Bulletin No. 204

Hydrometallurgical Applications

Characteristics of Pressure Reactor Systems used for Hydrometallurgy Extractions.

One of the principal applications for which Parr Pressure Reactors are used is in the field of hydrometallurgy or the extraction of metals from their ores by leaching with acids at elevated temperatures and pressures. Over the years Parr has furnished more than one thousand High Pressure Reactors for this specific application.

There are several characteristics that are common to leaching reactions which we will address in this Tech Note.

Materials of Construction

These reactions are generally carried out using sulfuric acid as the leaching acid. Occasionally hydrochloric acid is used. While the corrosive considerations are similar for both of these acids in this application, sulfuric acid is “easier”, or perhaps “less difficult”, to work with.

Titanium is almost the universal metal chosen as the material of construction for reactors used in this field. While Titanium has poor resistance to pure sulfuric or hydrochloric acid, the presence of the high-valence metal ions such as ferric, cupric, nickel, etc., resulting from the extraction process dramatically reduces the corrosive effects of these acids on Titanium. Interestingly, these same ions have just the opposite effect on Hastelloy Alloys B-2 and B-3 which offer excellent resistance to these acids in the pure form.

Because the successful use of Titanium for these extractions depends upon the presence of the multivalent metal ions, PTFE or glass liners must not be used as these will permit the pure acid vapors to distill over the liner top and reach the walls of the vessel. In some cases it may be necessary to add a few of these ions at the beginning of the run to provide the resistance until the leaching process builds up a sufficient presence from the ore.

It is important to remember that Titanium offers the best material choice we have for this process even though it does not offer complete resistance to these harsh conditions.

Grades of Titanium

Titanium is generally used in its “unalloyed” version. Commercially Pure Titanium comes in two grades; Grade 2 and Grade 4. Grade 4 has slightly higher iron content (0.3 % max) and is approximately 30% stronger than Grade 2. Unfortunately Grade 4 is not approved for vessels that are ASME or PED Certified.

Titanium Grade 7 contains 0.15% Palladium. This small addition of Palladium makes this alloy somewhat more corrosion resistant to these leaching conditions and significantly more expensive than Grades 2 and 4. Grade 7 has the same strength as Grade 2. While we can obtain Titanium Grade 7 in sizes and quantities suitable for the heads and cylinders of these reactors, we can not obtain Grade 7 tubing or the small sizes required for drive shafts and inner fittings. We do offer hybrid units with Grade 7 heads and cylinders and Grade 2 internals.

Reduced Strength at High Temperatures

Because it has a tendency to creep, or stretch slightly, at elevated temperatures, the allowable stress levels and hence the maximum allowable working pressures for Titanium at elevated temperatures are about 40% of those of the same vessel constructed of stainless steel. The Maximum Operating Temperature for Titanium vessels is 316°C based upon the ASME Pressure Vessel Code values.

Titanium and Oxygen

Titanium will rapidly oxidize in air and produce a protective oxide film. Raw Titanium will burn in the presence of high pressure oxygen.

Essentially all hydrometallurgy extractions are done under a high pressure oxygen atmosphere to maintain the oxidative leaching conditions. So great care must be taken to avoid conditions where the Titanium can be ignited in the oxygen atmosphere. Fortunately it is difficult to ignite Titanium in the steam – oxygen environment present inside the reactor.

The principal hazard is in the valves on these reactors. Here the rapid flow of pure high pressure oxygen can cause ignition; particularly on parts such as valve needles and seals which do rub together and can wear away the protective oxide coating and expose raw Titanium which can be readily ignited under these conditions. For this reason we do not furnish Titanium valves and fittings for these reactors. Because these valves are generally not exposed to the liquid phase and are not as hot, stainless valves will generally provide an acceptable service life to these external components.

Abrasive Slurries

These leaching slurries are normally very free flowing and do not require the high torques associated with viscous polymers. Good three-phase mixing is produced at stirring speeds of 600 – 800 rpm. The slurries are however quite abrasive. Particles can get caught in the PTFE foot bushings and rapidly wear away the stirrer shaft. Users commonly move these bushings up and down the shaft to find unworn sections and extend the service life of those components.

The optional Footless Magnetic Drives, offered for these reactors were designed to overcome this problem specifically for these applications. These have no bearing down in the slurry and are shown in Figures 1 and 2.

