CONCEPTUAL DESIGN OF A WHITE SUGAR FACTORY OFFERING MAXIMUM COGENERATION

By

PEDRO AVRAM-WAGANOFF
IPRO Industrieprojekt GmbH, Braunschweig, Germany

Abstract

The increasing market demand for white sugar of high quality has led to the development of microfiltration and other techniques enabling juice purification and sugar boiling processes in cane sugar factories to be simplified. When these techniques are applied together with high-pressure steam boilers and condensing-extraction turbogenerators, wholly electrified drives and continuous process stations, the resultant white sugar factory can save at least 40% of the available bagasse during a 150 day crop, while still exporting approx. 35 kWh of electrical power per tonne of cane. The excess amount of bagasse is baled during the crop and employed for firing the power station during the off-season, generating an additional 77 kWh/t electrical power. In total, approx 112 kWh/t of cane can be generated for export to the grid on a year-round basis, without employing any additional fuel or sophisticated methods like bagasse gasification.

Introduction

Demand for 'white sugar' with colour levels of 100 I.U. (or less) has continuously grown in most countries of the world. With the advent of ultrafiltration membranes, combined with efficient short retention clarifiers and separate clarification of filtrate and retentate, it is possible to reduce colour and turbidity levels entering the sugar end of a cane sugar factory to such a degree that direct production of good quality white sugar is practicable without refining steps.

In order to increase cane sugar factory productivity, cogeneration of electricity from surplus bagasse has been proven to be a commercially viable option in several countries like Mauritius, Guatemala and Hawaii for many years. In order to maximise their cogeneration potential, the energy efficiency of most cane sugar factories has to be improved markedly. The techniques of how to accomplish this are already available, as summarised by Bullock (1999) and discussed in detail by Wunsch and Avram-Waganoff (1999).

This paper presents the conceptual design of a large (24 000 t/d) modern cane sugar factory incorporating the following features:

- single-line continuous process stations where possible;
- proven modern technologies offering high sugar yield and/or high energy efficiency;
- high quality white sugar production without sulphitation or refining;
- high-pressure boilers and extraction-condensing turbogenerators;
- baling of the excess bagasse during the crop and employing it during the rest of the year;
- simplified layout with a significant part of the equipment placed outside;
- white sugar storage partly in bulk (in 2 large cylindrical silos) and partly in bags.

The poster paper will present the base data employed for designing the factory, tabular results of the mass and heat balances for the main process stations and basic flow diagrams of juice extraction, clarification, evaporation and the sugar boiling house. Further, two simplified schematics showing the operating parameters of the steam boilers and turbogenerators during the crop and during the off-season will be included. An investment cost summary shows the result of detailed price estimates of the necessary mechanical equipment plus pro-rata estimates for all other costs. A gross income calculation shows the expected annual turnover of the proposed factory and an overall layout drawing how the factory could look from the air and its total land requirements.

Process aspects

One of the main design targets of the investigated case was to obtain the lowest possible process steam consumption in order to be able to create a sizable bagasse surplus. Due to having chosen cane diffusers for the sake of high pol extraction and lower power consumption than conventional milling tandems (Rein, 1999) 'hot' raw juice at 65°C is obtained. This fact limits the use of lower temperature vapours and therefore a process steam demand of 30.4% on cane (304 t/h) was the lowest value that could be obtained.

Another important design target was the production of white sugar with colour levels of 90-110 I.U. without employing sulphitation or refining steps. Figure 1 shows the factory flow scheme. Simple lime defecation is followed by sedimentation in short retention clarifiers. Mud juice is desweetened in rotary filters and the resulting filtrate goes to a separate flotation clarifier. Retentate from the microfiltration membranes is also sent to this clarifier. Clarified filtrate is recycled to the main liming tank due to its higher load of non-sugars and colourants.

KEYWORDS: Factory Design, Cost-Effectiveness, Year-Round Cogeneration, Economics.
Clarified juice from the main clarifiers is pumped to the microfiltration plant. Based on long-term experience in Hawaii and many trials at different cane sugar areas, the French Company Applexion recommends a pore size of 0.1 microns as a good compromise. Ceramic membranes with this pore size can give a 50% reduction in colour of clarified juice, besides removing over 90% of the turbidity and over 50% of dextran and starch.

