Food and Beverage

Durable Solutions for Large Volume Vinegar Clarification and Stabilization

Summary

As an environmental friendly solution for vinegar clarification and stabilization, free of filter aids and solid residue generation, Pall Membralox® systems deliver higher quality product despite the aggressive operating conditions.

Overview

Vinegar is a dilute solution of acetic acid (CH_3COOH) produced through double fermentation of raw materials. The first fermentation uses yeasts to produce ethanol while the second fermentation uses *Acetobacter* to convert ethanol into acetic acid. The acetic acid concentration in the broth is typically 10-15% (by volume) but can be as high as 21% in special conditions.

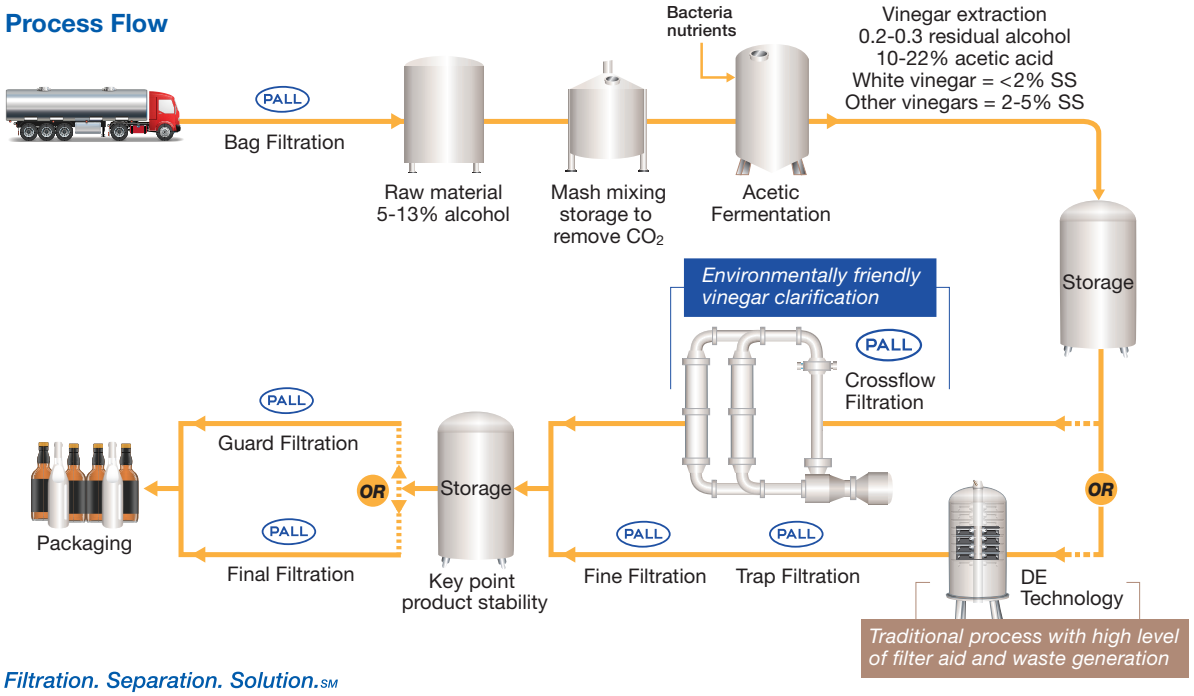
The fermented raw materials often include grapes or wine, fruit or berries, cider, spirits from agricultural products and products containing starch or sugars. Additionally, fermentation aids like malt, corn syrup, glucose syrup, phosphate and ammonium salts may be added to facilitate the biological process.

