tech-info

► *Beet extraction plants*

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extraction plants

are employed for extracting

sugar from beet cossettes.

Processing the cossettes through

a countercurrent cossette

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Sterile operation,

without air contact, minimizes

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BMA

Efficiency wins through

BMA is recognized as the world leader in developing, designing and constructing continuously operating vertical sugar beet extraction plants. BMA's sugar beet extraction plants are among the most efficient plants on the market, both in terms of technology and heat economy.

The novel extraction tower, now without bottom screens, but with side screens only, offers substantial advantages with regard to reliability, minimization of infections, maintenance and repairs. This new concept offers an extended range and allows BMA extraction plants to reach beet slice rates of up to 16,000 mt/d in one single unit.

BMA's continuously operating vertical BMA extraction plants are employed for extracting sugar from beet cossettes. Processing the cossettes through a countercurrent cossette mixer and an extraction tower yields a raw juice characterized by high purity, high dry substance content and low temperature. Sterile operation, without air contact, minimizes infections and sugar losses.

Beet extraction plant

Technological principles

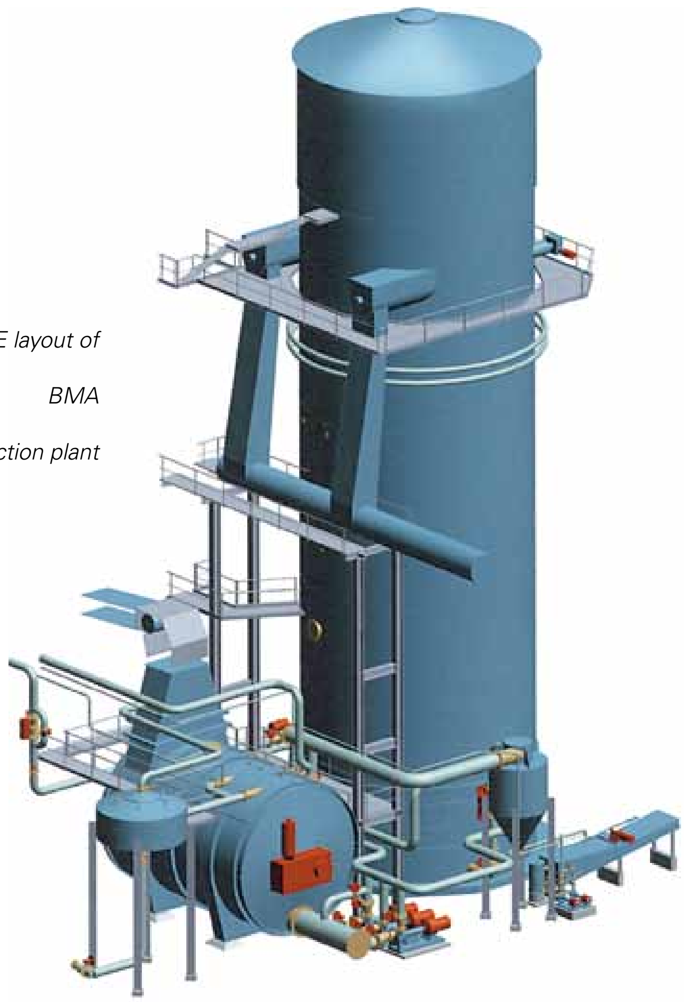
During solid/liquid extraction, the cells of the sugar beet cossettes are induced to give off the sucrose they contain; the extraction liquid used in this process is water. As the cell walls are impermeable to sucrose molecules, they have to be denatured prior to extraction. While part of the cell walls are mechanically destroyed when slicing the beets, most of the denaturing work is done when exposing the cells to short-time thermal action.

To be efficient both technologically and energetically, an extraction plant has to yield a raw juice of high purity, high dry substance content and low temperature. Countercurrent flow of cossettes and extraction liquid, complete press water recirculation and low extraction water rates are factors that achieve this goal. Operation out of contact with air minimizes infections and sugar losses following from microbiological destruction of sucrose.

