Process technologies for the White Nile Sugar Factory

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abstract

This paper describes and discusses modern technologies employed in designing the sugar process house in the 24,000 t cane/day capacity (TCD) sugar factory at The White Nile Sugar Project. The central aim is to minimize steam and power consumption, and maximize co-generation capacity with production of good quality sugar. The process is specially designed in such a manner that there is no use of SO_2 gas for juice clarification to avoid scaling in evaporators as evaporator vapor bleeding scheme is key to reduce steam consumption. Process don't produce raw sugar for making white sugar of 60-65 ICUMSA, this avoids excess melting of sugar and controls energy also.

Keywords: **energy saving, process technology, steam economy, sugar production, White Nile Sugar Project**

Tecnologías de proceso para el ingenio azucarero de White Nile

El proceso está especialmente diseñado de tal manera en la que no es necesario utilizar SO_2 gaseoso para la clarificación del jugo. Esto evita la incrustación en los evaporadores dado que el plan de purgado de vapor es clave para reducir el consumo de vapor. El proceso se diseña para reducir la carga de azúcar fundido dado que se evita la producción de azúcar crudo y se produce azúcar directamente comercializable de 60-65 ICUMSA.

Tecnologias de processamento para a fábrica de açúcar White Nile

O processo é concebido de tal maneira que não há uso do gás SO_2 na clarificação do caldo. Isto evita escamação nos evaporadores já que o esquema de purga de vapor do evaporador é chave para a redução do consumo de vapor. O processo é projetado para reduzir a carga de derretimento de açúcar já que a produção de açúcar bruto é evitada e o açúcar comercializável ICUMSA 60-65 é produzido.

Introduction

Isgec Heavy Engineering Limited designed, supplied and erected the 24000 TCD process house at White Nile Sugar Factory in Sudan (Figure 1). This plant is designed with most modern technologies and automation at 30-32% on cane steam consumption for maximizing co-generation and producing white sugar of 60-65 ICUMSA without sugar refinery process to make it more cost effective. 1st phase of this plant has been recently commissioned. The project overview is given in Table 1.

Table 1. Project overview

Plant	White Nile Sugar Company, Sudan
Capacity	24000 TCD
Process	✔ specially designed Isgec clarification process ✔ filtrate clarification ✔ micro filtration of filtrate ✔ syrup clarification ✔ syrup sulphitation ✔ low grade sugar melt clarification
Final product	White sugar of less then 60-65 ICUMSA
Steam consumption	30-32% on cane

Modern technologies adopted to minimize steam and power consumption in process house

Steam saving devices

Condensate flash recovery system: Normally condensate is collected individually from evaporators, juice heaters and pans and sent to overhead hot water tank. The inherent heat is not recovered and is lost to the atmosphere.

In flash recovery system as shown in Figure 2, all condensate from juice heaters, pans and evaporators is collected in multi compartment condensate flash tank at successive temperatures and pressures. The flash vapour is recovered from different compartments and fed to evaporator body operating at similar pressures.

Flash recovery results in reduction of steam consumption by 2-2.5% on cane. It also reduces power consumption due to reduction in number of condensate pumps. One of the installations of multi compartment condensate flash tank is shown in Figure 3.

Molasses conditioner: Direct contact type molasses conditioners are used to reduce steam consumption at pan floor. Third effect vapours of evaporator or noxious gases are used in these molasses conditioners with temperature and brix

Figure 1. White Nile Sugar Factory, Sudan (24000 TCD sugar plant)

Figure 2. Flash recovery system

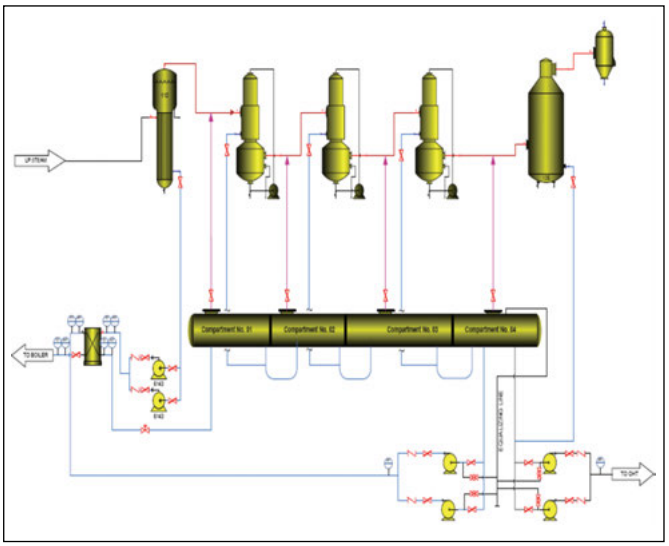


Figure 3. Multi compartment condensate flash

Figure 4. Continuous type horizontal sugar melter

control automation.

