Enhancing The Efficiency of Juice Heater by Utilizing Waste Hot Water

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Abstract

The increasing need for energy-efficient processes in industries has led to a requirement for innovative techniques to save energy. One of the ways is to make juice heating systems more efficient using waste hot water. Heating is an important step in juice processing plants, but it is highly energy-intensive. The system to be designed is centered around the recovery and reuse of waste hot water, which is commonly created by other processes in the production line, e.g., pasteurization, in order to preheat incoming juice. By incorporating this waste heat into the heating process, the energy needed to achieve the required temperature to either pasteurize or sterilize can be significantly lowered. This not only reduces energy use but also helps decrease operation cost and environmental footprint. The incorporation of waste heat recovery systems can result in enhanced overall system efficiency, decreased dependence on external energy sources, and a more sustainable method of juice processing. The ability of such systems to be applied across various food and beverage industries offers great opportunities for wider application, driving a transition toward more energy-efficient manufacturing processes. This research describes the technical, economic, and environmental advantages of the use of waste hot water in juice heating, giving insights into the viability of its application in contemporary processing plant.

Keywords: Energy Recovery, Efficiency Improvement, Sustainability, Technical Aspects

Introduction:

Energy efficiency is a crucial factor in optimizing industrial processes, especially in the sugar and beverage industries, where large amounts of heat energy are required. Juice heaters play a significant role in preheating raw juice before it enters the evaporation and clarification stages. However, conventional juice heating systems often rely on fresh steam, leading to high energy consumption and operational costs. This study explores an innovative approach to enhancing the efficiency of juice heaters by utilizing waste hot water as a supplementary heat source. Waste hot water is an underutilized byproduct in many industries, often discharged without recovering its thermal energy. By integrating a heat recovery system, the available waste heat can be effectively used to preheat the juice, reducing steam consumption and improving overall energy efficiency.

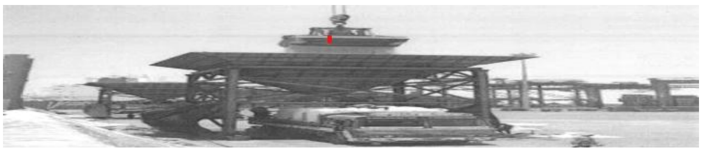

Fig 1 sugarcane loading

The proposed system offers multiple benefits, including lower fuel consumption, reduced environmental impact, and significant cost savings. Additionally, by minimizing heat loss and optimizing thermal energy usage, the process contributes to sustainable industrial practices. The study will analyze the thermodynamic performance, energy savings, and economic feasibility of implementing this approach.

By improving the efficiency of juice heaters through waste heat utilization, industries can achieve substantiaenergy conservation and enhance their overall productivity. This research highlights the importance of energy recovery strategies in achieving a more sustainable and cost-effective operation in juice processing plants.

Sugar Division

The Sakthi Unit, a pioneer that introduced Mechanical Cane Harvester in the country, was established in the year1964atSakthinagar in Erode District, Tamil Nadu with aninitialcapacityof1250TCD, scaling higher in stages, today, the Unit has consolidated its growth with an aggregate capacity of 9000 TCD. The Unit is strategically placed in terms of its location. It is situated in the most favorable climatic zone of the country that hosts more than 35,000 acres of sugarcane cultivation, well irrigated by Rivers and Canals. Nonetheless benchmarking its own records and operating all 365 days in an year, the Sakthi Nagar unit has recorded the highest cane crush of 22.35 Lakh M.T during 2006 -07 seasons. SakthiSugarsproducesHighQualityplantationwhitesugarandrefinedsugarusingsuperior technology and its time tested process. The sugar produced is at par with International Standards with very low NSR(Non Soluble Residue) value of less than 20ppm.

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Fig 2 sugar Division

JUICE HEATER

Juice Heaters find application further processing of screened juice through further heating itto65-700Cintubular juice heater. Post heating, air floatation process is utilized for juice clarification with clear juice obtained further sent to trip evaporator.

The operations these Juice heaters involve use of steam from boilers that assisting heating action. For safeguarding vapour seeping from evaporators, these juice heaters also colne with support of heat exchanger that is provided between vapour and juice.

Fig 3 Juice Heater

PROCESSES OF JUICE HEATER:

- Juice extraction
- Milling
- Diffusion
- Juice clarification
- Juice evaporating

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Milling

Juice extraction by milling is the process of squeezing the juice from the cane under a set mills using high pressure between heavy iron rollers. Those mills canhavefrom3upto6 rolls every set of mills are called tandem mill or mill train. For improve the milling extraction efficiency, imbibition water is added a teach mill: Hot water is poured over the cane just before it enters the last milling the milling train and is recirculated up to the reach the first mill. The juice squeezed from this cane is low in sugar concentration and is pumped to the preceding mill and poured onto the cane just before it enters the rollers, the juice from this mill is the same way pumped backup the milling train. Mixed juice (that is to say cane juice mixed with the water introduced at the last mill) is with drawn from the first and second mills and is sent for further processing. Milling trains typically have four, five or six mills in the tandem.

