# Control valve selection for SAF production

Increasingly, refineries are starting to retool their infrastructure to produce sustainable aviation fuel (SAF). However, new processes are required, creating challenges for control valve selection. **Scot Bauder and Janelle Prusha, Emerson**, discuss.

Green or sustainable aviation fuel (SAF) is a renewable replacement for the fossil-based aviation fuels that have historically powered most aircraft. SAF is a drop-in replacement for standard aviation fuel, but it is created from sustainable feedstocks, so it boasts significant carbon emission reductions over its lifetime. Although it is currently more expensive than fossil-based aviation fuel, SAF does offer a variety of green fuel credits for both producers and aviation companies, so production rates are rising rapidly.

Similar to green diesel, SAF has process differences that can pose significant challenges for

control valves in the conversion units. This article discusses the SAF production process, and offers suggestions for choosing the best control valves for the more difficult applications.

## SAF development

While the first flight using bio-based aviation fuels occurred in 2008, SAF did not become an approved fuel replacement until 2011 when ASTM International officially allowed commercial airlines to blend up to 50% of certain biofuels with their conventional jet fuel. Since then, a large number of bio-derived aviation fuels have entered the market and are being utilised by an increasing number of airlines. As of 2022, 450 000 flights have used some combination of sustainable fuels, although the price for these products can be as much as three times the cost of kerosene-based aviation fuel.

SAF is different to other bio-based aviation fuels in that it must be certified by a third party to verify that the fuel satisfies certain environmental, social and economic considerations. This does elevate the cost of production, but has driven strong product demand as producers and consumers are offered an array of governmental credits for the fuel's production and use.

While it is technically possible to create SAF from a wide variety of feedstocks, including sugar-bearing plants, algae, and even woody biomass, most of the SAF that is currently produced comes from the lipid conversion process. Extensive research is underway for the other pathways, but the similarity of lipids conversion to refinery hydrotreating/cracking makes it relatively easy to repurpose existing refining facilities for the production of SAF. Lipid feedstocks for SAF production are primarily used cooking oil, oil-bearing plants (such as rapeseed, carinata, soybeans, etc.), and tallow.

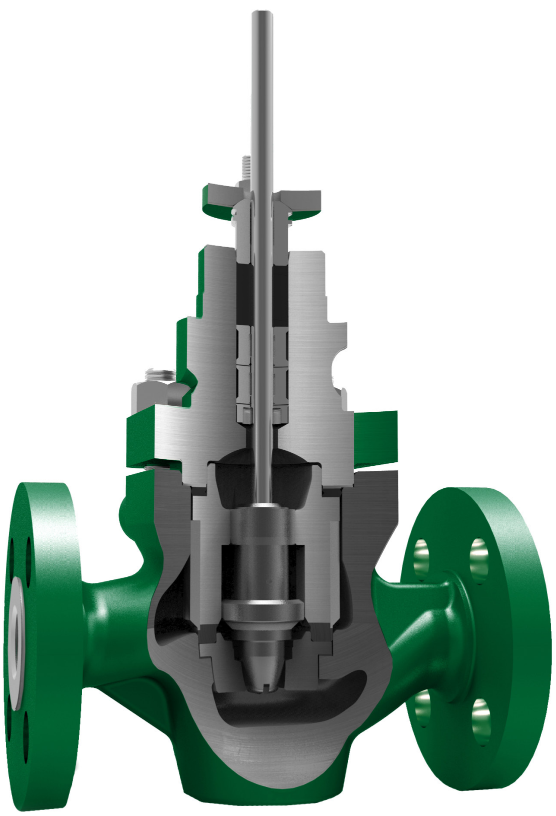

**Figure 1.** An unbalanced plug with tight shutoff is often employed in hydrogen quench valve service where product sticking/build up might occur. Material selection should account for the hydrogen service and possible corrosive attack from the reactor products.

Lipid conversion utilises feedstocks that already contain significant amounts of oil, so the chemical processing methods and equipment are familiar and well understood in the refining industry.

Regardless of the pathway used, nearly all SAF feedstocks require some kind of pretreatment to refine and break down the feedstocks and convert them into the common intermediates that feed the hydrotreater processing units downstream. These pretreatment processes are quite different depending on the particular feedstock involved, but generally all pretreatment processes strive to eliminate contaminants that can poison the reactor catalysts and chemically break down the feedstock into common and consistent intermediates to feed the hydrotreater section.

## SAF hydrotreatment

Once pretreated, the SAF intermediates are fed into a hydrotreating process that is very similar to that used in most refineries. Several different licensors are offering conversion methodologies. Honeywell's Ecofining process includes a deoxygenation reactor followed by deisomerisation and hydrocracking, and then a product separation section to create light fuels, green diesel and SAF.

Another lipid conversion process uses the Axens Vegan HVO process to deoxygenate the feedstocks and hydrotreat the resulting intermediate to create SAF, green diesel, and naphtha.

In either of these processes, there are certain critical valves that are extremely important, must endure particularly gruelling service conditions, or both. Although similar to the standard hydrocracking process in many ways, there are differences that pose challenges for SAF production.