These molasses conditioners have inbuilt static mixer therefore no mechanical agitation is required. As these are direct contact type, there is no requirement for addition of water for maintaining brix of molasses.

These conditioners are installed at pan floor above molasses pan supply tank

For sugar melting the use of exhaust / live steam is a common practice in sugar industry.

For steam economy, low grade vapour/ noxious gases are used for sugar melting instead of exhaust / live steam. For using low grade vapour, especially designed horizontal sugar melters, as shown in Figure 4, have been introduced. These can operate under vacuum (at 70-85°C) with temperature and

Figure 5. Battery of direct contact heaters

Figure 6. Continuous vacuum pan

brix control automation.

These melters with horizontal shafts are driven by highly efficient and compact planetary drives.

Direct contact heater for juice heating: Direct contact juice heaters are used for heating juice, syrup and melt.

These heaters operates at low approach temperatures, between 1.5-2.0°C, Due to this property of direct contact heaters, of operating at lower approach temperatures, bleeding scheme can be shifted to later effect.

In direct contact heaters, as shown in Figure 5, juice heating is accomplished though direct contact of juice with the heating media that is low grade vapours, the temperature of juice is increased close to the temperature of the heating media.

This facilitates continuous operation without any need for periodic cleaning of juice heaters. For efficient operation of

