NEW APPROACHES IN BATCH CENTRIFUGAL DESIGN AND ITS OPERATIONAL BENEFITS

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Introduction

Batch centrifugals rank among the key equipment in the sugar production process It is quite rightly expected that they should meet the highest requirements regarding process optimization and productivity even under heavy workloads. When selecting a new centrifugal, the following criteria are important for the decision making process: (a) optimum sugar quality depending on the individual requirements, (b) maximum yield, (c) high throughput together with the lowest possible power consumption, (d) minimized use of washwater, (e) simplicity of operation, (f) low maintenance (g) long service life of the equipment. For the development of a centrifugal it is thus equally important to combine these aspects in an optimal way and to ensure a safe and stable process.

To meet the ever increasing customer requirements and to further optimize an already highly sophisticated product, new design-engineering approaches are needed. As a worldwide leading manufacturer of centrifugals, BMA has accepted this challenge and developed a new standard-setting batch type centrifugal.

As an outstanding feature, the new and innovative basket design allows a significantly longer service life of the basket. In addition, the basket allows higher throughputs based on its volume and contributes to the smoother operation of the centrifugal. This in turn makes the process safer, even when difficult massecuites are being processed.

With the innovative monaxial discharger, BMA reduces the discharging time by up to 20%.

A significant amount of a centrifugal's life cycle costs are attributable to the regularly required maintenance. During the development of the new centrifugal BMA paid a lot of it's attention to the simplification of the mechanical system by reducing the number of components. This has helped to minimize not only the amount of maintenance and consequently the associated costs and downtimes, but also the risk of machine failure.

A new failsafe control system and redundant, certified sensors and analyzing units provide an increased operational reliability. The controlled and monitored breaking ramp leads to higher safety for operators and the machine itself.

This presentation highlights the most important innovations of the batch centrifugal and its operational benefits based on experiences with the first installations.

The challenge

For many decades, batch-type centrifugals have been absolutely vital for sugar production. Since their design and functions have been, and are, continuously improved, the machines that are available in the market today are already highly sophisticated products.
But faced with the challenge of ever-increasing expectations, a new design-engineering approach is needed.

User requirements can be classified according to the criteria listed here:

- Optimum sugar quality and maximum yield
- High throughput with low energy consumption
- Low wash-water consumption
- Simple operation and maintenance
- Operational safety
- Process reliability / availability

Focal points of developments

1.1 New basket design

According to scientific findings from recent years, only mechanical components made of stainless steel that are designed for more than 100 million load cycles can be said to have long-life fatigue strength.

If alternating stresses and corrosive effects act on an element at the same time, long-life fatigue strength is not be reached at all.

Given the conditions under which centrifugal baskets have to operate, they can never reach the number of load cycles that are required for long-life fatigue strength. They are therefore high-strength components with a limited service life.

The limiting factors for service life are the openings in a centrifugal basket, as it is here that maximum stresses appear. So far, baskets have been equipped worldwide with cylindrical boreholes. The graph below (Fig. 1) shows a detail of a basket shell with a quarter segment of a borehole and Fig. 2 shows a piece of basket wall.

The highest tangential stresses occur at the top and bottom of the borehole.

