Duplex Stainless Steel in Pharmaceutical Industry

The particular requirements of pharmaceutical manufacturing place many demands on materials used in the production environment. Vessels and piping systems must be highly corrosion resistant to withstand the fierce cleaning regimes necessary to guarantee drug purity and integrity. They must be resistant to the effects of high temperature and pressure and meet the industry's surface finish requirements.

By Tim Outteridge, Secretary-General, IMOA

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These demands have typically led to the selection of type 316L stainless steel for most pharmaceutical and biotechnology applications. For more aggressive environments, manufacturers have usually selected a highly alloyed 6% molybdenum stainless steel to reduce maintenance costs, even though it is more corrosion resistant than needed in most cases.

However, with 2205 (UNS S32205, EN 1.4462) duplex stainless steel, there is now an intermediate solution available for those cases where type 316 is not sufficiently corrosion resistant but 6% molybdenum is too expensive. Typically containing 3–3.5% molybdenum, 2205 demonstrates exceptional corrosion resistance even in the extremes of the pharmaceutical production environment. The S32205 grade has recently been included in the ASME Bioprocessing Equipment Standard as an approved construction material that has demonstrated ability to meet the stringent welding and surface finish criteria of the bioprocessing industry.

Strong Contender

Unlike type 316L stainless steel, which has a microstructure dominated by an austenite phase with a very small amount of ferrite phase, the microstructure of duplex stainless steels consists of approximately equal austenite and ferrite phases.

The increased nitrogen content and the fine microstructure of 2205 duplex stainless result in higher strength than austenitic grades such as type 316L. In many applications, this strength permits components to be made with lower wall thicknesses, within the confines of the applicable design code, saving weight and cost.

Duplex stainless steel equipment in a pharmaceutical clean room. Photo by istockphoto/xxapril

Chloride environments represent some of the biggest challenges to materials in pharmaceutical production, either from process ingredients or cleaning regimes, with pitting being the most common form of corrosion. The increased levels of chromium, molybdenum and nitrogen in 2205 duplex stainless steel provide substantially better pitting and crevice corrosion resistance compared with type 316L.

2205 duplex stainless steel offers an intermediate solution for those cases where type 316 is not sufficiently corrosion resistant but 6% molybdenum is too expensive.

Corrosion Resistance at Elevated Temperatures

Hot process streams present further challenges for production equipment. Type 316L stainless steel will readily crack at temperatures higher than 60°C with a combination of tensile stress and chlorides. Known as chloride stress-corrosion cracking (SCC), this phenomenon must be considered when specifying for hot chloride environments. Unlike type 316L, 2205 duplex stainless will resist SCC in simple salt solutions up to temperatures of at least 120°C.

Many pharmaceutical applications use high purity water environments, in which some stainless steels can develop a thin surface deposit known as rouge or rouging. The exact cause is not fully understood but the deposit consists mainly of ferric oxide or hydroxide particles, which can include shades of red, gold, blue, grey and dark brown. Type 316L stainless steel is resistant to rouging, therefore it is important that alternative materials are no more susceptible. Because of the need for absolute cleanliness, surfaces with heavy rouging must be thoroughly cleaned, which can be expensive and time consuming. Studies have demonstrated that 2205 duplex stainless steel is at least as resistant to rouging as type 316L stainless steel.

Product contact surfaces must be electropolished for many applications in the pharmaceutical and biotechnology industries. Duplex stainless steel can be electropolished to a smoothness of 0.38 micrometers or smoother, meeting or exceeding surface finish requirements, although an electropolished 2205 surface will not be as bright and lustrous as an electropolished 316L surface. This is due to differences in metal dissolution rates between ferrite and austenite phases.

Fabrication with 2205 duplex stainless is similar to fabrication with 316L stainless steel in many respects, however its higher strength must be taken into account when cold forming and machining.

Pharmaceutical production facilities present a number of challenges for construction materials due to the temperature, pressure and corrosive nature of process operations as well as stringent cleaning and sanitizing regimes. The higher performance of 2205 duplex stainless steel offers distinct advantages over type 316L grade in these unique conditions.

About IMOA

The International Molybdenum Association (IMOA) is a non-profit trade association representing the majority of the molybdenum industry worldwide, promoting molybdenum's unique properties and its contribution to superior materials performance and enhanced sustainability in a host of applications. Acting as the voice of the industry, the Association works to maintain and develop market access for its members. An unrivalled source of information on molybdenum, IMOA also manages a historical database on global production and use.