Diffusion

The diffusion process in a sugar juice heater plays a crucial role in efficiently transferring heat from steam to the sugarcane juice, preparing it for subsequent stages in sugar production. This process primarily involves thermal diffusion, where heat energy moves from a higher temperature region (steam) to a lower temperature region (juice) through conduction and convection mechanisms. The heater is an essential component in sugar processing, as it increases the juice temperature to optimize its viscosity, enhance evaporation, and improve the overall efficiency of sugar extraction. The heat transfer mechanism relies on the principle of Fourier's Law, which governs thermal conduction. As the steam condenses on the heating surfaces, latent heat is released, which then diffuses through the heater's metal walls into the sugar juice. The juice absorbs this heat, leading to a rise in temperature, which facilitates further processes such as clarification, evaporation.

Juice clarification

Juice clarification in a sugar juice heater is a critical step in the sugar production process, ensuring the removal of impurities, non-sugar substances, and unwanted solids from the extracted sugarcane juice. This process is essential for improving the quality of the final sugar product, enhancing efficiency in later stages such as evaporation and crystallization. The juice heater plays a crucial role in clarification by raising the temperature of the raw juice, which aids in coagulation, sedimentation, and the separation of impurities. The heating process facilitates chemical reactions that help remove suspended solids, organic compounds, and colloidal particles that can affect sugar recovery and color.

When raw sugarcane juice is extracted, it contains a mixture of sugars, organic acids, fibers, and impurities such as soil particles, waxes, and proteins. If left unclarified, these impurities can interfere with the crystallization process, lower the sugar yield, and degrade the quality of the final product. To initiate clarification, the juice is first heated to an optimal temperature, usually between 70°C to 105°C, in a juice heater. The heating process enhances the effectiveness of subsequent chemical treatments, such as lime addition (liming), which helps neutralize acidity and coagulate non-sugar impurities.

Juice evaporating

Juice evaporation in a juice heater is a critical step in the sugar production process, as it plays a pivotal role in concentrating the juice by removing excess water, which prepares it for the subsequent stages of crystallization. The process of evaporation in a juice heater involves the transfer of heat to the juice, causing the water content to evaporate, thereby increasing the concentration of sugars and other soluble components in the juice. This step is essential for producing a syrup with the desired consistency and sugar content that can be further processed into sugar crystals. Evaporation not only concentrates the juice but also helps in removing volatile impurities, which contributes to the overall purity of the final sugar product.

In a typical juice heater, the raw sugarcane juice is heated to a specific temperature, usually between 70°C to 105°C, using steam or other heat sources. This heating process causes the water in the juice to vaporize, leaving behind concentrated sugar syrup. The heat transfer mechanism in the heater relies on either direct or indirect contact between the juice and the heat source. In indirect contact systems, steam flows through tubes or jackets, transferring heat to the juice without mixing with it, thus preventing contamination. Direct contact systems, on the other hand, allow steam to come into direct contact with the juice, providing a more efficient heat exchange.

CONCLUSION

Enhancing the efficiency of a juice heater by utilizing waste hot water is a sustainable and cost-effective approach that significantly improves energy conservation in sugar processing. By integrating waste hot water into the heating system, sugar mills can reduce steam consumption, lower operational costs, and minimize thermal energy losses. This method utilizes heat recovery principles, where the excess heat from condensate, evaporators, or other industrial processes is redirected to preheat the sugar juice before it enters the main heater. The incorporation of waste hot water not only improves heat transfer efficiency but also contributes to environmental sustainability by reducing fuel consumption and greenhouse gas emissions. Additionally, preheating the juice enhances the clarification process, leading to better removal of impurities, improved juice quality, and higher sugar yield. Moreover, this technique ensures uniform heating, prevents scaling and fouling in heat exchangers, and extends the lifespan of equipment by reducing thermal stress. The optimized energy usage enhances the overall productivity of the sugar mill while maintaining product quality. In conclusion, utilizing waste hot water in juice heating is a highly beneficial strategy that aligns with modern industrial efficiency goals. It offers both economic and environmental advantages, making sugar manufacturing more energy-efficient, sustainable, and cost-effective. Implementing this approach can lead to significant savings in energy costs, improved process control, and a more eco friendly sugar production system.

REFERENCES

1. Anderson A., (2014). "Improved energy efficiency in juice production through waste heat recycling." Vol 22, No. 3, pp. 757-763.
2. Butrymowicz, D., (2015). "Experimental study on the waste heat recovery system using exhaust gas of combustion engines for heating applications." Vol 4, No. 45, pp. 96-77.
3. Jia, X., (2017). "Energy saving and economic evaluations of exhaust waste heat recovery hot water supply system for resort." Vol 11, No. 42, pp. 77-89.
4. Sivaram, A. (2015). "Experimental investigations on the performance of a water heater using waste heat from an air conditioning system." Vol 91, No. 35, pp. 57-86.
5. Soni, L. (2017). "Review on study of waste heat utilization techniques in vapour compression refrigeration system." Vol 14, No. 55, pp. 2036-2039.