POPE, JAMES D., and HUDE, JEFFREY M., LURGI PSI, 1790 Kirby Parkway, Suite 300, Memphis, TN 38138. **Industrial performance of the mechanical vapor recompression and multiple effect evaporator system: successful operation and significant reduction in steam usage.**

Introduction

During January of 2000, a new evaporator system was started up to meet the needs of a new molasses desugarization (MDS) process installed and started at the same time. The evaporator system described in this paper is part of the MDS facility owned by Crystech, LLC and operated by the American Crystal Sugar Company factory in Hillsboro, North Dakota. Preparation for this startup included time for conceptual development, feasibility studies and evaluations, detailed design, modeling runs, construction, operator and maintenance training and subsequent successful startup. This paper shall document the design and present the results of the operation of the evaporation system selected.

Design Criteria

The MDS process takes soft molasses from the factory sugar end and converts it into at least two streams, product and byproduct. The primary sugar carrier is the product stream, often termed extract. The main non-sugar stream is commonly referred to as raffinate. Intermediate streams must also be evaporated to meet the process needs. The following criteria had to be considered in the design of the molasses desugarization evaporator system:

- Multiple streams to concentrate
- Low initial feed concentrations to the evaporator system
- Recycle of clean process condensate for process usage
- Turn-down capability
- Flexibility to change the number of streams feeding the evaporator
- Year-round operation
- Handling non-sugar stream with precipitation of salts during and after concentration
- Stainless steel material of construction
- Limited excess steam available for new evaporators
- Available electricity

Due to limits on available steam supply at the selected site for the molasses desugarization facility, a single or multiple-effect steam heated evaporator system alone was not an acceptable option. Boiler capacity to meet the process demands could not be met without the addition of new equipment and costly infrastructure upgrades. The use of energy saving techniques, such as mechanical vapor recompression evaporation, was evaluated and ultimately selected to meet the criteria of that situation.

A mechanical vapor recompression evaporator system is similar to a conventional steam heated, single-effect evaporator, except that the vapor released from the boiling solution is compressed in a mechanical compressor. Compression raises the pressure and saturation temperature of the vapor so that it may be returned to the evaporator steam chest to be used as heating steam. The latent heat of the vapor is used to evaporate more water instead of being rejected to cooling water in a condenser. The compressor provides energy to the vapor that increases in pressure and temperature, thereby recycling the evaporated water into usable steam to meet the evaporative load of the incoming fluid. This reduces the steam needed to meet the evaporative load of the overall system. The energy or driving force for pressure increase is provided through shaft horsepower. The most widely used drive applied to MVR systems is the constant speed motor. For high evaporative loads, like in an MDS facility, these motors may be large sizes requiring high voltage electric supply.

A system of mechanical vapor recompression units for initial concentration where acceptable to remove large quantities of water followed by multiple-effect, steam heated units to finish evaporate the process streams was the solution for the processing and project requirements. Another key factor was that the site had available the necessary electrical capacity to meet the requirements of the MVR system.

MVR Benefits

- Steam and overall energy consumption was significantly reduced compared to conventional steam heated evaporator systems with the same capacity.
- Cooling water requirements were reduced
- The main vacuum pump for the evaporator system was reduced in horsepower, capacity and size compared to one required without use of a MVR
- A vacuum pump for the raffinate MVR was not required due to its operation at pressure above atmospheric pressure
- Higher condensate temperatures provide additional steam savings by providing hot water (95-100 °C) source for use in the process.

MVR Disadvantages

- A higher capital cost than a conventional steam heated system
- A MVR could not be utilized on all streams to be evaporated as part of this process. The extract stream from the MDS process could not be evaporated in a MVR because operation at pressures near one atmosphere would result in boiling temperatures that would be too hot for the heat sensitive high purity and high concentration sugar solutions
- High electrical consumption was required with two 1250 HP motors on the raffinate MVR compressors, and these required a high voltage power supply
- Spares such as turbine blades and bearings were required for inventory.