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World Largest Tower Diffuser from BWS - Buckau-Wolf system

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1. Introduction

The development of the Continuous Counter current Extraction **System Buckau-Wolf** began in 1952. The first plant for a beet processing of 1,500 metric t/d with a tower diameter of 4.0 m (13.1 ft) and a cossette column of 9.0 m (29.5 ft) was realized in 1954.

At this time, about 170 extraction towers **System Buckau-Wolf** are working in nearly all beet processing countries.
Today towers with a capacity of more than 14,000 metric t/d and a diameter of nearly 12.5 m (41 ft) and a cossette column of over 25 m (82 ft) are constructed.

During the sugar beet campaign of 2000, **BWS** started up successfully a new Tower Diffuser Extraction System at the Lillers sugar factory in France. The world's largest extraction plant consists of the continuous counter-current mixer and continuous extraction tower. The complete plant is designed for a capacity of 14,000 metric tons per day.
The installation is equipped with modern measuring and automatic control equipment, which makes the whole system reliable and easy to operate.

The new diffusion plants have to meet high demands such as:

- high performance
- high operational safety
- low maintenance requirements (all parts are made of massif stainless steel)
- long service life
- small raw juice draft and low sugar loss
- energy-saving technology (vapour consumption less than 1 kg per 100 kg beets)
- automatic operation
- low operation cost

2. Design of the new Extraction Plant

Operational experience with a 10,000 tons/day nominal capacity extraction plant (in reality reaching more than 12,000 tons/day) served as a basis for the development and design of the largest diffuser plant in the world.

Following scale up formula help to define the right mechanical and process design to fulfil the costumer requirements. The daily beet handling (m_t in t/d), The spesific screen load (t/d.m^2) is given by the factor f1, the specific arm length load (t(/d.m) is given by f2 and the specific extraction volume load (t/d.m^3) defined by f3.

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Parameter	Formula	Result
Factor f1	$f_1 = \frac{m_t}{z_R . L_R}$, [t/24 h ft]	107 to 213
Factor f2	$f_2 = \frac{m_t}{A_s}$, [t/24 h ft^2]	15 for tower 31 for mixer
Factor f3	$f_3 = \frac{m_t}{V_e}$, [t/24 h ft^3]	0,2 lower juice draft (for a given sugar loss) 0,26 higher juice draft (for a given sugar loss)

Table 1: Design formula

Tower		
Diameter of the tower	[m]	12.4
Height of the tower	[m]	25.1
Extraction Volume	Ve [m^3]	1900
Screen surface	[m2]	75
Residence time	[min]	140
Throughput	m_t [t/24 h]	14,400
Cossettes mixer		
Diameter of the mixer	[m]	6.7
Length of the mixer	[m]	9.8
Residence time	[min]	15
Volume	Ve [m^3]	290

Table 2: Technical data of the new extraction plant

The whole plant (mixer and tower) is made of massive stainless steel. This design provides a high sterilization effect that reduces the infection and sugar losses in the tower and increases the quality of the raw juice. The equipment is manufactured by ERES-France, who already has many years of experience in building the extraction plants for BUCKAU-WOLF. Complete engineering, assembly supervision and commissioning has been furnished by BWS Technologie GmbH.

3. Extraction process

The BWS diffusion plant consists of the main units, counter-current cossette mixer and the diffusion tower. The total plant also includes: preheater, degassing tank, pumps, water treatment plants, pipe systems, switchgear and control equipment, etc.

The washed and cut beets are fed without air (anaerobe process) to the horizontal counter-current mixer in which they are heated, denaturised and degasified. After passing through the cossette mixer and after being mixed with a large quantity of juice the cossettes are pumped into the tower. The tightly packed column of

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cossettes inside the tower travels upward while the actual desugarization takes place.
The press water and the additional needed fresh water is fed to the tower separately at two different levels below the liquid surface. The diffusion liquid accumulates an increasing amount of sugar during its downward travel through the cossettes column and leaves the tower through a bottom screen covering the entire cross section of the tower.
Part of the flow is directly guided to the cossettes mixer whereas the remaining part is pumped to a preheater and takes up the quantity of heat required to heat up the cossettes. The extracting liquid which is cooled down on its way through the mixer is drawn off through a screen as the „cold" raw juice and lead to further processing.