The intermediates tend to be more corrosive and stickier than with conventional feedstocks, and they are prone to paraffin and/or waxy build-up. The process also requires significantly more hydrogen, elevating process pressures and temperatures. Finally, the intermediate feed quality tends to be variable, so reaction chemistry is impacted and less consistent. All of these issues can complicate process control and increase the need for constant maintenance and intervention to keep the plant in operation.

Choosing the right control valves for these services is critical, as proper selection can extend time between outages and increase uptime. The more challenging applications will be discussed in the next section of this article.

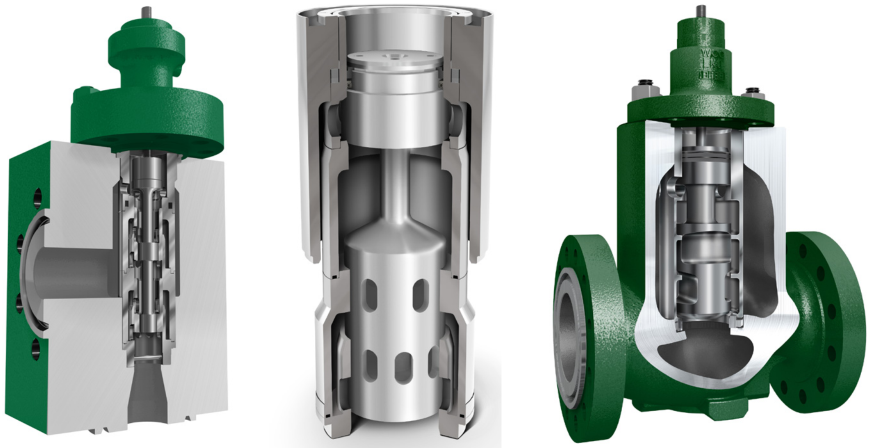

**Figure 2.** Separator letdown valves require multistage pressure drops, large flow passages, and high strength alloys to handle the flashing, entrained particulates, and corrosion of this service. Valves such as the Fisher™ DST-G (left) and Fisher™ NotchFlo DST (right) can be good options.

## Pretreatment control valves

While the specific process conditions will vary depending on the feedstock, all pretreatment processes generally involve corrosive fluids and gumming-type applications. As a result, any control valve in this application will require special alloys to resist corrosion, along with special body and trim coatings to minimise build-up. The best body designs also incorporate simple, unrestricted flow paths that are less prone to clogging.

These same rotary valve body styles also tend to shear away any build-up as they operate, allowing the valves to remain in service for longer between cleanouts.

## Reactor feed valves

The biofuel intermediate feed valves must provide a consistent and carefully controlled flow to the reactor in order to maintain stable operation and maximise catalyst life. This requirement is complicated by the corrosive and sticky nature of the feed. The best option for a specific reactor will depend upon the process temperatures and pressures, but regardless the valve will likely require carefully chosen alloy internals. A body design that addresses the specific reactor shut-off requirements and incorporates specific body styles to handle material build-up is also needed.

## Reactor quench valves

Many of the reactors in an SAF process have quench valves that supply cooling hydrogen between the reactor catalyst beds to control the exothermic reaction. Tight temperature control is critical for catalyst life, so these valves must operate quickly and accurately. This requirement is made more difficult by the fact that the valves do not tend to move much once temperatures have stabilised, so they are prone to sticking over time.

Tight shut-off and elevated temperatures and pressures are typical in this service, so the valve must be specified carefully (Figure 1). A post-guided unbalanced trim design will be less prone to sticking and can handle the temperatures and pressures of this service.

Careful material selection is critical for this valve as it involves pressurised hydrogen, and it might be subjected to reactor materials, which tend to be corrosive at certain points in the SAF process.

## Separator/sour water letdown valves

Nearly all SAF processes include one or more high pressure letdown valves. These valves control the liquid level in a high-pressure separator and must pass a corrosive liquid containing significant amounts of entrained hydrogen gas and particulates, down to a much-reduced pressure downstream. As the material passes through the valve, the gases exit the solution, creating a three-phase mixture that is extremely challenging for any control valve.

A typical high-pressure drop design would employ numerous small internal passages to stage the pressure drop and handle the flashing conditions, but such a valve would plug quickly in this application. A better valve design would incorporate a multi-stage letdown with large flow passages to avoid particulate plugging (Figure 2). The entire trim must be constructed of an appropriate hard alloy that can handle the corrosive and flashing nature of this difficult service.

Additive manufacturing has enabled production of a host of new body and trim designs that are well suited for this very difficult application. This same manufacturing methodology also creates a wider range of available high alloy options to suit most applications.

## Conclusion

The very strong demand for increased SAF use has many refiners retooling older units to produce the product, but there are strong competitive pressures to drive down production costs.

Proper control valve selection can have a dramatic impact on how well a unit operates and how long it can run for between maintenance outages. The SAF lipid conversion process is similar to typical hydrotreating, but it certainly has special challenges that make valve specification more difficult.

If a refining unit is undertaking an upgrade to SAF production, it is important to carefully evaluate each valve application to fully understand the process and corrosion challenges. It is also worth consulting a valve vendor to investigate the wide range of new valve technologies, as proper control valve selection will have a direct impact on the productivity, longevity and profitability of the production unit.