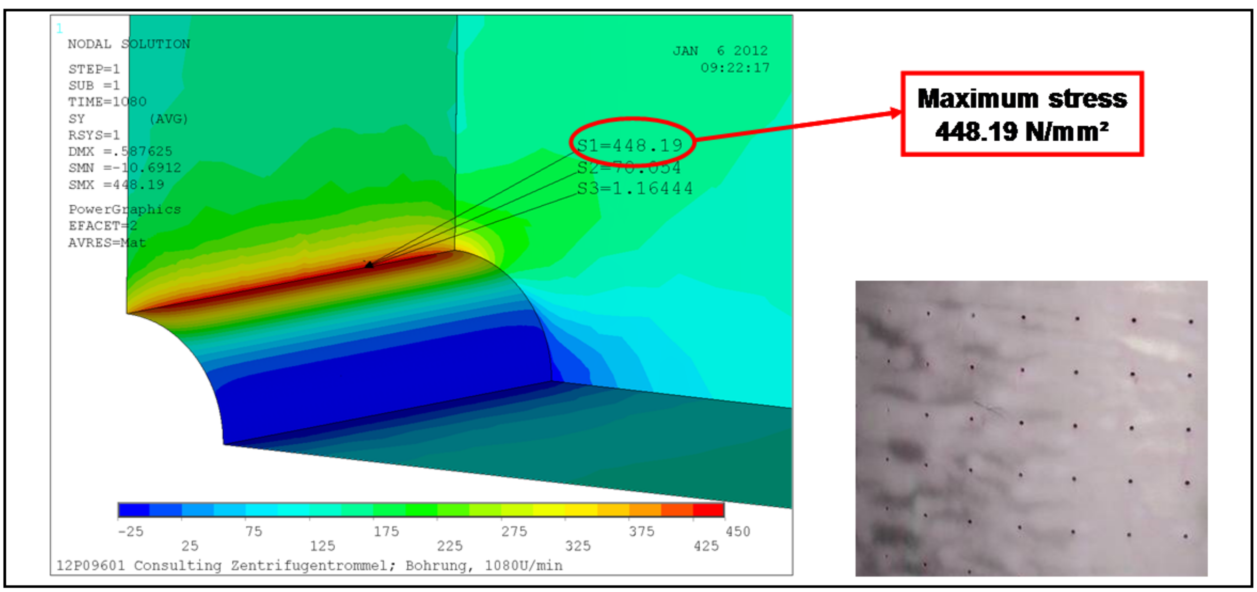

Fig. 1: Stresses of a quarter segment of a borehole [N/mm²]

Fig. 2: Basket wall with cylindrical boreholes

In order to increase safety and performance, BMA has adapted the basket openings to reduce the peak stress. The new basket design is based on openings with an elliptical shape Fig. 4. The stress pattern for an elliptical opening is shown in the graph in Fig. 3.

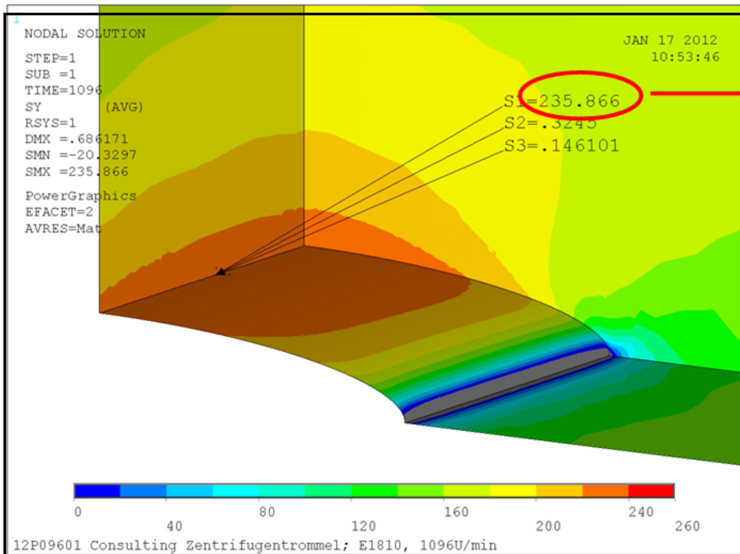

Fig. 3: Stresses of aquarter segment of elliptical opening [N/mm²]

Fig. 4: Elliptical openings in new basket´ design

Compared with boreholes, the maximum stress found with elliptical openings is about 40% lower!

With regard to notch effects, such as those caused by the openings of a basket, the geometry of a component has an important influence. The notch effect is much smaller with elliptical basket openings than it is with boreholes, therefore the surface roughness inside is much less relevant than it is with boreholes.

It is not only the comparison of maximum stresses that is decisive, but the comparison of the calculated service life values under a dynamic load. Figure 5 compares the expected service life of the optimized new design with that of the old boreholes design.

