IN THE MEDIA

KATIE BEANE, CHRISTY CATALYTICS, USA,

REVIEWS CATALYST SUPPORT MEDIA OPTIONS FOR FERTILIZER PLANT APPLICATIONS.

Selecting the proper inert catalyst support and hold-down media for ammonia plant applications is very important. The primary function of the inert support media is to protect and support the catalyst without contributing to or inhibiting catalysis. Inert support media also serve as heat retention media, ensure process streams are properly distributed and help to retain contaminants before they reach the catalyst bed. The media must perform these functions and remain highly inert while withstanding the temperatures and pressures of the application.

The most common catalyst support media come in the form of balls. There are two main classes: high alumina and ceramic. Ceramic support balls are primarily made from naturally occurring alumino-silicate clays, which are found in only a few locations globally. Ceramic media are suitable for moderate applications, generally up to approximately 980˚C, as with Christy's T-86 PROX-SVERS®. Premium grades, including Christy's T-38 PROX-SVERS (Figure 1), may be used at higher temperatures, up to 1370˚C. Ceramic support balls are commonly used in low- or medium-temperature shift units, desulfurisers, driers and guard beds.

Figure 1. T-38 PROX-SVERS.

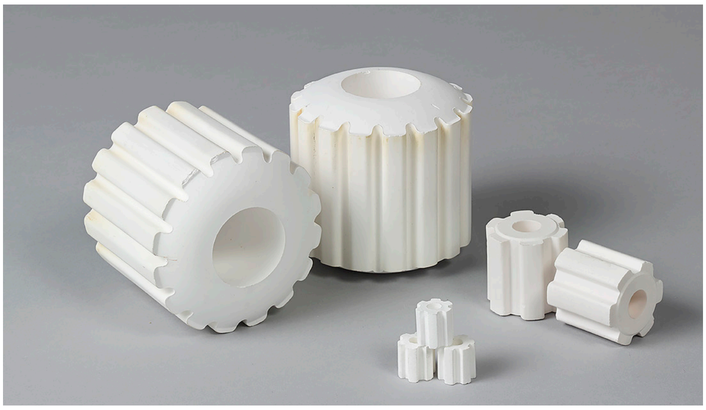

Figure 2. CATA-COGS.

Figure 3. Hexagonal target tiles and circle brick.

Alumina support balls are required in the most severe fertilizer plant applications. While they are typically used in high-temperature shift units, they are used exclusively in secondary reformer vessels. In secondary reformers, the temperatures are very high, which combined with the presence of steam causes metal oxides (such as silica) to corrode and eventually deposit as fine dust further downstream. This leads to an increased pressure drop, channelling, efficiency loss and eventually unplanned shutdown. Therefore, it is crucial that the support media be made from refractory raw materials with very low levels of silica, typically less than 0.35%. Although, the emphasis is often placed on the alumina content of these supports (specifications often require 99% or 99.5% alumina), ensuring that they contain very low quantities of silica is the main priority.

Both alumina and ceramic balls come in a variety of sizes ranging from 3 mm to 100 mm in diameter. In support applications, the media is graded by size, from a smaller size ball supporting the catalyst, down to a larger size. The size of the slots in the support screen, support dome or elephant stool beneath the catalyst (if any) may be the determining factor when choosing the largest size support ball to be used. Pressure drop considerations may be another factor, as the larger support balls will have a lower pressure drop. In general, a 'rule of two' is used to size support media whereby for each size ball selected, the size of each subsequent layer is either doubled or halved to prevent migration of the smaller size into the layer of larger size media.

While balls are the most common shape used, other shapes, such as hollow rings, cogs or other unique shapes, are available. These may be used to reduce pressure drop, most often around the bottom collector in the shift units. Christy's CATA-COGS (Figure 2) are made from 99% alumina and are available in sizes from 16 mm to 85 mm. The larger sizes may be hand placed around the collector layering smaller sizes above until the catalyst bed is reached. A downside to using very large media is that they must be removed by buckets as they are generally too large to be removed by vacuum truck.

Hold-down media in secondary reformers

A special application for the inert fixed bed media in ammonia plants is the hold-down media for secondary reformers. As previously discussed, alumina support balls are commonly used as catalyst support, however there are other options for the hold-down media on top of the catalyst. This is the hottest part of the unit, so refractory materials with very low silica levels are required. This section is also prone to churning or even uplifting of the media, exposing the catalyst underneath, which can cause channelling and erosion of the media leading to premature shutdown.

