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Energy saving in sugar manufacturing through the integration of environmental friendly new membrane processes for thin juice pre-concentration

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ABSTRACT

In the present work energy savings in clarified thin sugar juice pre-heating and concentration are presented by integrating a new pressure-driven multistage membrane process with multiple-effect evaporator (MEE). The thin sugar juice is concentrated from 15 w% to 50 w% with membrane and from 50 w% to 70 w% in MEE. The new process will not only reduce the energy consumption of thin juice concentration process significantly but will also reduce the requirements of energy and heat transfer area of heat exchangers for pre-heating the thin juice before evaporation by 70%. The existing sugar factories may increase the capacity of their evaporation station through the integration of the new membrane process while new factories to be built will have a smaller sized evaporation station with more energy efficiency and environmentally friendly process performance and with a significantly smaller carbon footprint.

1. Introduction

World sugar production in the year 2009/10 was 158.830 Mt and is expected to reach 170.375 Mt in the year 2010/11 [1]. Sugar manufacturing is one of the most energy intensive processes. Increasing fuel prices and stringent environmental regulations are convincing sugar manufacturers to search for alternative energy efficient and environmentally friendly processes. To improve the economic and environmental performance of the beet sugar industry, Krajnc et al. [2] proposed a zero-waste emission strategy in a case study of a beet sugar factory in Slovenia. In their study they investigated the possible use of waste and by-products from sugar processing to approach zero-waste from beet sugar processing. For utilizing by-products in a useful way, Vaccari et al. [3] proposed the use of pulp and carbonation sludge for the production of paper.

Extensive efforts have been made by the researchers to minimize the energy consumption in sugar manufacturing by one or the other way. The most extensively used approach was retrofitting. A sugar factory retrofit often includes improvements in the factory's energy system comprising power plant, multiple-effect evaporator and process heating equipment [4]. Presently the sugar juice is concentrated by evaporation in MEE which is a very energy intensive process.

Therefore, most of the research work presented in recent years for decreasing the energy consumption in sugar manufacturing has been devoted to the retrofitting of the multiple-effect evaporators and heat exchanger network [5].

By the application of retrofitting techniques and optimization through sophisticated simulation tools the evaporation stations of the sugar factories are extremely efficient in terms of steam and equipment usage. Consequently, there is not much scope for energy optimization by using the present technology of evaporation for concentrating thin sugar juice. Membrane technology has the advantage to remove the water from solution without phase change. Therefore it requires low energy with less thermal damage for concentrating aqueous solutions compared to conventional evaporation.

The potential of membrane technology in the sugar industry has been studied by many researchers but the focus was mainly on sugar juice purification in order to avoid or to decrease the use of lime and multiple purification steps [6,7]. Reverse osmosis (RO) is a type of pressure-driven membrane that has the capability to pass water and reject other dissolved solutes hence concentrates the solution without phase change. The driving force for passing the water/solvent through the membrane is the difference in applied pressure by the pump and the osmotic pressure of the solution at the membrane surface. The technical feasibility of using RO for concentrating various sugar solutions has been demonstrated in

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