Additional service life with the E series basket

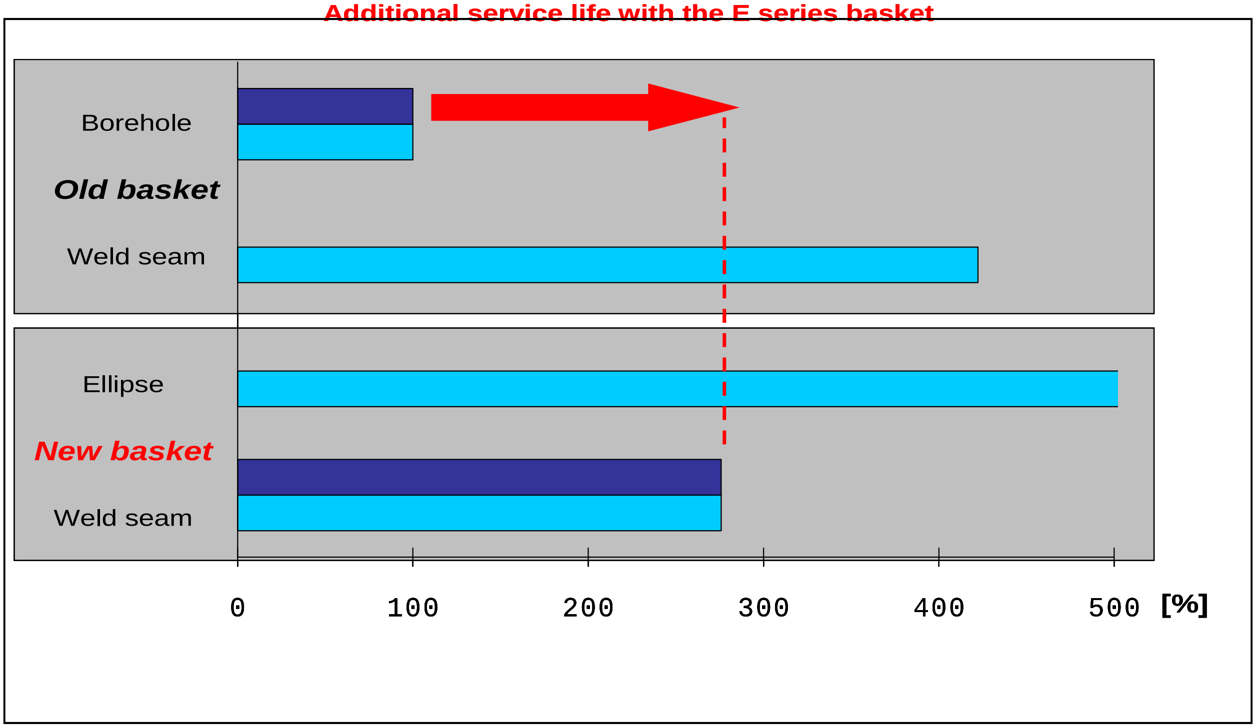

Fig. 5: Expected service life of old vs. new basket

The calculation model shows a service life that is at least 2.5 times higher than that of the old baskets (limited by boreholes).

The determining factors for the actual service life are the operating conditions. Factors such as speed, massecuite charge (quantity), operating temperature, vibrations and corrosion have a decisive influence on the service life that can be reached in practice.

In regards to fatigue resistance, linear changes in stress e.g. temperature changes result in an exponentially reduced number of operating cycles. Furthermore, changes in speed have a quadratic effect on stress. Speed is therefore the predominant factor influencing the strength of the basket.

Based on this new design approach, the basket has a lower weight because of the reduced plate thickness, while its volume has been increased. With the same required drive power (same energy input), the centrifugal can thus achieve a higher throughput.

1.2 Shorter cycle times

The performance of a centrifugal is primarily determined by throughput. That's why shorter cycle times must always be the aim of developments in batch-centrifugal design. The option of reducing acceleration and braking times by using larger drive units has limitations that have to be seen first of all in the process itself. In order to reduce cycle times with structural modifications, BMA has therefore continuously, i.e. over several centrifugal generations, reduced the minimum discharge time required.

- Short discharger: optimized in the G-Series; option in the B-Series with vertical motion axis for discharging (discharging time approx. 40 s)
- Long discharger in the B-Series: vertical motion only for the resting position; rotary motion for discharging the sugar from the entire basket (discharging time approx. 25 s)
- Monaxial discharger without up-down stroke in the E-Series: the vertical movement has been eliminated altogether (discharging time approx. 18 - 20 s)

The different development stages are illustrated in Fig. 6. Since the number of parts has been lowered, maintenance requirements have also been reduced.