The ***BMA beet extraction plant*** has two main components accomplishing different technological tasks:

- ***Countercurrent cossette mixer*** for thermal denaturation of the cells, heat exchange between incoming cossettes and outgoing juice, and defoaming work.
- ***Extraction tower*** for solid/liquid extraction of sucrose from the beet cells by the countercurrent principle.

Both components - countercurrent cossette mixer and extraction tower - are interconnected by a piping system and pumps and thus operate as one single unit.



CAE layout of BMA extraction plant

Process description

The washed and sliced beets enter the countercurrent cossette mixer through a feed hopper, where they are scalded with juice drawn off from the extraction tower to make the cell walls permeable for the sucrose molecules. Variable-speed pumps deliver the cossette/juice mixture produced in the cossette mixer into the bottom of the extraction tower.

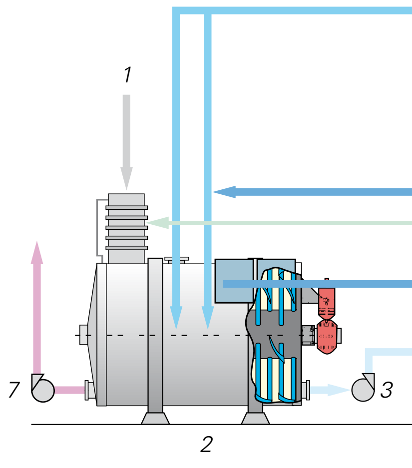
Inside the extraction tower, extraction of the sucrose molecules from the beet cells takes place while conveying flights and stops uniformly transport the densely packed cossettes from bottom to top. Two discharge screw conveyors withdraw the extracted cossettes (pulp) at the top end of the tower, and the pulp is then mechanically freed from water in downstream pulp presses. The slightly sacchariferous press water obtained at this stage is completely returned to the extraction tower.

The extraction liquid used is fresh water and press water, both entering the tower at two different levels. The liquid flows down countercurrent to the cossettes and enriches with sugar due to the existing concentration gradient. The resultant juice is drawn off from the tower base via side screens provided on the entire circum-ference, passes through a sand catcher, and flows back to the countercurrent cos-sette mixer.

Part of the recycled juice serves to pro-duce a pumpable mixture with the cossettes; the other part flows through the heat exchanger compartment of the cossette mixer, where it gives off most of its heat to the fresh cossettes, and then leaves the mixer through face-end screens as „cold“ raw juice and is subjected to further treatment in the juice purification plant.