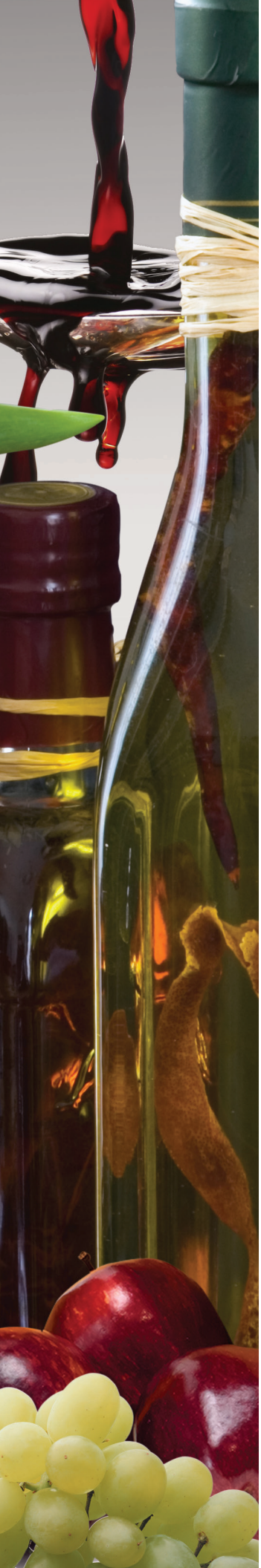
Finally, to adjust vinegar taste and color, natural ingredients may be added (within 100-150 g/l specific limits). These ingredients could be plants, fruits, spices (fresh or extracts), sugar, salt, honey, fruit juices and authorized additives (within specific limits) such as SO_2, salts (E220-227), caramel colorants (E150), L-ascorbic acid (E300), MSG (E620-621-623) and natural aromas may also be added.

Vinegar can be classified according to raw material and method of manufacturing:

- Spirit or distilled vinegar: acetic fermentation of dilute distilled alcohol
- Sugar vinegar: two-fold fermentation of dilute sugar syrup or molasses
- Malt vinegar: two-fold fermentation of barley malt or other cereals where starch has been converted to maltose
- Wine vinegars: acetic fermentation of wines
- Raspberry red wine vinegar: natural raspberry flavor is added to aged and filtered red wine vinegar
- Rice vinegar (or rice wine vinegar): acetous fermentation of sugars derived from rice
- Balsamic vinegar: Modena traditional balsamic vinegar from cooked grape must slowly fermented, aged and concentrated in wood casks (no addition of spice / flavor) or

Process Flow





commercial balsamic vinegar (no geographic or processing restrictions)
- Other specialty vinegars: from coconut and cane (*India, Philippines, Indonesia*) or date (*Middle-East*)

Commercial vinegar is characterized by its total acid content (expressed in pure acetic acid / SNIF-NMR), as well as by its total SO_2 content, residual alcohol, soluble dry extract, ashes and caramel.

Industrial vinegars are used by other food companies as an ingredient in dressings and sauces, pickles, mustard, tomato products and processed foods. White vinegar is most of the industrial vinegar volume.

The Challenge

High in acid content, vinegar (especially white vinegar) is self-preserving with an almost indefinite shelf life. However, with consumer expectation for a clear product, vinegar is clarified after acetic fermentation to remove suspended solids including *Acetobacter* and other microorganisms.

Traditionally, clarification is achieved using Diatomaceous Earth (DE) filtration. While these systems can handle high solids, the open design allows for oxygen pick up which can impact product quality. DE based technologies can also require large volumes of filter aid. This increases the waste, disposal, labor, and product losses; all factors contributing to high operating costs.

Additionally, during storage of some vinegar types, haze formation or settled sediment may be observed due to the precipitation of protein aggregates. To prevent the haze, typically a fining agent like bentonite is added prior to DE filtration for protein stabilization.

In recent years, to overcome the drawbacks associated with DE filtration and eliminate environmental and health concerns surrounding DE, crossflow filtration with membrane based solutions has become more widespread.

Crossflow filtration using tight ultrafiltration membranes advantageously combines acetic fermentation broth clarification and protein removal, thus delivering a very clean and stable solution.

However, in some cases microfiltration membranes may also be suitable. For example, if the proteins are denatured at high temperature, microfiltration allows simultaneous removal of suspended solids and denatured proteins.

Today, there is a solid base of hollow fiber membrane system installed worldwide by various suppliers. In this chemically aggressive application, these modules suffer from operational limits (corrosion of potting and fibers, temperature limitations) that may dramatically reduce service life, therefore increasing operating cost (maintenance, production downtime, contaminated batches, etc.).

Pall was challenged with finding a cost effective and efficient solution for vinegar filtration that could withstand long-term exposure to acetic acid.

The Solution

With exceptional mechanical strength, thermal and chemical stability, Pall's Membralox crossflow membranes provide a reliable and durable solution for vinegar filtration. Installed in a 316L stainless steel housing, Membralox ceramic membranes can operate in acetic fermentation broth and other aggressive operating conditions, in filtration temperatures up to 200 °F (93 °C) and 150 psi (10 barg).