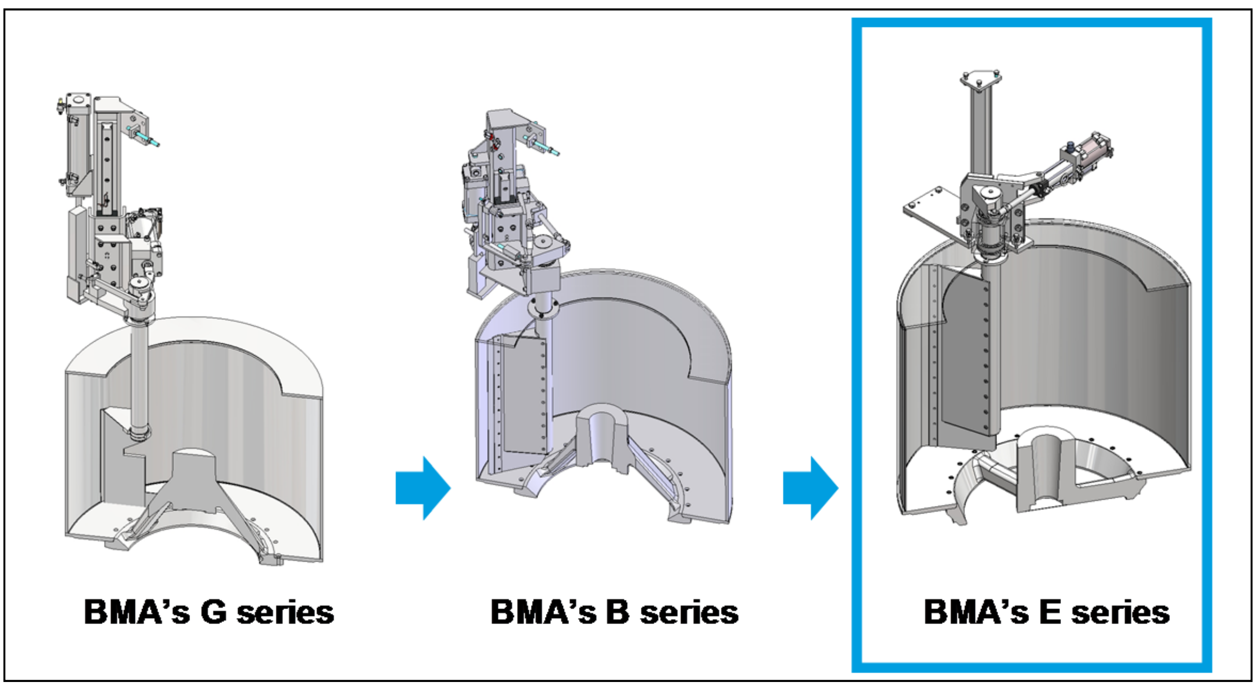

Fig. 6: Discharger development stages

In the new E-Series, the discharging time could be further reduced by up to 20 % in comparison with the long discharger in the B-Series (B1750R). The elimination of the vertical movement was possible, because the E-Series comes with a flat hub geometry. This is the result of FEM calculations and additionally provides a greater torsional rigidity than the earlier series.

Together with the larger basket volume (+60 kg/batch), the shorter discharging time provides for an up to 8 % higher throughput.

1.3 *Simple and efficient syrup separation*

For efficient syrup separation, the mother liquor and the dissolved sugar obtained during the water washing and screen washing phases (after the basket has been emptied) must be very carefully separated. The challenge of syrup separation is to prevent the separated mother liquor from mixing with the wash syrup, in order to produce a sufficient amount of syrup with a very high purity. The separated wash syrup of high purity and low color can thus be returned into the process. This produces a higher sugar yield and a higher purity drop in the corresponding crystallization step, and, consequently, allows for lower molasses purity. Recirculation of non-sugars can thus generally be reduced.

