Título de la Tesis: "Concentración de jugo clarificado de fruta en un evaporador de película descendente"

Magister en Ingeniería Química

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Resumen

El objetivo del trabajo fue determinar los parámetros de transferencia de calor de un evaporador piloto de un solo efecto bajo diferentes condiciones operativas, a fin de extrapolarlos a un múltiple efecto.

Se utilizó un evaporador de película descendente marca ALVAL, de 12 tubos verticales de acero inoxidable, con un diámetro de 0,0254 metros y 3 metros de longitud, con una capacidad de evaporación de 240 kg/hr.

En su único efecto se simularon las condiciones de cada efecto de uno múltiple, variando la concentración de la alimentación y la presión del sistema, con lo que se definió la temperatura de ebullición y el régimen de transferencia.

Se midieron la presión del vapor saturado a la cámara de calefacción, los caudales de ambas corrientes, las temperaturas y concentraciones de entrada y salida de la corriente de proceso, y se efectuaron los balances de masa y energía y cálculo del coeficiente global de transferencia calor en cada caso. A partir de éste surgió el coeficiente interior:

$$\frac{1}{h_i} = \frac{1}{U} - \sum R_i$$

donde las R_i son las diferentes resistencias a la transferencia de calor (exterior, suciedad, pared del tubo).

Por último se correlacionaron los datos a través de una ecuación que vincula el coeficiente de transferencia con las propiedades de las fases líquida y vapor, las dimensiones características de los tubos y las condiciones de flujo. Se efectuaron comparaciones con correlaciones existentes en la literatura.

Las experiencias se efectuaron con jugo modelo consistente en soluciones de sacarosa de distintas concentraciones, cuyas características físicas y reológicas son similares al producto real.

El trabajo comienza con una introducción al tema, donde se detalla brevemente la importancia de la evaporación en la industria juguera, se describen diferentes tipos de evaporadores y se plantean los objetivos de la investigación (Capítulo 1).

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Abstract

The aim of the work was to carry out the experimental operation of a single effect falling film pilot evaporator, under different operating conditions, in order to extrapolate its performance to that of a multiple effect unit. The ultimate aim was to produce a correlation for the calculation of the process side surface heat transfer coefficient as a function of the governing dimensionless numbers.

The falling film evaporator, made by ALVAL, has 12 vertical pipes of stainless steel, 1 " OD and 3 meters in length, with a capacity of evaporation of 240 kg/hr.

The conditions prevailing in each effect of a three effects unit of the same characteristics were simulated in the single effect unit by changing the conditions, namely the feed concentration and the boiling chamber pressure, as to change the fluid temperature and consequently the heat transfer rate.

Mass flow rate, concentration and temperatures of process fluid were measured at both inlet and exit of the boiling chamber. Also mass flow rate and pressure of heating steam at the boiling chamber were known. With all this data, mass and energy balances were performed allowing the calculation of the overall heat transfer coefficient. The calculation of the process stream side coefficient is straightforward from:

$$\frac{1}{h_i} = \frac{1}{U} - \sum R_i$$

where the R_i are the different resistances to the heat transfer placed in series in the system (outside condensate film, outside fouling, pipe wall, and inside fouling).

Finally the information was correlated with an equation linking the coefficient of transference with the process stream properties, both liquid and vapor, the tube dimensions and the flow regime. Comparisons were carried out by existing correlations in the literature.

The experiences were performed by juice model solution consisting sucrose water solutions of different concentrations, having physical and rheological properties similar to that of the actual product.

The work has been formatted as follows:

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Abstract

Chapter 1 begins with an introduction to the subject, where the importance of the evaporation in the juice industry is briefly commented, different types of evaporators are described and the object of the work is stated.

In Chapter 2 the unit used is described, detailing the instrumentation to measure all process variables. The work done to connect the unit to the auxiliary services (steam, cooling water and electric power) is detailed.

Chapter 3 is devoted to present the literature review, the theoretical background and the existing correlations for the calculation of the heat transfer coefficients on both the steam side and the process side. In particular, the latter will be compared with those experimental obtained by my experiences.

Chapter 4 includes all the information regarding the experimental work, carried out in three stages: the first, with tap water, to test the equipment under working conditions, the second with a saline solution, to set the proper operating conditions and the third by using the model juice solution.

Finally, the experimental data obtained and correlated as well as the conclusions drawn from those results are presented.