Moreover, the wide range of pore sizes (from 10 nm to 5 µm) covers vinegar´s requirement for microfiltration or ultrafiltration depending on customer constraints and product characteristics.

With microfiltration membranes, suspended solids are removed to produce a crystal-clear vinegar solution. With ultrafiltration membranes, suspended and some dissolved solids like proteins are removed to achieve long term stability of the vinegar solution by preventing haze formation. See Figures 1, 2 and 3 for examples of Membralox modules and membranes.

The case studies below highlight 2 examples of how vinegar producers benefitted from installation

Figure 1: HCB module

Figure 2: HCS module

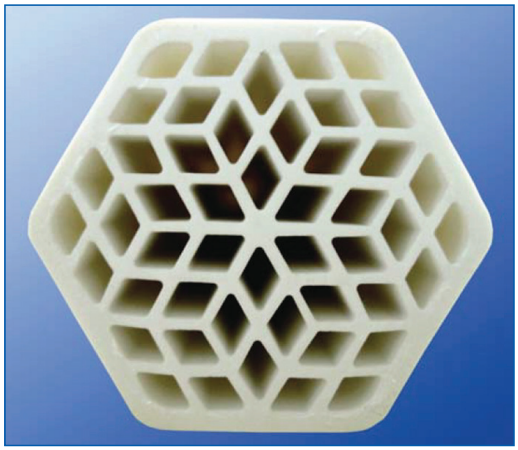
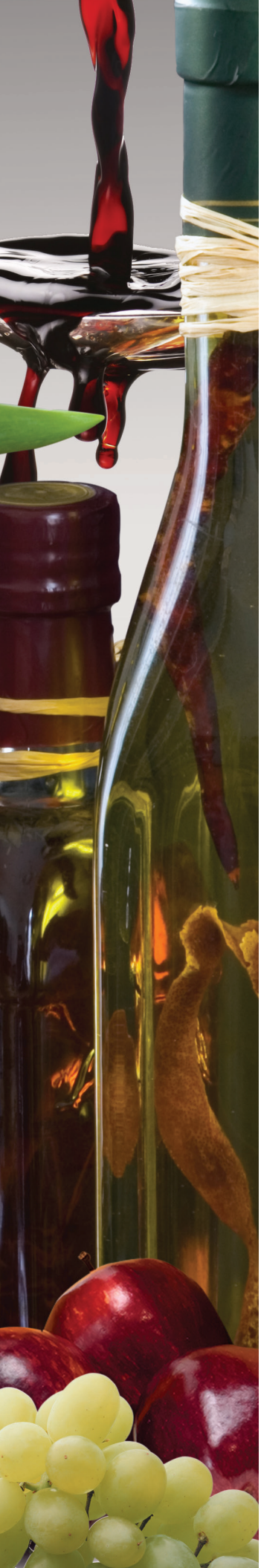


Figure 3: Ceramic membrane



of systems incorporating Membralox ceramic membranes.

Case Studies

Case 1: Microfiltration

A producer of specialty vinegars was looking at eliminating bentonite and DE from their production process. They employed a 4-day bentonite treatment, with removal of bentonite over sequential DE-based filtration technologies, including a Sparkler Filter and a Rotary Vacuum Drum Filter (RVDF). This long processing train resulted in high losses, electrical consumption and labor. In addition, the producer was looking to improve the working conditions by eliminating the health concerns associated with DE powder handling.

At this customer, testing was key to demonstrate the benefits of crossflow ceramic membranes performance for filtration of red wine, cider, malt and corn vinegar.

Data gathered during the trials allowed calculation of potential savings from consumable DE spend and disposal, electricity & gas consumption, manpower and product losses by installing Pall crossflow ceramic system.

With a favorable ROI, Pall was awarded the contract to deliver a crossflow ceramic MF system to filter up to 37 gpm (8.5 m^3/h) of vinegar at about 100-110 °F (38-43 °C).