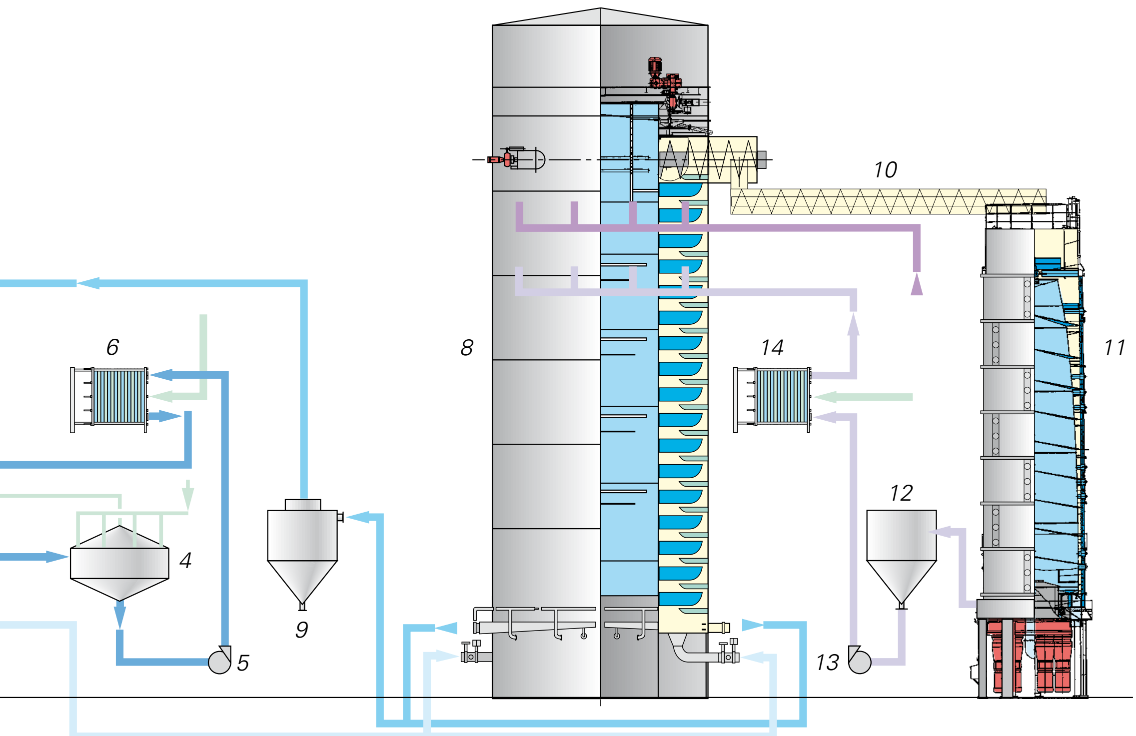
Extraction

tower



Manufacture of BMA extraction plants

Raw juice	*1. Fresh cossettes*	*8. Extraction tower*
Tower juice	*2. Countercurrent cossette mixer*	*9. Sand separator*
Defoamed juice	*3. Cossette/juice pump*	*10. Screw conveyor*
Cossette/juice mixture	*4. Defoamer*	*11. Pulp press*
Press water	*5. Pump for defoamed juice*	*12. Tank for press water*
Fresh water	*6. Heater for defoamed juice*	*13. Pump for press water*
Steam	*7. Pump for raw juice*	*14. Heater for press water*



Countercurrent cossette mixer

The countercurrent cossette mixer is composed of a heat exchanger and a mixing compartment.

The fresh, cold cossettes enter the countercurrent cossette mixer through the heat exchanger compartment out of con-tact with air. The arrangement and design of the conveying flights and stops in this compartment, and the steplessly variable mixer shaft speed provide for a homogeneous and dense cossette packing as required for optimum heat exchange.

The raw juice cooled by countercurrent contact with the cossettes is withdrawn through a screen in the face end. This screen, made from double-conical stainless-steel wires, provides an open screen area of 34%.

The mixing compartment of the cossette mixer is designed to loosen up the densely packed cossette bed, to complete cossette heating, and to produce a pumpable cossette/juice mixture.

The ***temperature profile*** for the countercurrent cossette mixer shows a steep rise within the microbiologically unfavourable temperature range between 30 and 40 °C. The fact that this region is passed through very quickly helps reduce the risk of infections to a minimum. For the same reason, the raw juice drawn off from the countercurrent cossette mixer should have a temperature of less than 30 °C.

A special feature of the countercurrent cossette mixer is the „cold" raw juice it produces, which, depending on raw juice draught, has a temperature of 10 to 15 K above that of the fresh cossettes. Waste heat remaining without further use (crystallization vapours, condensate) can be utilized to heat this „cold" raw juice in downstream production processes. Thus, steam savings can amount to 5% to 7% o.b. as against extraction plants operating without a countercurrent cossette mixer.

Depending on an adequately dense cossette packing, the temperature gradient that can theoretically be achieved between the drawn off raw juice and the fresh cossettes depends on the difference between the temperature in the mixing compartment and that of the fresh cossettes, and also on the quantity of raw juice drawn off. This is shown in the figure on page 5.

The temperature gradient that can practically be achieved between raw juice and fresh cossettes depends on the heat exchange efficiency which, subject to the cos-sette quality and the associated packing density, is between 90% and 95%.

Optimum operation of the countercurrent cossette mixer and sterile conditions in the entire plant presuppose efficient ***defoaming***. Foam can be the result of gases released when beet cells are denatured, or when processing not fully matured or microbiologically damaged beets. Air entrained with the cossettes can also add to foaming.

A wedgebar screen in the top of the mixing compartment provides for removal of the foam together with part of the juice. The foam is then eliminated in the down-stream defoamer using steam or, where required, a mixture of steam and antifoaming agent.