Figure 7. Sugar model-clarification section

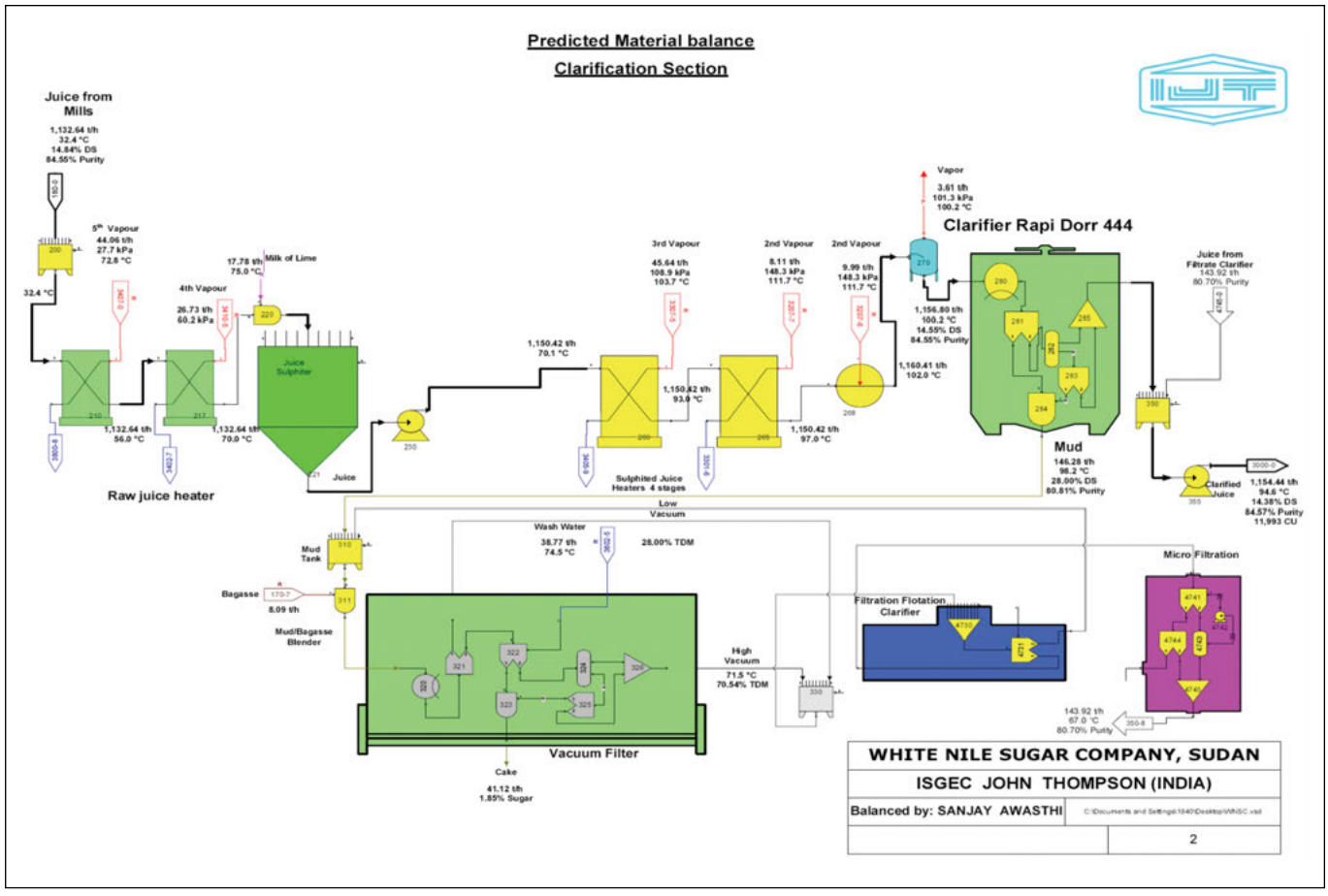


Table 2. Design basis

Crushing capacity	24000 TCD
Crushing rate	1100 T/h
Pol % cane	13.51
Fibre % cane	15.50
Mixed juice % cane	102.96
Defecated juice % cane	104.53
Clear juice % cane	104.94
Untreated syrup % cane	21.67
Brix of clear juice	14.38
Brix of syrup	70.05

Table 3. Steam condition

Heating media	Pressure Kg/cm²(a)	Temperature (Deg. C)	Latent heat (kcal/kg)
L.P. steam	2.53	127.5	520.43
1st body vapour	1.78	117	527.23
2nd body vapour	1.48	111.7	531.20
3rd body vapour	1.08	103.70	536.10
4th body vapour	0.60	87.7	546.12
5th body vapour	0.27	72.3	556.17

these heaters, automation for temperature and level control is provided.

Continuous vacuum pans: Steady state operation in a continuous vacuum pan as shown in Figure 6 provides predictable crystal growth. The massecuite in each compartment can be maintained at constant brix and crystal content with the help of suitable automation.

The high heating surface to volume ratio and low boiling head allows the use of lower grade vapour in continuous vacuum pans (CVP) which can not be achieved in batch pans.

Further, higher circulation ratio is ensured in the design of continuous vacuum pans. The advantage of having higher circulation ratio is that it improves the exhaustion of sugar from molasses therefore resulting in low molasses purity.

Another important feature which is available in the design of certain specific continuous vacuum pan is under-base heating, which also helps to promote massecuite circulation and prevent crystallization on the shell of continuous vacuum pan.

Falling film evaporator: The falling film evaporators are more advantageous than Robert and rising film evaporators.

The residence time of juice in falling film evaporators is very low Hence falling film works on low inversion, less color formation and low sugar loss.

As the hydrostatic head in falling film evaporators is very low, they can work on very less temperature gradient (ΔT) and can