Upon installation and over 1-year operation, the customer reported the following benefits and savings:

- Permeate turbidity consistently below 10 NTU (typically < 2 NTU)
- Approximately 100K USD savings/year in materials, utilities and labor
- Product losses reduced from 4% to below 0.5%
- Filtration and stabilization time reduced from 1 week to 1 day

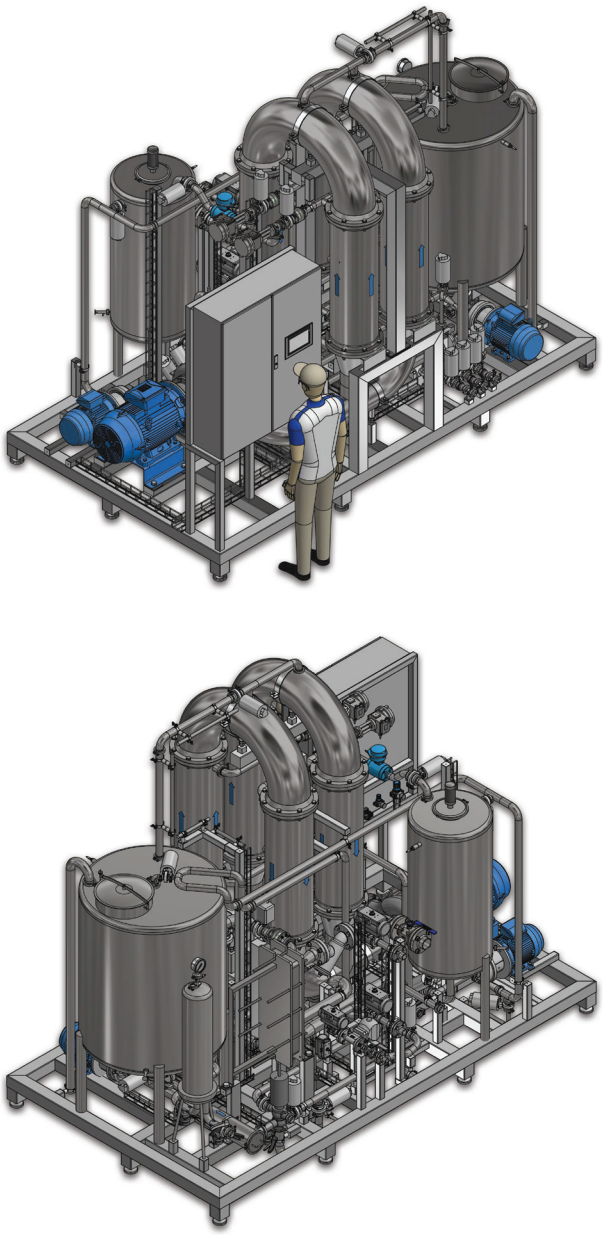


Figure 4: Example of a Pall system with 4 x Membralox modules

Case 2: Ultrafiltration

A vinegar producer was looking to remove proteins larger than 50 kDalton from high acid vinegar (~ 16% acetic acid) to prevent haze formation during vinegar storage. This vinegar is quite corrosive and the customer reported experience short membrane life with a competitor's ceramic membranes previously installed in this application.

Based on a similar reference installation, the customer agreed to evaluate Pall's UF solution for this project.

To ensure protein removal, a crossflow ceramic fine UF membrane was selected. Long term semi-work pilot trials successfully demonstrated stable filtration performance matching customer goals.

Today, the industrial system operates with the following performance:

- 99.5% removal of > 50 kD proteins (customer target is > 90% removal)
- Consistent average permeate flux over 12-14h run (reported as 20% to 40% higher than previous installation)
- Recovery rate > 95%

The Benefits

By implementing Membralox ceramic membrane solutions, these vinegar producers found reliable and durable alternative solutions for clarification and stabilization with a short return on their investments by,

- Eliminating powder handling, avoiding waste generation and creating a safer and healthier workplace for their employees
- Cutting operating costs
- Reduction of product losses thus increasing process yield
- Delivering consistently high-quality product (eliminating the need to reprocess)

About Pall Corporation

Pall Corporation works to protect what matters everyday by providing filtration, separation, and purification solutions to businesses across the globe. Pall serves the food and beverage industries with advanced membrane filtration technology and systems, enabling companies to produce shelf-stable, consumer-safe products at the lowest operating cost.

There are only a few companies in the world that can effectively do what we do, and none of them match our combination of product breadth and performance across traditional filters and system solutions with our depth of application knowledge.

To learn more about Pall Food & Beverage visit www.pall.com/foodandbev.

Pall Corporation

Better Lives. Better Planet.SM

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FBABVINEGAREN November 2020