The heat required for denaturation of the cossette cells and for extraction is supplied by the fresh or press water, and also by the partial juice stream returned from the defoamer cycle. A heater integrated into this cycle heats the circulated juice at a rate of 80% o.b. to approx. 80 °C. A microbiologically beneficial side effect of this heating process is partial juice sterilization, which much reduces the bacterial content in the juice.

Countercurrent cossette mixer for optimal heat exchange

All countercurrent cossette mixer components in contact with the cossettes are made from corrosion-resistant steel or are stainless-steel lined.

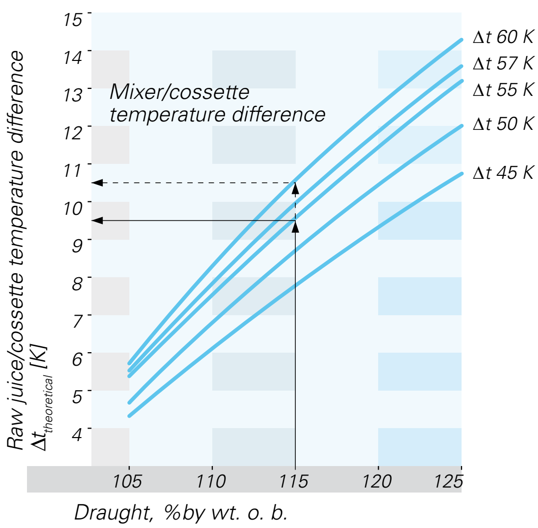
For the ***measuring and control system*** employed for the countercurrent cossette mixer, the following principle applies: For cossette denaturation in the mixing compartment, it is important that the required temperature of approx. 70 °C be strictly maintained. This is achieved by controlled heating of the defoamed juice and can proceed automatically as a function of the temperature in the mixing compartment.

To achieve the intended low raw juice temperature, cossette load monitoring in the heat exchanger compartment is indispensable. Under the filling ratio control system employed for this purpose, the mixer shaft speed is varied as a function of the driving motor current input. The level in the countercurrent cossette mixer is maintained constant by adjusting the speed of the cossette pumps.

Before entering the countercurrent cossette mixer, the defoamed juice heated to 80 °C is mixed with the colder tower juice, thus precluding local overheating and the known negative consequences this implies for the cossette structure.

The countercurrent cossette mixer ***drive*** unit comprises a shaft-mounted gearbox and a flanged electric motor providing for stepless speed variation.

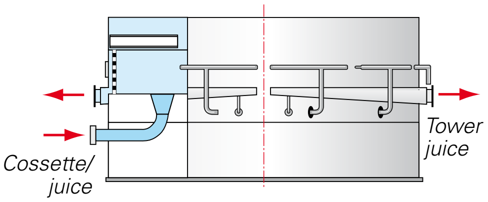
Both the front-end screen for raw juice draught and the defoaming screen are kept clean by scrapers flexibly mounted on the rotating conveying blades.



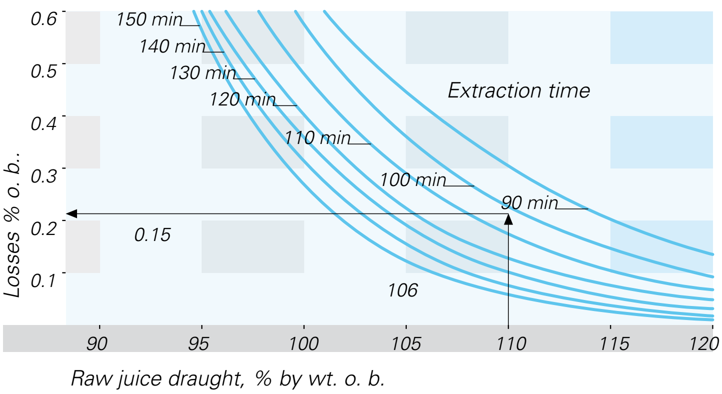
Correlation of cold raw juice temperature with draught

The new BMA tower extraction concept

Novel tower base



Correlation of extraction losses with raw juice draught and extraction time



The BMA extraction tower is composed of the cylindrical tower body fitted with stops, the conveying shaft which has conveying and distributing blades attached to it, the drive, the discharge screws, and the base with side screens. The extraction area proper, which has an improved geometry as compared with the previous version, is the annular space between outside section and inside conveying shaft.

