BENEFITS OF AUTOMATING SHEAR IN STARCH COOKING

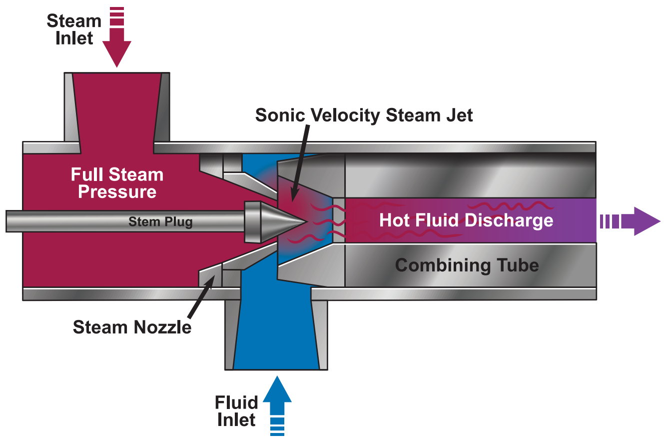
The Jetcooker™ is a critical component and the first step of the liquefaction process in ethanol production. It is generally located after the slurry tank, where a slurry of corn mash, water, and enzymes is formed. A pump feeds that slurry into the Jetcooker, where it is mixed with steam. Heating the mash in the Jetcooker is the first step to opening the starch molecules so the enzymes can break it down into sugar.

Maintaining a constant pressure drop across the Jetcooker will optimize shear, mixing characteristics, and overall performance efficiency. Adjustments can be made to keep the optimal pressure drop during operation, even as process conditions change. This is done by adjusting the gap between the combining tube and nozzle (see illustration 1).

As the gap is widened or opened, the pressure drop is decreased (lower shear). As the gap is narrowed or closed, the pressure drop is increased (higher shear).

Adjusting the gap can be done by turning the drive nut, which rotates the drive shaft, moving the combining tube stud, and combining tube laterally.

Illustration 1: Jetcooker detail shown at optimum position



Automation

Automation controls can also be added, which automatically adjusts the combining tube's position to maintain the desired pressure drop.

The control panel receives signals representing differential pressure setpoints and signals from pressure transmitters in the slurry inlet and discharge. Compared to the target setpoints and signals, pressure measurements are sent to the pneumatic package to adjust the combining tube position.

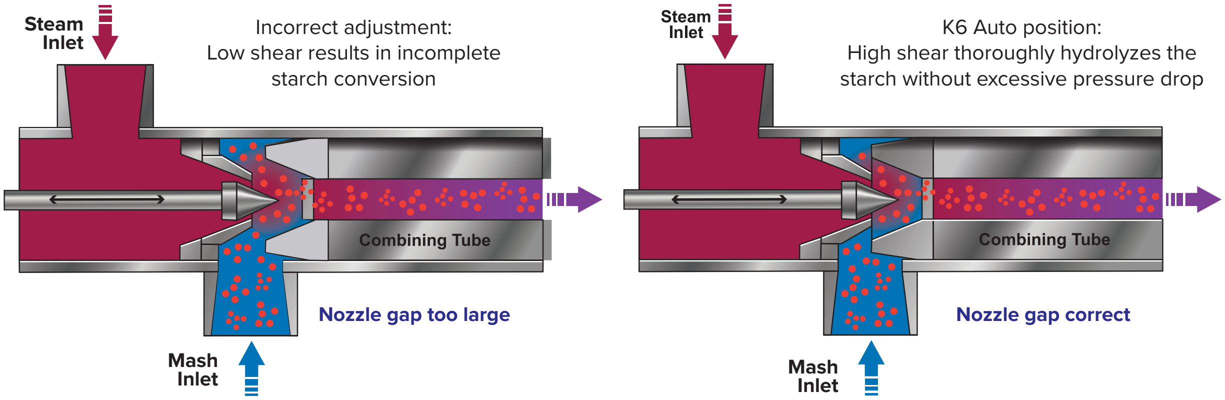
Optimum Position

If the combining tube and nozzle gap is too large, there is low shear and low-pressure drop. This results in an incomplete starch conversion, which is a loss of efficiency.

If the gap is too small, there is high shear and excessive pressure drop. The result is excessive wear to the internals of the Jetcooker and increased pumping cost (see illustration 2).