Figure 8. Sugar model-clarification section

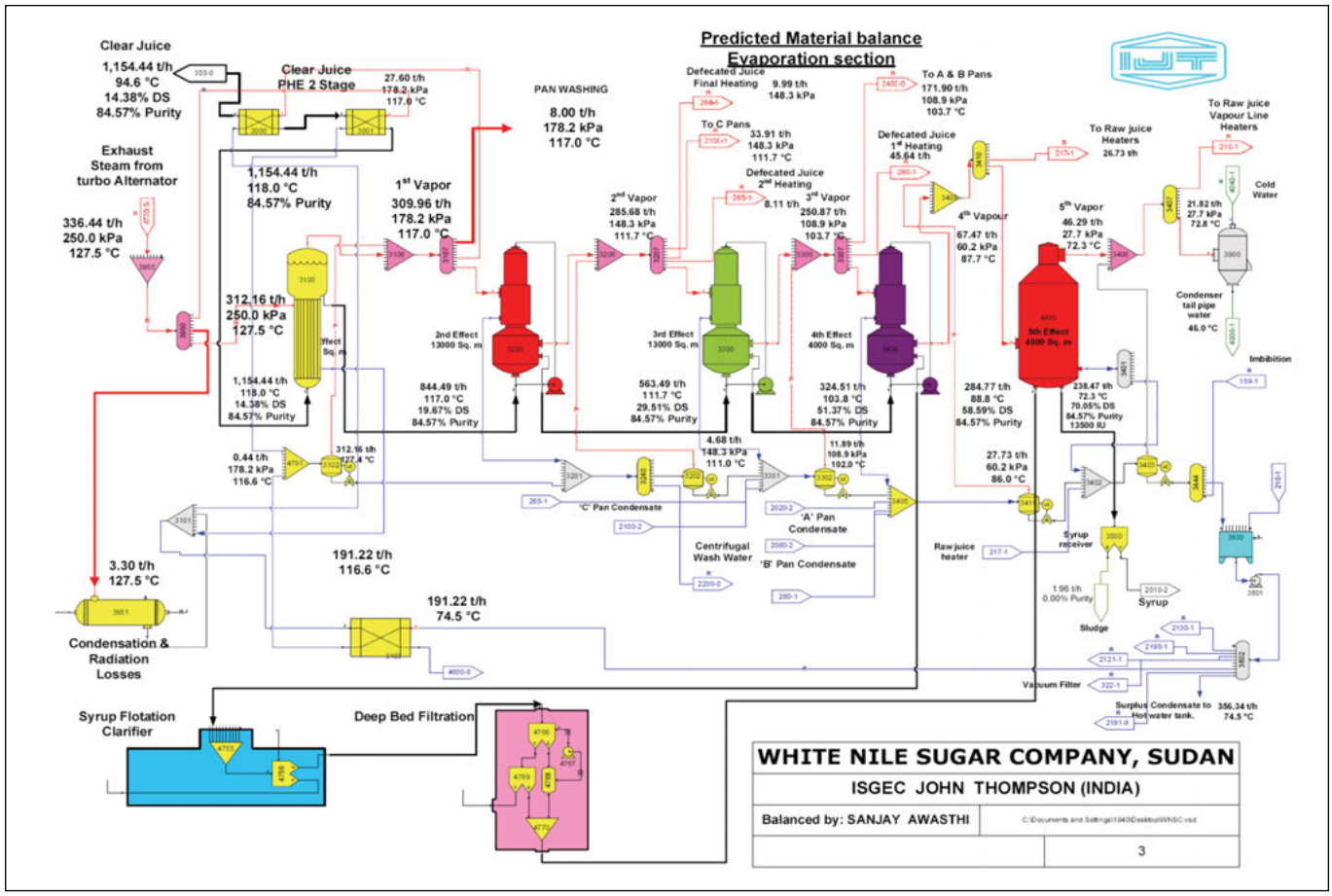


Table 4. Total steam requirement for boiling house

Description	T/Hr	% cane
L.P steam requirement	333.14	30.28
Condensation and radiation losses	3.30	0.30
Total steam requirement	**336.44**	**30.58**

be used at lower effects i.e. 2nd, 3rd and 4th effect of quintuple evaporator set.

Power saving devices

The following devices are adopted to reduce power consumption in process house:

Use of variable frequency drives on:

- Batch type centrifugal machines
- Air compressors
- Injection pumps and spray pumps
- All pumps for juice, molasses, massecuite where flow regulation is required

Use of planetary gear boxes on:

- Crystallizers
- Clarifiers
- Pug mill and magma mixers
- Sugar melter

Selection of clarification and boiling process

The following parameters were considered by Isgec in designing of the process house for the White Nile factory:

