treated part has the original part's dimensions but now has the same chemical properties and corrosion resistance as pure tantalum metal, which surpasses the corrosion resistance of nickel alloys, titanium and zirconium metals in most acidic environments.

Figure 3

Figure 4

Tantalum Surface Alloy

Because of the tantalum surface alloy that is formed, Tantaline products are extremely rugged and durable compared to typical coatings where bonding is primarily mechanical. To demonstrate the ruggedness of the surface alloy, samples were indented with a Rockwell C cone indenter at the midpoint and u-bent 180° over a mandrel before submerging in boiling 37% HCl for 24 hours (see Figures 3 and 4). All the samples survived with no signs of corrosion.

Quality Control

We know the corrosive, toxic and lethal environments in which Tantaline products are used. Failure is not an option. At Tantaline, all products and parts are put through a rigorous acid test, among others. To pass this test, all parts are submerged in boiling 28% HCl for a period of at least 48 hours. At these conditions, 316 stainless steel will bubble away, nickel alloys will show severe pitting, and titanium will dissolve. Tantalum and Tantaline show little affect, however (see Figure 5). This test ensures the integrity of the surface that we are providing our customers and also demonstrates that the surface is pure tantalum metal.

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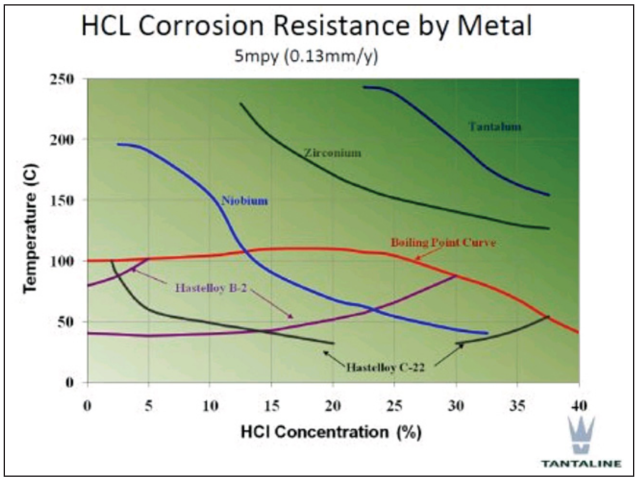
Tantalum Surface Alloys: New Extremely Corrosion-Resistant Materials

Case Studies

An example of a case study that Flowserve did in collaboration with Tantaline is at the silicone manufacturer, Momentive Performance Materials (formally a GE Silicones facility). At Momentive, silicones are produced through the direct reaction process. During this process, hydrochloric acid is formed by reacting dimethlydichlorosilane; as a result, materials are exposed to HCl acid at temperatures between 150-200°C.

Figure 5



Momentive observed problems with hydrochloric acid diffusing through Flowserve's Atomac® PFA valves, particularly on the valve stems. This led to severe corrosion of the stainless steel valve bodies and also the nickel alloy valve bodies that were subsequently tried to enhance product life. Even with PFA-lined nickel alloy valves, the valve life was only approximately six months.

A solution was developed between Flowserve and Tantaline to utilize its tantalum surface alloy technology. In this case, Flowserve requested Tantaline treat its Atomac® ball valve stems and then PFA line them to be consistent with materials previously tried. The treated valves were installed in the Momentive facility in 2005.

The valves have been performing flawlessly and are still performing today. Momentive personnel claim this is the only valve solution that has truly worked in this application. As a result, Momentive has saved money, reduced maintenance, minimized downtime and improved the reliability of their system at a cost that is competitive with nickel alloys material.

Tantaline Availability

The Tantaline treatment is now available on the Flowserve Durco® Mach 1 and G4 plug valves as well as the McCanna, Series 44 and Series 51 ball valves, and the list continues to grow. In addition to valves, Tantaline's technology may have useful applications in mechanical seals and pump parts.

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We welcome feedback from readers in addition to article ideas for future issues. Contributions from Flowserve associates on material related topics may be forwarded to our editors:

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