The fact that mother liquor collects at the housing bottom where it becomes mixed with purer wash syrups is the disadvantage of conventional syrup separation outside the centrifugal housing . The internal syrup separation in the B-Series already provided for much more efficient separation directly in the centrifugal, but was based on sophisticated mechanics. The principle of internal syrup separation was optimized in the new E-Series eliminating the internal mechanical elements altogether.

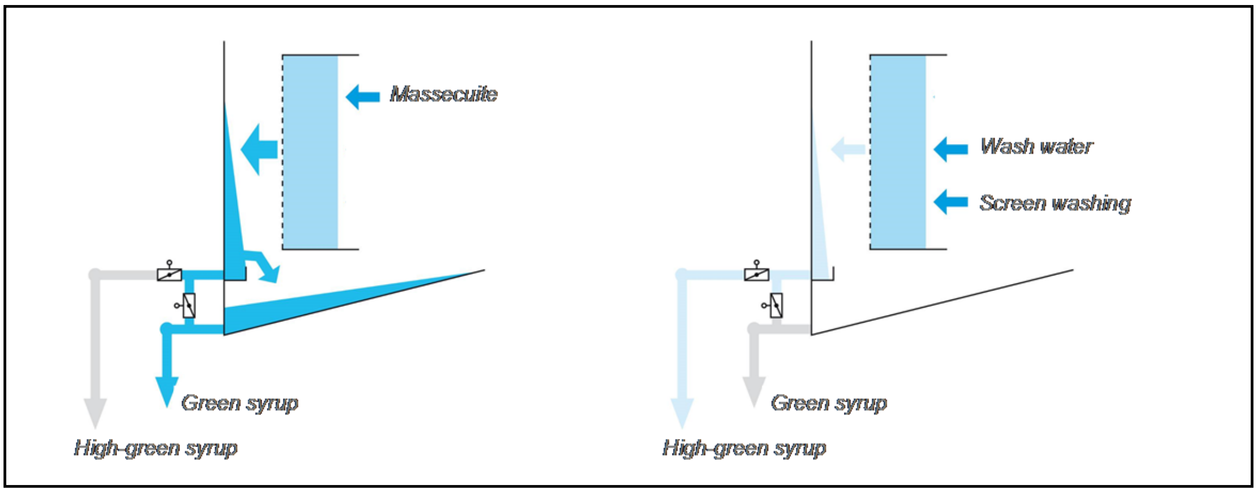

Fig. 7: New syrup separation

Fig. 7 shows the new syrup separation principle, which is based on two separate outlets, two butterfly valves and a fixed syrup separation channel inside the housing. During the green-syrup separation phase the syrup that runs down the housing wall fills the separation channel - surplus green syrup overflows the channel. The green syrup is led through both outlet pipes. Once the system is switched to wash syrup (right), this syrup is discharged through the wash-syrup channel only. The likelihood of green and wash syrups mixing has thus been minimized. By setting the time after water washing at which the green syrup valve closes and the wash syrup valve opens, the syrup quality can be controlled in a reproducible manner.

The graph in Fig. 8 highlights the results that were achieved in practical tests. This graph contrasts the development of the wash syrup color with conventional external syrup separation and with the new system. There is a striking difference in particular in the rapidly decreasing color of the wash syrup shortly after wash-water application.

