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Mechanical Vapor Recompression Options and Limits for Juice Evaporators and Crystallizers with Piller MVR Blowers

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ABSTRACT

Energy efficiency involves reducing the amount of energy consumed to achieve the same outcome. Mechanical Vapor Recompression (MVR) has long been recognized as a key technology for reducing primary energy consumption in steamreliant processes. The sugar industry, in particular, could significantly benefit from the MVR technology by recycling vapors that would otherwise be condensed, thus reducing net energy usage and enhancing overall process efficiency. This presentation shall give basic insights on the MVR technology based on blowers. This includes knowledge on mechanical features and operational limits as well as examples on the integration of MVR into the juice evaporation and crystallization processes. In detail there will be charts and graphics to present the mechanical aspects and the operational limitations. Challenges and considerations for integrating MVR into existing plants are also discussed to provide a holistic view. The potential for MVR to enhance by-product utilization and support a circular economy is also highlighted. The presentation concludes by emphasizing MVR's strategic relevance in meeting the global demand for sustainable and efficient sugar production, aiming to encourage industry stakeholders to adopt this technology.

Keywords: Mechanical vpor recompression (MVR), carbon emissions, industrial heat recovery systems, decarbonizing, energy efficiency, blowers and compressors.

INTRODUCTION

Case study - energy efficient bio-ethanol production with piller mvr blower systems

The largest single site bio-ethanol plant in Europe, located in Hungary, was already considered as the most efficient refinery in the world, using state-of-the art technology. But there still were high ambitions to minimize carbon emissions and to increase energy efficiency.

Decarbonizing biorefineries

In biorefineries, distillation and dehydration are among the most energy intensive processes, constituting a significant part of the overall energy consumption.

Within the process, condensation and subsequent evaporation of rectified (hydrous) ethanol turned out as massive waste of energy. Therefore, cooling and reheating should be bypassed, but the conditions of the vapor streams did not match. The solution: increasing the pressure and temperature by compressing the highly concentrated ethanol (190 proof / 95 Vol.%) vapors.

Beacon in energy transition: integrating heat pump systems

Recapturing the energy previously lost to cooling towers and returning it to the plant‘s processes leads to smart heat integration and boosting energy efficiency. This project turned out as a beacon in the energy transition. Retrofitting the process with industrial scale heat pumps leads to:

- Minimized production costs
- Minimized carbon emissions and thus a competitive advantage

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As main result of the open loop heat pump integration, the steam production from boilers dropped by more than 40 tons of steam per hour.

The direct 190 proof vapor compression significantly reduced carbon emissions and energy costs by electrifying process heating at a high COP.

Additionally, the debottle necked steam generation enables further growth on other production facilities.

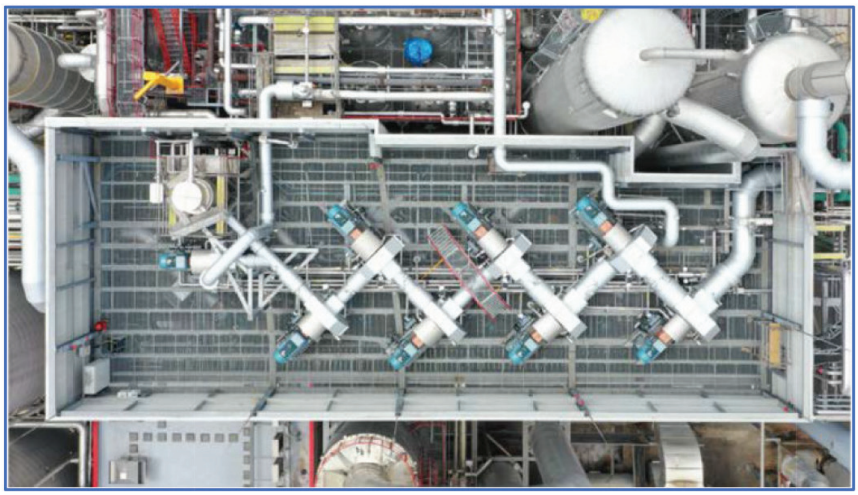


Figure 1 : Heat pump technology – vapor compression line with PILLER MVR blowers

Ethanol compression with PILLER MVR Blower Systems

- Mass flow app. 100 t/h in two compression line.
- Temperature Rise 64 K saturated
- 33 MW natural gas were saved at a cost of 5.9 MW electricity
- Cuts the plant's energy needs in half
- Reduced greenhouse gas (GHG) emissions by 6.75 t/h of carbon dioxide
- COP of 4.56 for heating

Vapor compression systems – made by piller

Two production lines of bio-ethanol were completely retrofitted.