One of the main characteristics of the BMA extraction tower up to now was that the tower juice is withdrawn through bottom and side screens. The maximum load on the bottom screens is approx. 65 $m^3/[m^2*h]$, limited by the cossette package acting on the screen and influencing the throughput.

Series of tests have shown that the specific throughput of the side screens, unlike that of the bottom screens, can be increased to 200 $m^3/[m^2*h]$. In the new tower, the tower juice is drawn off through novel side screens only.

Cossette pumps convey the cossette/ juice mixture, which has been prepared in the countercurrent cossette mixer, to the extraction tower and feed it into the tower through connections in the bottom against the direction of flow/rotation. Large-area distributing blades uniformly distribute the cossettes across the extraction tower cross section and rapidly move them upwards through the tower. This produces a zone near the side screens, where primarily juice will be found so that it can be drawn off easily.

Well-positioned conveying blades and stops provide for gentle conveyance of the cossettes through the extraction area and to the top of the tower, from where they leave through discharge screws.

The high and uniform cossette packing inside the tower, following from the specific arrangement of conveying blades and stops, allows 110% o.b. raw juice draught to be achieved after an extraction time of only 105 minutes, the sucrose loss being 0.25% o.b. It is evident from practical oper-ation that such results can also be achieved for high fine pulp percentages. The relation-ship between juice draught, extraction time and sucrose losses is illustrated in the figure below.

Sugar extraction from the cossettes pro-ceeds in the extraction tower by counter-current contact with fresh and press water. While fresh water is uniformly distributed across the entire extraction cross section as it enters the tower below the discharge screws, press water feeding proceeds in that tower section where the sugar content corresponds to that of the surrounding extraction liquid.

Instead of the old bottom screens, the ***tower base*** has a solid stainless-steel bottom.

The advantage of the new design is that the absence of bottom screens avoids damage by foreign matter, eliminating the need for maintaining them after the campaign and, consequently, reducing both capital and maintenance cost.

Another, decisive, advantage of the new bottom design is the much reduced infection hazard, as there are no juice zones under the bottom screens that are endangered by infections, resulting in a more sterile tower operation.

We mentioned earlier on that the side screens are able to handle a load of up to 200 $m^3/[m^2*h]$. For safety reasons, i.e. to have a sufficient safety margin, the screen load in the new tower was limited to 100 $m^3/[m^2*h]$.

The ***side screens*** are fully incorporated in the outer shell, allowing conventional juice chambers to be dispensed with, and the screens are flush with the outer shell.

The design of the juice collecting chambers outside the screens is such that they are rinsed 100%, not leaving a chance for sediments to settle.

The slot width of the all-around side screens was changed slightly. Experience has shown that there is no danger of damage to the side screens. Nevertheless, just to be on the safe side, rinsing pipes are provided to allow clearing of the screens in case of a malfunction, e.g. inferiorquality cossettes.

The juice collecting chambers need not be opened after the campaign, resulting in reduced maintenance costs.

The extraction tower conveying shaft is ***driven*** by a number of vari-speed drive units. To be able to safely and smoothly transmit the high torques that go along with operation at high filling ratios, BMA has designed, in collaboration with gearbox manufacturers, a special drive in which the driving pinions rotate in flexible bearings, safeguarding absolute flank parallelism with the bull gear. The torque transmitted by one drive unit is constantly measured and monitored.

The new drive concept provides a different ratio between pinion and bull gear and involves a reduced number of drive units, which are centrally mounted planetary gearboxes. For additional safety, a coupling serving as a torque limiter prevents excessive overloads.

The following ***measuring and control equipment*** requirements apply for the extraction tower: Optimum extraction work necessitates high and constant cossette packing. Filling ratio adjustment is achieved by changing the liquid level in the tower or by varying the conveying shaft speed.

In practice, a speed matching the required filling level will be set. Any variations in the filling ratio as may result from irregularities in the amount or quality of the cossettes processed will be compensated by automatic variation of the liquid level in the tower.