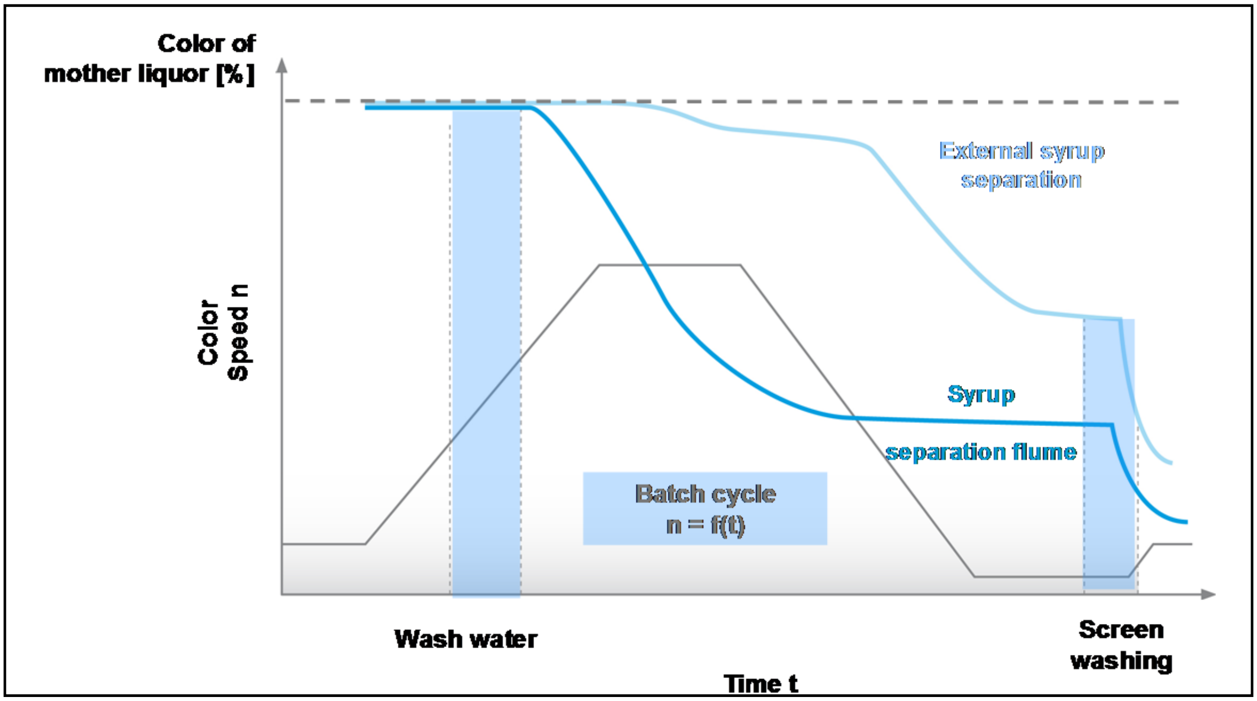

Fig. 8: Color of the wash syrup for external syrup separation and syrup separation channel

The relationship between wash syrup color and the wash-syrup percentage of the total syrup is shown in Fig 9. Provided that 50 % of the color of the mother liquor is accepted in the wash syrup, this corresponds to a wash syrup percentage of approx. 20 % with external syrup separation. With the new syrup separation, this percentage reaches 35 %.