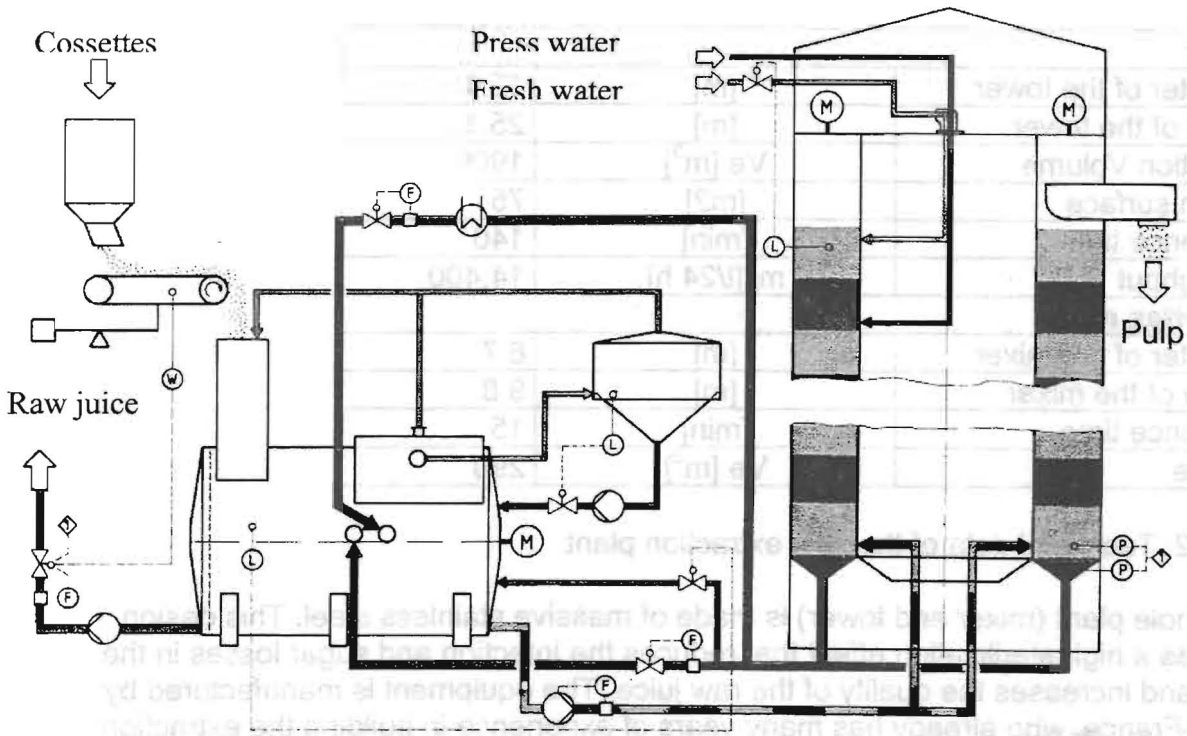

Fig. 1: Flow sheet

4. The cossettes mixer

Inside the counter-current mixer a large portion of the juice is mixed with the cossettes and flows back to the cossette pump. The remaining juice quantity equivalent to the desired raw juice draft flows through the fed cossettes in a counter-current operation, delivers its heat to the cossettes and is drawn off as a raw juice through a screen. The counter-current principle enables the rapid, stable and continuous heating of the cossettes with the vapours. This system helps to minimize the sugar plant energy consumption.

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Using circulation juice for heating up the cossettes, it is ensured that enough heat energy is always available. The consumption of the Continuous Counter current Extraction **System Buckau-Wolf** equal to 1 kg steam per 100 kg beets.