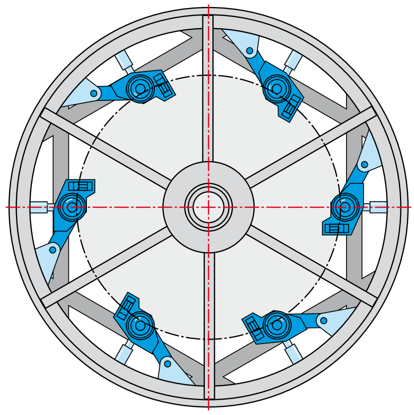
Depending on tower size and processing rate, the normal liquid level inside the tow-er will be 1 to 2 m below the discharge screws. Lower level settings make it more difficult for the cossettes to leave the tower, which is due to the longer dry section they thus have to overcome. As a consequence, the cossette retention time inside the tower is extended and the filling ratio raised. Higher levels facilitate cossette discharging from the tower. As this increases the cossette rate leaving the unit, the cossette retention time is reduced, as is the filling ratio.

Independently of filling ratio control, extraction water supply keeps the filling level in the extraction tower constant and in line with the relevant setpoint value.

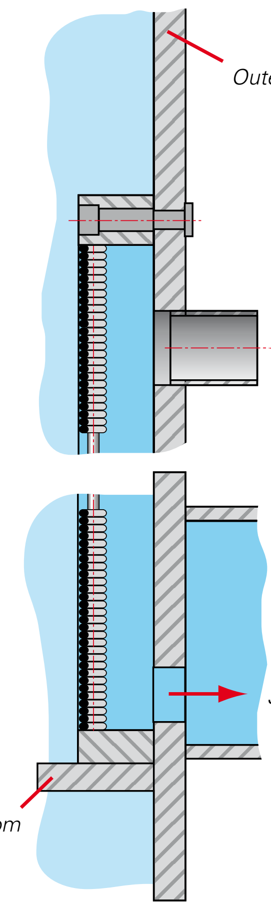
Medium-contacted components of the extraction tower are provided with a stainless-steel lining or are made from corrosion-resistant steel.

All bearing elements are positioned so as to facilitate maintenance.

Drive unit with planetary gearbox



Side screens



Advantages, Features and sizes

BMA beet extraction plants stand out for the following features and advantages:

- experience from more than 360 extraction plants in almost all the beet processing countries in the world
- small space requirements
- system allowing of great distances between countercurrent cossette mixer and extraction lower
- outdoor installation of the extraction tower even under extreme weather conditions
- very high operational reliability
- very high flexibility to adapt to operating conditions and cossette quality (with processing rates between 65 and 120% of rated capacity)
- option of combining a countercurrent cossette mixer with two or more extraction towers, or one tower with a number of countercurrent cossette mixers
- production of „cold" raw juice, thus substantially reducing heat requirements
- extremely low extraction losses at low juice draughts
- processing of Königsfeld, Goller or sliced cossettes
- optimum defoaming work in the countercurrent cossette mixer
- largely sterile operating conditions thanks to a short critical temperature zone in the mixer's heat exchanger compartment and a defoamer cycle including partstream sterilization
- amply dimensioned screen areas for smooth juice discharging
- gentle cossette treatment
- no local cossette overscalding
- exhausted pulp with 10 - 12% dry substance content
- complete press water recirculation
- minimum maintenance and servicing requirements

Beet slice rate nominal [t/d]	***Extraction tower*** diameter [m]	***CC cossette mixer*** diameter / length [m]
4,000	6.5	4.2 / 7.0
5,000	7.0	4.7 / 8.0
6,000	7.6	5.2 / 8.0
7,000	8.2	5.6 / 8.0
8,000	8.9	6.0 / 8.0
9,000	8.9	6.0 / 8.0
10,000	9.6	6.7 / 8.5
11,000	10.6	6.7 / 8.5
12,000	10.6	7.5 / 9.5
13,000	12.0	7.5 / 9.5
14,000	12.0	8.2 / 10.0
15,000	13.6	8.2 / 10.0
16,000	13.6	9.0 / 11.0
17,000	13.6	9.0 / 11.0

Tower extraction length varies subject to operating requirements and plant size.

BMA

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