Figure 1

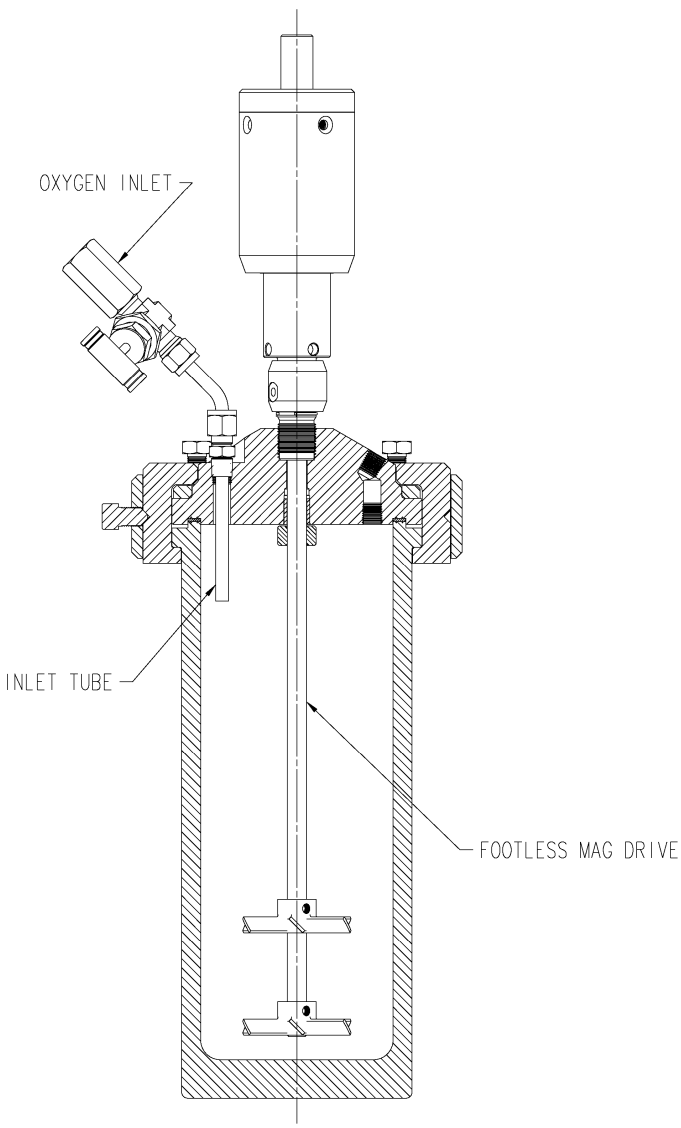
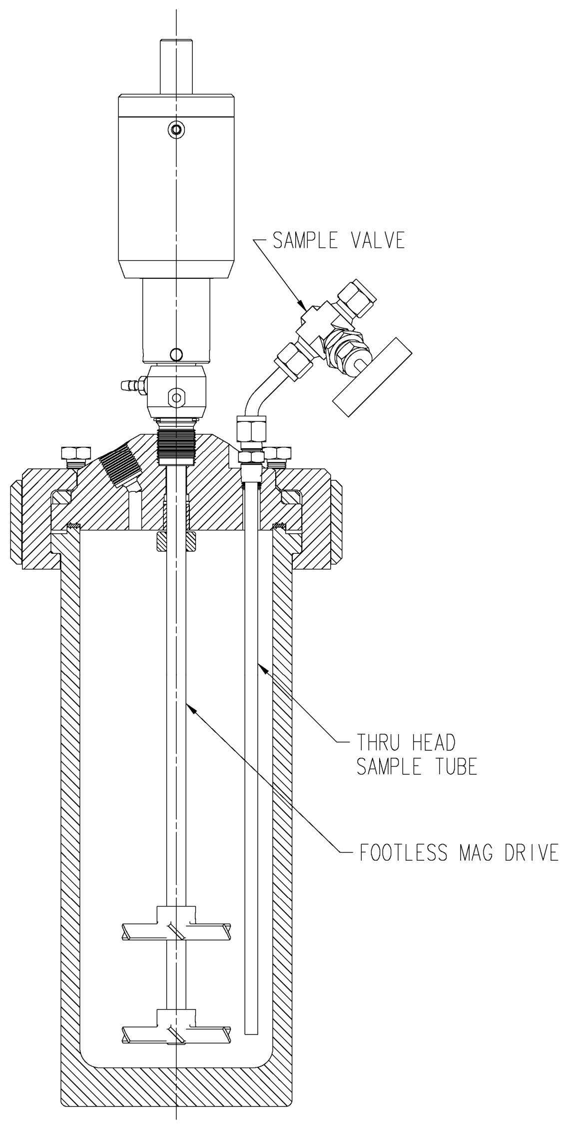


Figure 2



Custom Head Design

In addition to the Footless Magnetic Drive we have made two custom modifications which users are finding useful for this application. The oxygen inlet line and slurry sampling valves described below apply to both removable and fixed-head reactors.

Oxygen Inlet Line

Figure 1 shows an oxygen inlet line where a tube (usually Alloy 20Cb-3) leads thru the Titanium Head of the reactor and discharges into the vapor phase of the vessel. This eliminates any possible contact between the incoming oxygen stream and Titanium Metal. The tubes are readily replaceable but do stand up reasonably well to the corrosive vapors in these reactors.

Slurry Sampling Valve

In the design shown in Figure 2 the sample tube runs directly thru the head to the sample valve. This eliminates any passages in the head that can trap solids and become plugged. The Sample Valve can be either a needle valve or a ball valve.

Users who have worked with this design fitted with a ball valve and a sealed sample receiver vessel report that they are able to withdraw samples that are not only representative of the liquid phase concentrations, but also of the solid to liquid ratio within the reactor.

Higher Pressure Design

The one and two liter Series 4520 Reactors have been the most popular size for these investigations. These vessels rate a Maximum Design Pressure of 775 psi at 300°C constructed of Grade 2 Titanium. For users who wish to have a higher pressure rating than this, we have designed a vessel with a 0.375 inch thick wall instead of the 0.250 inch wall. These vessels have 970 ml and 1900 ml capacity and rate 1200 psi at 300°C when constructed of Grade 2 Titanium.

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