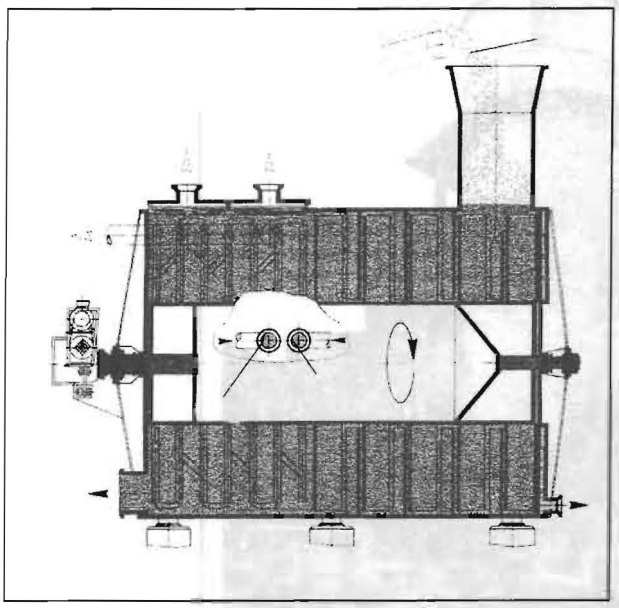

Fig.2a :Cossette mixer

Fig.2b: Inner part of the cossette mixer

5. The vertical extraction tower

The vertical extraction tower of Buckau-Wolf system provides the maximum desugarization of the cossettes with a lower juice draft at a normal extraction time. The design offers maximum safety of operation, gentle processing of the cossettes and optimum use of the extraction volume.

The heated and degasified cossettes are fed into the tower from below together with about 200 % of circulation juice. They are conveyed through the tube connections that are fixed in the tower bottom plate into a circular channel rotating together with the inner tube of the tower. The number of agitating arms and baffle plates depends on the size of the tower.

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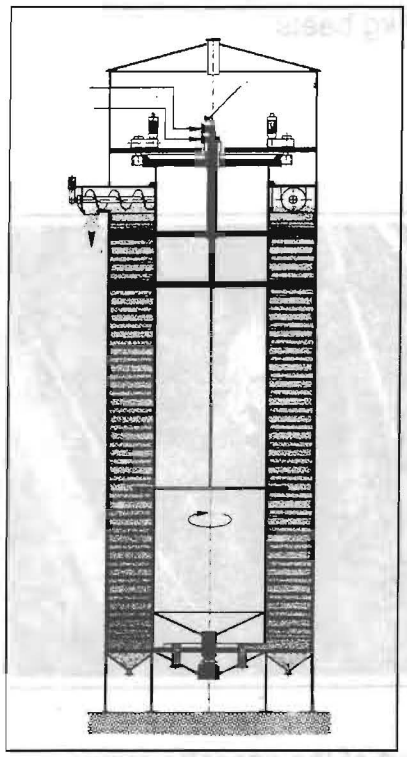

Fig.3a: Section view of the tower

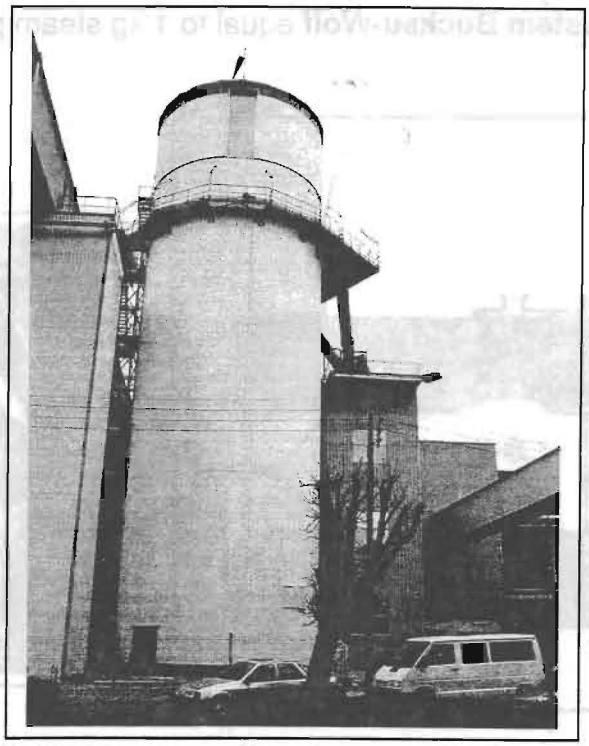

Fig.3b:Extraction Tower at Lillers factory (France)

6. Design features of the new BWS Extraction plant

6.1. Rotating cossettes supply

The special design for entering of the cossettes into the extraction tower ensures an extremely uniform distribution of the cossettes coming from the counter-current mixer and carried into the extraction area of the tower.