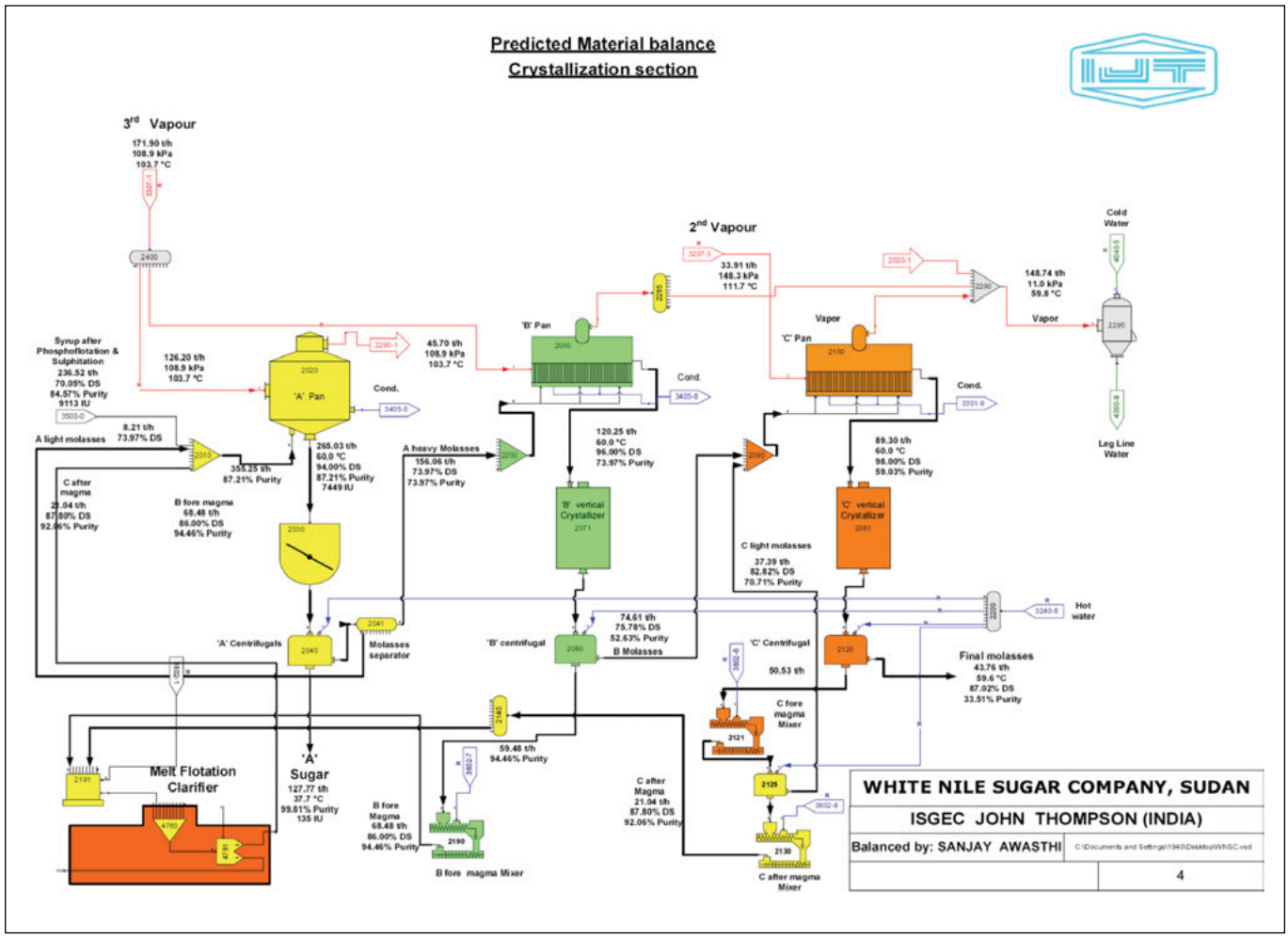
- Production of good quality sugar having sugar color from 60-65 I.U. without refinery process
- Minimum steam consumption
- Minimum production and operational cost.

Isgec's specially designed clarification process for White Nile Sugar Company is as follows:

a) For juice clarification, defecation process is adopted to reduce sulphur content in sugar and scaling in evaporator.

b) For achieving sugar quality as per international standards following processes are adopted:

Figure 9. Sugar model-evaporation section



- Filtrate clarification followed by micro filtration of filtrate to mix it with clear juice as shown in Figure 7
- Syrup clarification followed by multi-bed filter and syrup sulphitation
- Low grade sugar melt clarification system for decolorization of melt.

c) Specially designed boiling scheme is adopted which helps in reducing steam consumption.

Heat and energy mass balance

This plant uses a quintuple effect evaporator along with flash recovery system. Bleeding system is designed for 30-32% steam consumption (as shown in Table 4). Detailed calculation of steam and mass balance is given below in Tables 2 and 3 and Figure 8.

Vapour bleeding scheme

As shown in Figure 8, maximum vapour bleeding is done by 3rd and 4th effect to achieve the minimum steam consumption.

As shown in Figure 9, continuous type vacuum pan is used for B and C massecuite boiling using 3rd and 2nd vapour respectively.

Batch Pans with mechanical circulator is used for 'A' massecuite boiling using 3rd vapour. The melt of B and C sugar is clarified through melt clarification system and used for A massecuite boiling.

Conclusions

Modern sugar plants offer the following:

- Good quality sugar can be made with out refinery process.
- Less steam consumption in process means less boiler capacity
- In order to have at least 300 days of operation of cogeneration, the saved bagasse can be used to prolong the co-generation beyond season.
- In co-generation, less extraction and more steam to condenser leads to more power generation. It makes a sugar plant a model for aself-sustained business.