Core element of the installed solution is the vapor compression system with PILLER MVR blower technology.

In the initial process, 190 proof vapors are fully liquified on the rectifier's main condenser losing the heat to the cooling towers. After the rectification, the distillate is evaporated again with boiler steam to feed the mole sieves for dehydration. The rectifier column had the lowest temperature level within the original heating cascade. This heat potential can only be unlocked with a heat pump technology.

Retro fitting for a greener bio ethanol

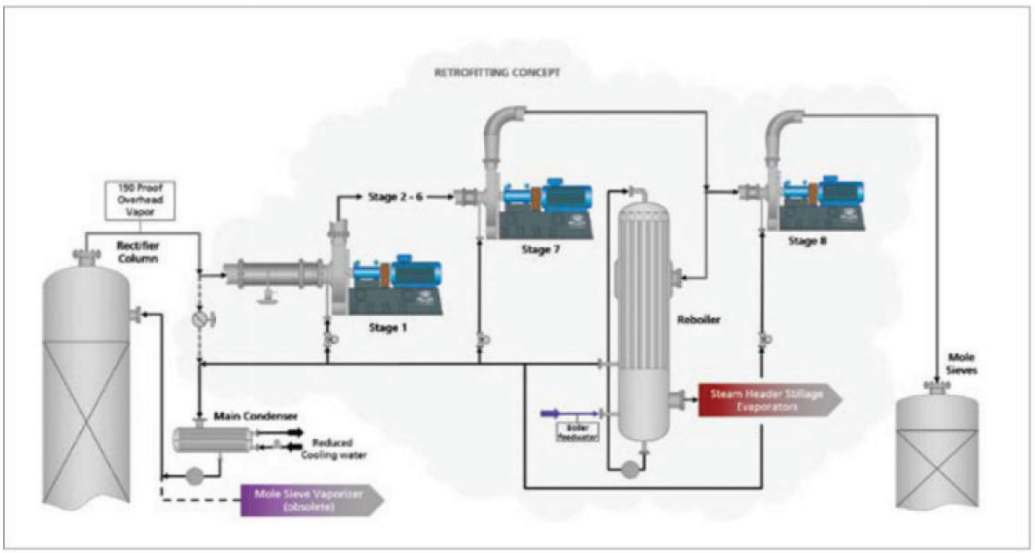
In the retrofitted process, the Mechanical Vapor Recompression (MVR) system with PILLER Blower Technology compresses a major part of the columns overhead vapor to directly feed the dehydration unit and to produce steam for the stillage evaporation.

The compression takes place in two steps. In the first step, two compression trains, consisting of seven MVR blowers– each for one rectifier column – lift the vapor from 340 mbar A and 53 ^{0}C to 3000 mbar A and 108 ^{0}C saturation temperature. After the seventh stage, the vapor flows are split into two streams:

- One stream is directed to the steam generating heat exchangers (reboilers). This stream condenses and generates 100 ^{0}C water vapors for the stillage evaporation process – replacing steam from the natural gas fired boilers.

- The other stream goes into the eighth stage which feeds the molecular sieves at 4000 mbar A and 140 ^{0}C superheat.

To perfectly control a superheat of 23 K, a small amount of the 190-proof condensate produced in the reboiler is injected into the compressors.



PILLER MVR retrofit – direct 190 proof vapor compression for steam generation and mole sieve supply

Matching conditions with vapor compression lines

The high temperature heat demand of the dehydration unit and the stillage evaporator was consuming large quantities of steam from the boiler house. The mechanical vapor compression systems link the low temperature waste heat of the rectifier with the high temperature heat demand and perfectly close the heat recovery cycle over the whole production.

Piller's system integration services

The key to the project's success is the heat pump effect created by the mechanical vapor compression

Figure 3 : PLLER High - Performance blower in the bio-ethanol plant

unit. PILLER supports its customers in the development of initial concepts for heat pump systems based on vapor compression. The blowers and compressors – Made by PILLER – are therefore customized to the individual process conditions and connected to a multi-stage system.

Solutions for heat pumps with temperatures up to 200 deg C, even in hazardous areas, can be realized with that technology.

CONCLUSION

With a COP of 4.56 the heat recovery is an outstanding business case. The success of this recovery cycle outlines that various industrial separation processes can be turned into heat pump loops. Further compression for higher temperature demand is possible and more likely to be considered in regions with high gas prices or high ambitions on CO_2 reduction.