World Academy of Science, Engineering and Technology
International Journal of Nutrition and Food Engineering
Vol:12, No:07, 2018

A Regression Model for Predicting Sugar Crystal Size in a Fed-Batch Vacuum Evaporative Crystallizer

Authors : Sunday B. Alabi, Edikan P. Felix, Aniediong M. Umo

Abstract : Crystal size distribution is of great importance in the sugar factories. It determines the market value of granulated sugar and also influences the cost of production of sugar crystals. Typically, sugar is produced using fed-batch vacuum evaporative crystallizer. The crystallization quality is examined by crystal size distribution at the end of the process which is quantified by two parameters: the average crystal size of the distribution in the mean aperture (MA) and the width of the distribution of the coefficient of variation (CV). Lack of real-time measurement of the sugar crystal size hinders its feedback control and eventual optimisation of the crystallization process. An attractive alternative is to use a soft sensor (model-based method) for online estimation of the sugar crystal size. Unfortunately, the available models for sugar crystallization process are not suitable as they do not contain variables that can be measured easily online. The main contribution of this paper is the development of a regression model for estimating the sugar crystal size as a function of input variables which are easy to measure online. This has the potential to provide real-time estimates of crystal size for its effective feedback control. Using 7 input variables namely: initial crystal size (Lo), temperature (T), vacuum pressure (P), feed flowrate (Ff), steam flowrate (Fs), initial super-saturation (S0) and crystallization time (t), preliminary studies were carried out using Minitab 14 statistical software. Based on the existing sugar crystallizer models, and the typical ranges of these 7 input variables, 128 datasets were obtained from a 2-level factorial experimental design. These datasets were used to obtain a simple but online-implementable 6-input crystal size model. It seems the initial crystal size (L_o) does not play a significant role. The goodness of the resulting regression model was evaluated. The coefficient of determination, R^2 was obtained as 0.994, and the maximum absolute relative error (MARE) was obtained as 4.6%. The high R^2 (~1.0) and the reasonably low MARE values are an indication that the model is able to predict sugar crystal size accurately as a function of the 6 easy-to-measure online variables. Thus, the model can be used as a soft sensor to provide real-time estimates of sugar crystal size during sugar crystallization process in a fed-batch vacuum evaporative crystallizer.

Keywords : crystal size, regression model, soft sensor, sugar, vacuum evaporative crystallizer
Conference Title : ICFPSI 2018 : International Conference on Food Processing Systems and Industries
Conference Location : Prague, Czechia
Conference Dates : July 09-10, 2018