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Warming to the challenge

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Regional focus: biofuels in the US

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Warming to the challenge

Second generation ethanol processes are gradually moving from the pilot and demonstration stages to full-scale production plants. Having solved initial issues like getting processes to work, ethanol manufacturers must now focus on optimising production economy to become competitive.

Energy cost is a large part of any ethanol plant's budget, putting energy efficiency high on the agenda for all plant managers. Optimising the use of heat often has a big impact on profitability, so heat integration is a straightforward way to improve energy efficiency and can lead to big cuts in operating cost.

There are many ways to reuse energy in a second generation ethanol plant. One example is using low-grade steam, such as evaporated vapour, as a heating medium instead of exhaust steam. Another is to use the energy in hot streams, for instance condensate or warm product, to preheat cold streams.

Investments in heat integration have proven profitable and have short payback times. As an added bonus, CO_2 emissions and climate impact are often reduced as well. Keeping CO_2 emissions to a minimum is important for the credibility of the ethanol industry and can also have a monetary value if operating under a cap-and-trade system.

Trailblazing

Beta Renewables (BR) began production at its Crescentino plant in northern Italy in late 2012. It is the first full-scale second generation ethanol plant in the world and will initially produce 40,000 tonnes per year (tpy). The company will then gradually ramp up production to 60,000 tpy.

Development started at laboratory scale in 2007 before building a one tpd pilot plant, which has been operational since 2009. The result is a new lignocellulosic bioethanol process called Proesa that offers feedstock flexibility, chemical-free pretreatment and low costs. The Crescentino plant is the first full-scale test of the Proesa process, but BR and its partners have already started working on their next plants.

The entire project has had a strong focus on production economy. The goal has been to develop a complete and financially viable solution for production of ethanol and other bio-based chemicals from non-edible biomass such as energy crops, corn stover, rice husk, bagasse and straw.

To ensure good production economy, BR also invested in agronomic research and investigated how to improve crop yields, crop management, harvesting, handling and transport.

The company minimised investment and production costs by simplifying the process as much as possible. One example is the chemical-free pretreatment that saves

The heat exchanger is a key component in a heat integration system chemicals and means lower grade materials can be used in the plant. Another is that the biomass can be used as collected, without prior drying.

Heat integration at Crescentino

Minimising energy consumption has been an important part in keeping operating costs down in the Proesa process. The entire Crescentino plant has been designed with energy efficiency as a guiding principle.

An example of this is the heat integration between the pretreatment and distillation stages. To reduce exhaust steam consumption, the engineers at BR designed a solution where vapour produced in the pretreatment stage is reused as heating medium in the mash column reboiler. This leads to energy savings and a cut in operating cost.

The set-up requires a reboiler on the mash column that can operate with a very small driving temperature difference, i.e. the temperature difference between the heating and boiling media. A standard shell-and-tube heat exchanger would be impossible to use in this duty since it requires at least a 10°C temperature difference.

The engineers at BR contacted equipment manufacturer Alfa Laval for advice on how to realise the design. Having worked with numerous ethanol plants, Alfa Laval engineers helped pick a suitable heat exchanger for the task.

The solution was to use plate heat exchangers as reboilers as their higher thermal efficiency means they can operate with a driving temperature difference as small as 3°C.

Most processing industries have some type of heat integration in their processes, but many still use shell-and-tube heat exchangers with low thermal efficiency. The heat exchanger is a key component in a heat integration system and choosing the right type has a direct impact on bottom lines.

Modern plate heat exchangers offer many benefits over shell-and-tubes. They allow companies to use low temperature streams for heating and can increase heat recovery by up to 50%. More energy is put back to use; energy that would otherwise have gone to waste.

A knowledgeable equipment provider is important when building plants in developing industries, such as second generation ethanol. The provider must have a holistic view, the expertise to be able to read between the specification lines and a focus on getting the process to work.

Turbulence and counter-current flow

The superior thermal efficiency of a plate heat exchanger is the result of its highly turbulent flow. The small thickness of the plates also has a positive effect on heat transfer. The result is an overall heat transfer coefficient that is three to five times higher than for a shell-and-tube heat exchanger.

An important feature of plate heat exchangers is their capability to operate with a counter-current flow (i.e. the hot fluid enters the heat exchanger at the end where the cold fluid exits). This makes it possible to handle crossing-temperature programmes in a single heat exchanger (i.e. to heat the cold fluid to a temperature that is higher than the outlet temperature of the hot fluid). This is especially important in heat recovery since the maximum amount of energy is recovered when the cold fluid is heated to a temperature close to that of the hot fluid.

The high efficiency means plate heat exchangers can exploit very small temperature differences and makes it possible to profit from heat recovery from sources that have previously been deemed worthless.

Design and maintenance

When designing the utility system for a new plant, or when upgrading an existing one, it is a good idea to investigate how heat integration can help keep investments in heating and cooling capacity to a minimum.

Switching from shell-and-tube to plate heat exchangers can often be a good way to resolve bottlenecks related to cooling and heating in existing plants. With a little luck production can be increased with new heat exchangers and existing utility systems.

A key feature of a plate heat exchanger is its highly turbulent flow. Apart from improving heat transfer, it also makes it less susceptible to fouling.

High turbulence means fouling deposits do not build up as fast as in a shell-and-tube heat exchanger. The result is longer service intervals, more uptime and more recovered heat than for a shell-and-tube solution. Less fouling also leads to lower cleaning costs.

Summary

Second generation ethanol processes have proven to be technically feasible in a number of pilot plants across the world. Through its Crescentino plant, BR has proved that it is possible to produce second generation ethanol on a commercial scale at a competitive cost.

Heat integration is an easy and straightforward way to increase energy efficiency and lower operating costs. But it is important to choose the right heat exchangers for the different positions. To obtain the best results a close contact with an experienced supplier is recommended. ●

For more information:
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All bases covered: Crescentino ensures all byproducts are produced as viably as ethanol