The clarified and microfiltered juice ('thin juice') with a colour level of approx. 4000 I.U. enters the falling-film plate evaporator station. Due to moderate temperatures (juice temperature in the first body is 121°C and in the preevaporator 107°C) and short retention time (approx. 20 min.) we have estimated a 10% colour increase. As shown in Figure 3, thick juice with 4560 I.U. colour is mixed with melted 2nd sugar and affinated 3rd sugar giving a 'standard liquor' of 3120 I.U. which feeds the first product pan. Due to the previous removal of dextran, gums and waxes as well as 50% of macromolecular colourants first product sugar colour will be approx. 90-110 I.U. All products are boiled in continuous pans. To ensure good C.V. values and uniform crystals, seed magma is boiled in dedicated batch pans for each product.

**Power station and cogeneration**

Steam production required for process, deaerator, etc. during the crop is 324 t/h at 85 bar, 525°C. We have foreseen 2 boilers (of 180 t/h maximum capacity each) and 2 condensing-extraction turbines driving generators capable of producing 33.4 MW each. During the crop 150.5 t/h of exhaust steam at 2.5 bar (abs.) is extracted from each unit for process purposes and 12 t/h at 0.06 bar for condensation and return to the boiler feedwater system (Figure 2).

After the crop, the same units operate in wholly condensation mode. Each turbine can absorb nearly 102 t/h of 85 bar steam and condense it at 0.120 bar absolute pressure. The maximum possible electrical generation is 30 MW each under these circumstances (Figure 3).

During the crop (150 d/a), the sugar factory requires approx. 31 MW, so that there is a remainder of 35 MW for export, i.e. $35 \times 150 \times 24 = 126$ 000 MWh. The excess bagasse (128-132 t/h depending on the specific steam consumption of the boiler) is baled during the crop and stored in rectangular piles outside. A paved area of 64 000 m² has been foreseen for storing up to 470 000 t of surplus bagasse produced during the crop. This amount will be used up during 200 d/a generating 30 MW per turbogenerator, giving an amount of 278 000 MWh of export power.

A gross income calculation for the products of the factory (sugar, molasses and electricity—Table 5) shows that, even at world-market prices, this approach should be interesting to a number of cane sugar producers.
REFERENCES

CONCEPTION D'UNE USINE DE SUCRE BLANC OFFRANT UN MAXIMUM DE COGÉNÉRATION

PEDRO AVRAM-WAGANOFF
IPRO Industrieprojekt GmbH, Braunschweig, Germany

Résumé
L'augmentation de la demande en sucre blanc de très bonne qualité a amené le développement de micro-filtration et d'autres techniques permettant la simplification de l'épuration du jus et de la cuite en sucreries de canne. Quand ces techniques sont utilisées avec des chaudières à hautes pressions, des turbo-alternateurs à condensation-extraction, des moteurs complètement électrifiés et des procédés en continu, la sucrerie peut économiser au moins 40% de la bagasse disponible durant les 150 jours de roulaison tout en exportant approximativement 35 kWh d'énergie électrique par tonne de canne. L'excédent de bagasse est mis en ballots durant la campagne et utilisé par la centrale durant la période hors saison, générant de l'énergie électrique additionnelle de 77 kWh/tonne. En totalité, approximativement 112 kWh/tonne de canne peuvent être exportés aux réseaux durant toute l'année sans l'apport additionnel de combustible ou des méthodes sophistiquées comme la gazéification.

Mots clés: Conception des sucreries, rentabilité, cogénération durant toute l'année, économie.

CARACTERÍSTICAS DE UN INGENIO PRODUCIENDO AZÚCAR BLANCO CON COGENERACIÓN MÁXIMA

PEDRO AVRAM-WAGANOFF
IPRO Industrieprojekt GmbH, Braunschweig, Germany

Resumen
La demanda creciente de azúcar blanco de alta calidad ha propiciado el desarrollo de las técnicas de microfiltración y otras de tal manera que es posible simplificar los procesos de la clarificación del jugo y en la casa de cocimientos de ingenios cañeros. Aplicando estas técnicas junto con calderas de alta presión, turbogeneradores de condensación-extracción, impulsiones totalmente electrificadas y líneas de proceso sencillas, es posible ahorrar aprox. el 40% del bagazo disponible durante una zafra de 150 días. A la vez se pueden exportar ("cogenerar") 35 kWh por tonelada de caña procesada. El bagazo sobrante se puede embalar en pacas durante la zafra y es empleado como combustible en las calderas el resto del año, generando adicionalmente 77 kWh/t caña. O sea en total se pueden generar 112 kWh/t caña para exportar a la red, sin emplear combustible adicional o métodos sofisticados como gasificación del bagazo.

Palabras clave: Factory design, economics, inversión económica, year-round cogeneration, economics.