It consists of fixed connection pieces (for 14.000 t/d tower: 3 connection pieces) through which the cossettes are pumped below the inside tube of the tower into an annular channel, which is mounted on the bottom of the inside tube and rotating together with it. From this annular channel the cossettes are carried into the extraction area of the tower by means of 8 lateral channels also rotating together with the inside tube. The symmetrically arranged screen scrapers work away that the lateral channel orifices situated between two screen scrapers brush over the largest possible free screen surface.

Since the cossettes are supplied through the inside tube, additional pipelines at the outside shell are not necessary.

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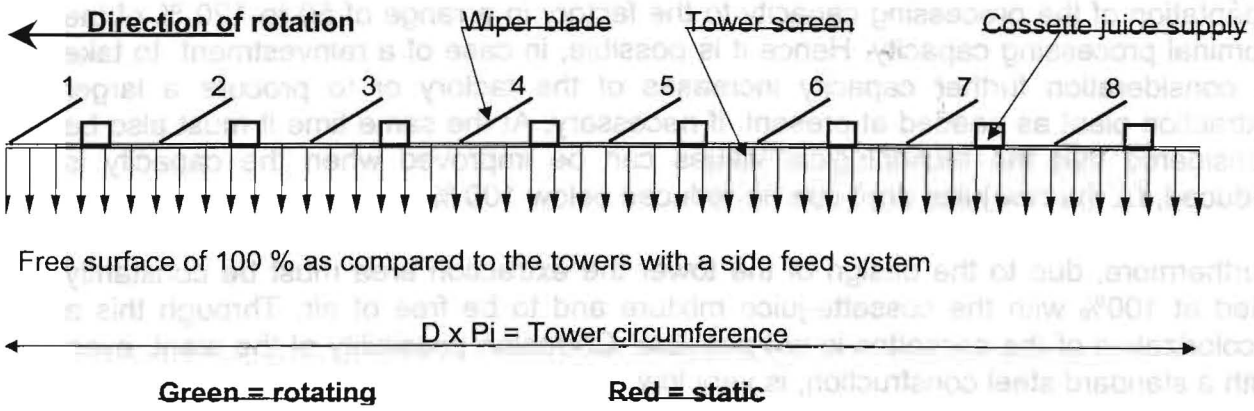

Fig. 4: Rotating cossette supply

Due to the larger open screen face and the special way of cleaning the tower bottom screens (mechanical and hydraulical) the installation of the lateral screens to increase the screen surface is not necessary. This leads to the several advantages. The main advantage consists in the fact that the dead corners are avoided. And they inevitably occur with lateral screen boxes increasing the susceptibility to infections.

6.2. Central addition of water and disinfectant into the tower

Fresh and press water are added separately from the top by means of tubes fit concentrically into one another and led through the upper bearing into the inside tube. From there they are distributed via two radially arranged pipe systems rotating together with the inside tube, and fixed below the corresponding agitator arm at a height corresponding to the sugar concentration. This system doesn't require additional pipework at the outside shell of the tower.

Disinfectant (f. a. Formalin) is added in a similar way by means of a third pipe system about halfway of the extraction area. Because of this, an optimum result is obtained to disinfect the cossette-juice mixture in the extraction tower.

Some countries do not use formalin to disinfect the extraction plant. Hydrogen peroxide (H2 O2) or ß-acids of hop (Lupulone) are alternately used. The effectiveness of both substances is very similar to formalin. The amount to be added in between 30 and 150 g/t beets depending on the quality of the beets.

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6.3. Advanced Design

Design and construction of the BUCKAU-WOLF extraction system allow an adaptation of the processing capacity to the factory in a range of 50 to 120 % of the nominal processing capacity. Hence it is possible, in case of a reinvestment, to take in consideration further capacity increases of the factory or to procure a larger extraction plant as needed at present, if necessary. At the same time it must also be considered that the technological values can be improved when the capacity is reduced, f.i. the raw juice draft can be reduced below 100 % o.b.

Furthermore, due to the design of the tower the extraction area must be constantly filled at 100% with the cossette-juice mixture and to be free of air. Through this a dicolorization of the cossettes is not possible. Corrosion possibility of the plant, even with a standard steel construction, is very low.

Important advantages are also observed when cossettes are introduced (kg/l). The cossettes filling is approximately 70 to 75 %. This means in connection to the above mentioned hundred percent filling, an optimum utilization of the existing extraction volume.