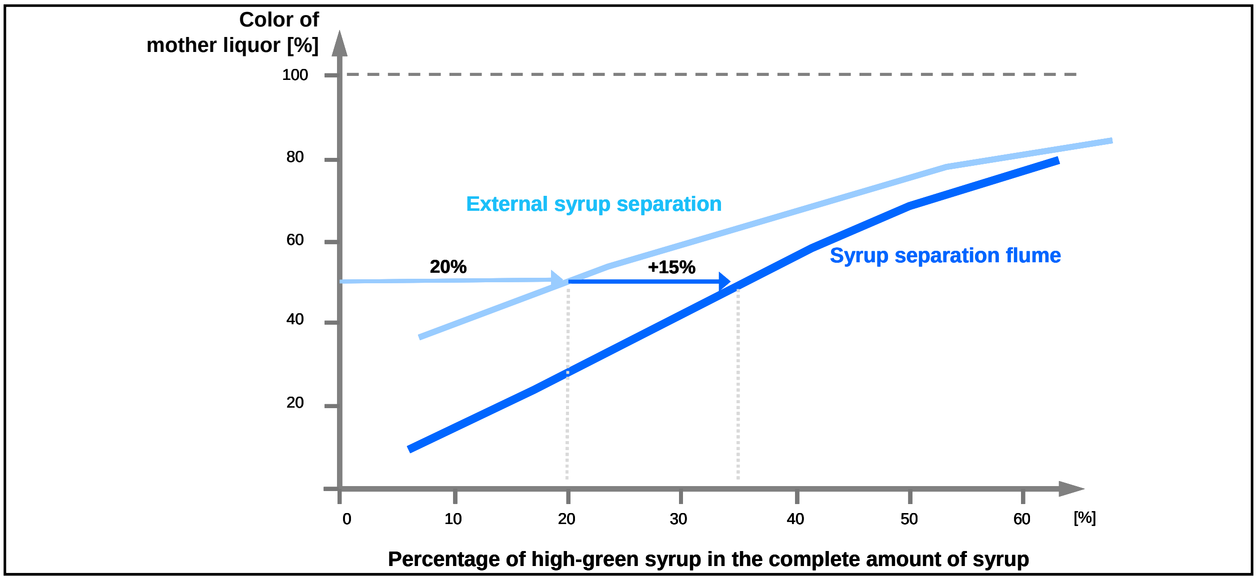

Fig. 9: Color in the wash syrup as a function of the wash-syrup percentage of the total syrup

If, however, the wash syrup percentage is kept constant, the color is reduced to approx. 25 % of the mother liquor. It is also possible to provide for effective separation with screen washing only. This option is particularly interesting for refinery applications.

1.4 Higher operational safety

The aim of the previous control concept was to eliminate dangerous situations caused by electrical energy through use of galvanic isolation. In case of emergency the mains contactor was switched off and the centrifugal was braked mechanically to standstill.

The aim of the new control concept is to eliminate dangerous situations by reducing the kinetic energy of the basket as quickly as possible. The generator-based braking and mechanical brakes have to interact, once the emergency stop has been activated. The control system provides for failsafe monitoring of the braking ramp. In the unlikely event that the actual turning speed exceeds the calculated speed, the frequency converter is shut off immediately and the mechanical brake decelerates the basket to standstill.

A reason for using the emergency braking function could be critical oscillation. In this situation the frequency converter decelerates the basket to a safe speed of 100 rpm. The residual speed is kept to avoid that the massecuite drops onto the basket bottom.

To reliably detect and react to extreme faults, BMA uses a failsafe control system as well as certified sensors and analyzers.

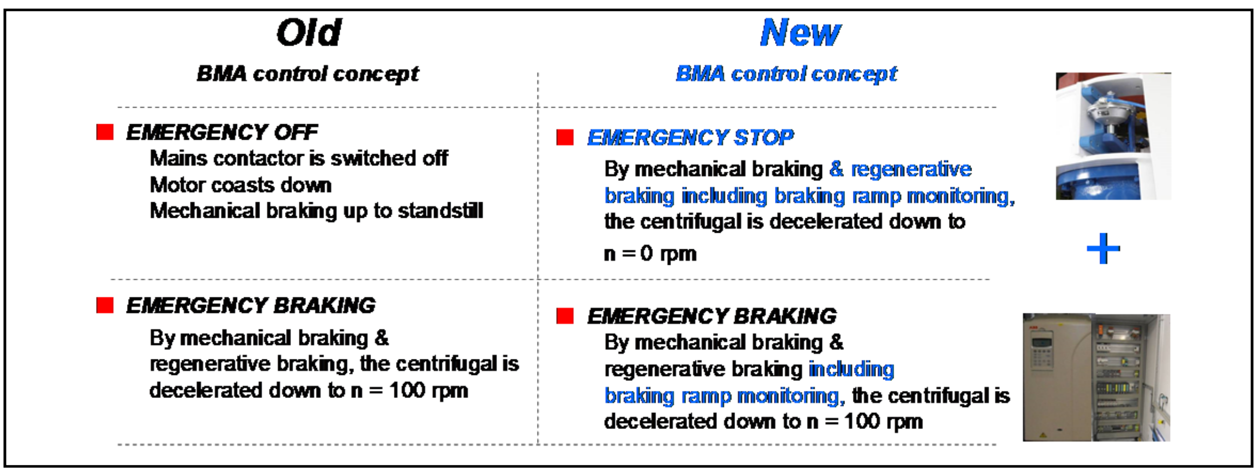

Fig. 10: Old vs. new control concept

2 Implementation

2.1 The prototype

In spring 2011, a prototype of the E-Series was installed at the Plattling sugar factory of Südzucker Group (Fig. 11) and completely integrated into the production process immediately after it had been commissioned. The E machine was placed alongside existing white-sugar centrifugals on one common centrifugal platform.

