Energy consumption in ethanol production by enzymatic hydrolysis – The integration with the conventional process using Pinch Analysis

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Introduction

Ethanol is produced in Brazil in large scale using sugarcane as raw material by fermentation of sugars and distillation. The sugarcane bagasse is the major by-product in sugar and ethanol production, it is burnt in boilers to attend the steam and power requirements of the process.

Nowadays, the ethanol production from lignocellulosic materials through hydrolysis process is being researched all over the world, including the installation of pilot plants to test different process types. Sugarcane bagasse, as well as other lignocellulosic materials, can be also used for ethanol production but, the introduction of the bagasse hydrolysis process in the current ethanol production system is a real challenge, being bagasse the fuel of the current process and at the same time, raw material for the new one.

The aim of this study is to make a diagnosis of the possibilities of ethanol production increasing through the introduction of bagasse hydrolysis process, considering the limiting situation of bagasse use. Simulations in ASPEN PLUS® software were performed, in order to evaluate the mass and energy balances, for both, integrated processes, considering the pre-treatment by steam explosion.

The cogeneration system was also modeled and integrated with the ethanol production process. It consists of a steam cycle with backpressure steam turbines and parameters of steam of 67 bar and 480°C. Steam turbines have a bleed at 22 bar to feed direct driven turbines and at 6 bar to fulfill requirements in the must sterilization and ethanol dehydration processes. In all the Cases studied it was considered that the steam flux used in the system was just that is necessary to fulfill the process thermal needs, so, it was assumed that the surplus of bagasse was used to produce ethanol. The use of sugarcane trash was considered in order to accomplish the energetic needs of the overall process.

Three cases were evaluated which include the conventional ethanol production plant without hydrolysis (Case I), the conventional plant joint with hydrolysis process without thermal integration (Case II), and the conventional plant joint with hydrolysis process considering thermal integration through Pinch method (Case III).

Results and Conclusions

Results showed that Case II has an ethanol production increase of 9.4% in comparison to Case I, while Case III has an ethanol production increase of 13.8%. On the other hand, the steam consumption increases 53.7% and 38% for cases II and III respectively. Electricity surplus resulted 22.8 MW, 37.2 MW and 31.9 MW for Cases I, II and III. Case III showed the highest ethanol production; however this is a prospective study and pilot plant/industrial data would be necessary in order to adjust the modeling. The Pinch analysis showed to be a useful tool to evaluate the thermal integration potential for the cases considered.

The results of steam consumption showed that the concentration of glucose liquor from hydrolysis process has a high steam consumption (approximately 24% of the total consumption of the plant in Case II), due to it is very diluted (approximately 1.8%). In order to reduce this increase in steam consumption in the concentration operation, new technologies can be considered, as the use of membranes to concentrate the glucose liquor until Brix levels appropriated to fermentation process or the adoption of higher solid content in the hydrolysis reactor. This reduction in the steam consumption would permit a higher increase in the ethanol production.

Keywords: sugarcane, ethanol, enzymatic hydrolysis

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