The target for this study was to approach the theoretical maximum yield. By optimizing the combining tube position, the plant could more closely reach this maximum (see illustration 3). The optimal differential pressure, and therefore opening size, will be different for each ethanol plant. Many factors will come into play, such as incoming viscosity, flow rate, combining tube diameter, size of the Jetcooker, temperature, and slurry makeup conditions. An optimal combining tube position can be established by testing for the minimum pressure drop, which produces optimal starch hydrolysis.

Illustration 2



Golden Triangle Experience

Ron Bennett, maintenance manager at Golden Triangle, Craig, MO, shared the plant's experience with automating its Jetcooker. Bennett outlined the typical parameters of its ethanol production process:

- Starch levels of corn measuring about 72%
- Corn grind steady at 500 to 600 microns
- Fermenter temperature target is 90°F [32° C]

Several process variations at the plant justified automating the Jetcooker, including:

- Slurry tank has varying input flows and therefore resultant temperatures
- Target flow rate varies by 5%
- Pre-gelatinization of starch caused by varying temperatures and tank pre-heating methods
- Dough balls: inconsistent agitation; size ranged from BB to very large clusters

To determine the optimal pressure drop for Golden Triangle, the plant started with 30 psi [2.06 barg]. This required de-bottlenecking.

Bennett said he could not achieve that pressure drop, and he did not want to change pump sizes. The solution was to remove pressure drops in other parts of the process. This was done by removing a restrictive valve and installing one on a pump ahead of the Jetcooker.

The differential pressure drop was increased in 5 psi [.344 barg] increments. Sugar and alcohol concentrations were measured, and relative sugar and alcohol contents were evaluated via kinetics curve.

Benefits

At 42 psi [2.8 barg], there were some fermentable sugars left over. The enzyme dosage was changed to convert the sugars to alcohol. Optimizing the shear point resulted in a 1% gain in alcohol volume or a 5% increase in alcohol production.

Consider theoretical yields that say it is possible to achieve a 93% yield to put that into context. Realistic production results are more commonly achieving 85% to 90%, optimizing its shear point allowed Golden Triangle to reach a 90.5% efficiency.

Simply put, the plant could produce more gallons of ethanol with the same amount of corn and other inputs.

Increased Starch Conversion

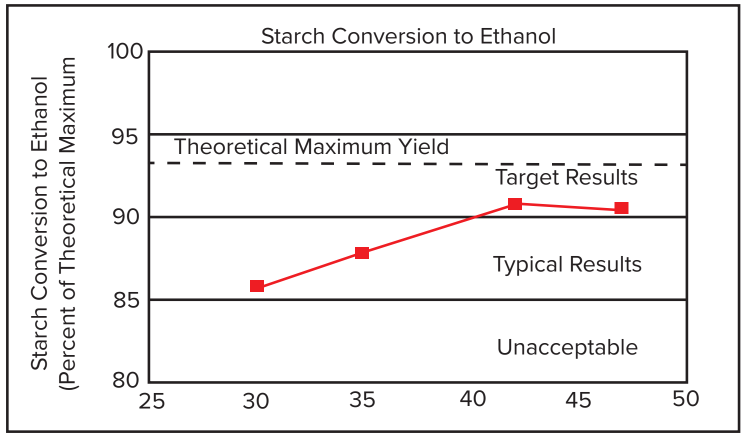


Illustration 3: Golden Triangle Results

Why It Happens

If the combining tube and nozzle gap is too big, the starch stream is too thick for the steam to penetrate. Penetration of the starch is only 50% to 75%.

When the gap is narrowed, the velocity is increased to a point where the starch stream is thinner, and therefore the steam can penetrate 100%. This allows for an instantaneous and efficient way of mixing steam and the starch molecules resulting in instant hydrolysis.

Secondly, pre-gelatinized starch particles are mechanically broken into smaller sizes by a properly adjusted combining tube. This results in complete starch conversion.

Return on Investment

Golden Triangle initially saw a 5% increase in sugar conversion. The continual optimization of automation is estimated to be a minimum of 1% increased efficiency.

The total cost of the Jetcooker automation is about $15,000. A 1% production increase for a 20 Million-gallon-per-year ethanol plant is worth $440,000 (with ethanol selling at $2.20 per gallon). There will be a reduction in DDG production of 1,324 tons/year due to the starch being converted to ethanol. Using $240/ton DDG selling price results in $317,880/year reduced revenue. This increase in yield will lead to a net increase in revenues for the plant of $122,120/year. That means a plant could recoup the investment cost of the automation in one to two months.

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