The first option for secondary reformer hold-down media is large (50 or 76 mm) alumina balls, such as Christy's T-46 or T-99 PROX-SVERS. The mass of the larger balls makes them less likely to move around than smaller support balls, and their spherical nature gives them a predictable pressure drop. A layer of 25 mm alumina balls is usually placed below the 50 or 76 mm balls and directly on top of the catalyst.

A second hold-down option available is the use of hexagonal target tiles (Figure 3). Hexagonal tiles are the best option to prevent milling or churning in the vessel. In particular, Christy's largest size, Super Jumbo, weigh approximately 22.7 kg, are 89 mm thick and are very unlikely to move and expose the catalyst during upset conditions. Smaller sizes, Jumbo and Standard, are also available. All tiles come with hole patterns designed to minimise the pressure drop while maintaining physical integrity, however the quantity and pattern of the holes may be customised based on the performance objectives and dynamics of the specific unit. For instance, if flame impingement beneath the burner is an issue, solid tiles may be installed in the middle of the vessel, protecting the catalyst and forcing the process gas stream to better distribute through the entire tile layout. Pre-cut special shapes are typically installed around the vessel perimeter to minimise gaps along the vessel wall, and circle bricks are installed along the wall between the catalyst and hex tiles to form a seal and prevent gas bypass.

Operators may select the type of tile based on the velocity in the vessel, the distance between the burner and the bed and the nature of any problems they may have experienced in the past. All hex tile shapes are made with corrosion- and wear-resistant 99% alumina and have an ultra-low silica content.

A third option for hold-down media is white-fused alumina lumps (Figure 4), in 25 x 50 mm, 50 x 100 mm, and 100 x 200 mm sizes. While many plants continue to use lumps over other options, there are several disadvantages to this type of media. Alumina lumps are made by melting alumina in an electric arc furnace and casting the molten material. The hardened material is crushed once cooled, resulting in irregularly shaped pieces. The material is screened into a specific size range, but due to the extremely brittle nature of the alumina lumps, it is possible for long, narrow shards to make it through the screening process. The lumps' irregular size and tendency to chip results in greater pressure drop over support balls or hexagonal target tiles, and the long, narrow shards can penetrate down into the catalyst bed, which can result in channelling. In addition, the melting and casting process of the lumps creates large amounts of internal porosity similar to coral rock, and this creates unwanted surface area for the process gas to react with leading to higher rates of corrosion than seen with balls or hexagonal tiles.

Figure 4. Alumina lumps.

All of the above options are alumina materials with very low silica content. However, some plants have experienced corrosion of their hold-down media when using these materials. This is likely due to the elevated temperatures in this area compared to other reformers in the industry, burner design issues or using a reduced distance between the burner and catalyst bed in an effort to increase throughput. In these cases, hexagonal tiles or support balls made from a low corrosion formulation, such as Christy's HT-LC Hex-Tiles and HT-LC PROX-SVERS, may be used. HT-LC is a proprietary, low corrosion metal oxide formulation that resolves the corrosion of alumina, silica, potassium, and sodium oxide. In addition to enhanced corrosion resistance, this formula has a 60% higher density than 99% alumina formulations, which is advantageous in serving as a catalyst hold-down media.

Required volume for hold-down media

When support balls are used as a hold-down media, a minimum bed thickness of 150 mm is typically required and 230 mm is preferred. Alumina lumps require a minimum bed thickness of 305 mm. Beds comprised of hexagonal target tiles vary between 50 – 150 mm, depending upon the tiles design. For plants that have experienced bed churning or erosion issues directly beneath the burner, a small area of 150 mm thick, solid tile may be considered in this area even if thinner tiles are used throughout the rest of the cross section.

Pressure drop

Due to their irregular size, tendency to chip and thicker bed volume requirement, alumina lumps have the highest pressure drop of any media options discussed herein, when compared to similar size balls and taking into account their thicker bed requirements. Large alumina support balls have significantly less pressure drop due to their round surface, consistent void volume and reduced bed thickness requirements. 76 mm support balls have approximately 30% less pressure drop than 50 mm. COG shapes have lower pressure drop compared to similarly sized support balls. Finally, with their comparatively thin layer thickness and open-hole patterns, hexagonal tiles have the lowest pressure drop of all hold-down media options, when 19 mm round openings are used. The pressure drop of hexagonal tiles can be increased if desired by reducing the opening size or reducing the number of openings. WF