6.4. Heat introduction to the extraction plant via heating of circulation juice and heat exchange in the mixer

Heating of the cossettes for denaturation of the cossette cells is made in the counter-current mixer. The juice running into the mixer must be heated in addition.

With the BUCKAU-WOLF system it happens by heating a part of the circulation juice flow coming from the extraction tower in the special free-flow plate exchangers.

As a result a uniform and constant heating of the cossettes in the mixer is obtained since the juice flow circulating between tower and mixer is independent of the introduced quantity of cossettes.

Due to the uniform and high rate heat exchange in the mixer the circulation juice partly flowing in the plate exchanges must only be heated slightly (2 - 4 K). Normally, the amount of circulation juice heated is only about 1,5 fold the introduced amount of fresh cossettes (total amount of circulation juice: 3 to 3,5 fold the amount of the fresh cossettes). Heating of the cossettes can thus easily be regulated via the introduced quantity of juice and heat energy.

Furthermore, the use of a modern counter-current mixer in connection with an extraction tower allows the production of the "cold" raw juice as it is called, i.e. through the intensive heat exchange between cossettes and circulation juice the raw juice drawn off from the mixer can be cooled below 20 °C, according to the temperature of the fresh cossettes. This again allows to use juice vapors with low energy for heating of the raw juice before the juice purification (f.i. juice vapors IV

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from the vapor station). Otherwise, these vapors couldn't be used anymore and should be lost.

7. Operational data

Temperature	69°C to 74°C	to avoid the degradation of the beet cell
P-H Value	5.6 o 7.4	to avoid the degradation of the beet cell
Extraction time	120 to 150 min	To be determined on the basis of the operational situation
Raw juice Draft	100 to 115% o.b.	A low raw juice draft is aimed at for thermal reasons
Sugar loss	0.2 to 0.3 % o.b.	Influenced by the raw juice draft. By increasing the draft by 1% on beets, the diffusion loss is reduced by about 0.01% on beets.
□T (raw juice-beet)	12 to 14	Depends on the raw juice draft

Table 3: Operation data

8. Summary

- Processing capacity of the Continuous Counter current Extraction system vary between 50 and 120 % of the nominal capacity. In particular, when processing below the nominal capacity raw juice draft and/or sugar losses decrease considerably with sugar losses of 0.20 - 0.25 % on beet, a raw juice draft of less than 100 weight-% on beet can be achieved. The advantage is the evaporation of much less amount of water, leading to the economizing of heat energy.

- Because of the exclusion of the air in the system, the danger of infection is low and oxygen consuming bacteria can hardly be produced.

- The high cossette filling leads to retention time of the cossettes in the tower of about 120 - 150 min. It takes only 40 min. for the extracted juice flow counter-currently through the tower. This high flow rate ensures a good transition of the extracted sugar into the juice.

- All parts of the plant are made of solid stainless steel. Service life is increased considerably and maintenance costs are extremely reduced.

- Amongst all extraction plants, the vertical extraction tower demands the smallest specific space and floor area. It can be installed everywhere, independently from the location of the beet slicing machines and/or the mixer.

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- With today's computerized process technique, an automatic operation of the extraction plant usually takes place. In this case, the operator has a monitoring function and can fulfil the additional control tasks.

- Because of the special cossette feeding system, the side screens requiring expensive maintenance and encouraging infections, are avoided

- Specially designed bottom screen segments, each with widening gaps in rotational direction, result in increased throughput even for cossettes of low quality

- Self cleaning of the bottom screens through rotating feeding channels

- Additional mechanical cleaning of bottom screen through rotating screen scrapers with movable scraping elements made of bronze

- pulp discharge with about 10 - 13 % D.S.

- Steady concentration gradient in direction of transport and small concentration difference between juice and cossettes due to optimal arrangement of stirring and guide arms, i.e. high number of transfer units

- Variable speed multiple drive with 3-phase motors and frequency controller for highest torque up to 14,000 kNm; rotational speed of the inner tube: 0.1 up to 0.3 rpm

- High extraction rate at a low raw juice draft due to the slim design of the tower

- Ordinary foundation due to the distribution of the weight and operational forces via a double ring support in the foundation.