The centrifugal continuously operated to the customer's full satisfaction. In parallel with the campaign service, BMA performed intensive trials to test the function of all new features under practical conditions.

Sampling points for green and wash syrups, and a tank for collecting and measuring the volume of the two syrups from one complete centrifugal batch were provided in addition.

A remarkable feature of the new centrifugal is that it runs extremely smooth thanks its excellent mechanical stability. The active operating status only became apparent when taking a look at the display.

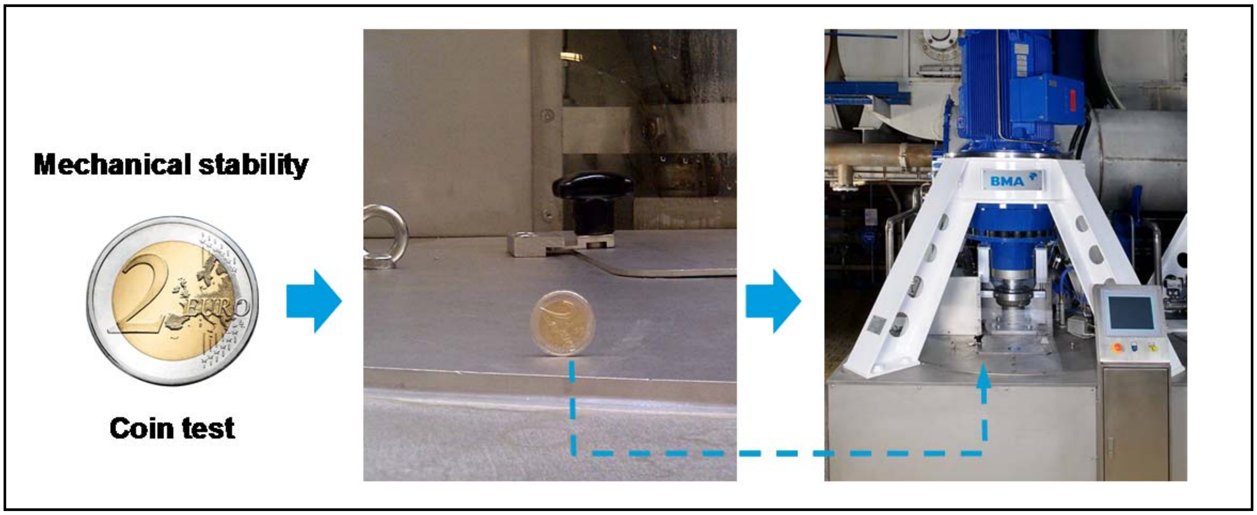

Fig. 11: Prototype E1810 and its smooth running characteristics

Fig. 12: New centrifugal station equipped with four E1810 Südzucker's Plattling sugar factory (Germany)

Centrifugal station equipped with two E1810 and one G1750, Ouvré Fils's Souppes factory (France)

4.1 The series

The mechanical system of the new centrifugal stands out for its consistent simplicity and the reduced number of components. The machine not only incorporates the monaxial discharger and the novel syrup separation channel which does not need any internal mechanics, as described above. The centring device and hood actuation from above have, in addition, been combined to form one single unit.

The different machine sizes (Fig. 13) permit a maximum sugar layer of 250 mm. For special products, the layer thickness can also be limited to lower values.
The housing and frame stiffness has been optimized with the aid of detailed FEM calculations. The result is a machine that runs extremely smooth, so stable process conditions are maintained even in the case of varying massecuite qualities.

The dimensions of the previous G-Series have almost completely been adopted for the E-Series to allow centrifugals to be replaced without having to modify the steel structure.

E-series performance

Massecuite properties			***E1390***	***E1810***	***E2240****
Very easily centrifuged	Quantity per batch	kg (lbs)	1,500 (3,307)	1,960 (4,321)	2,420 (5,335)
(e.g. refined sugar)**	Batches/h***		28	28	28
	Throughput up to	mt/h (sht/h)***	42 (46.3)	55 (60.6)	68 (75.0)
Easily centrifuged	Quantity per batch	kg (lbs)	1,390 (3,064)	1,810 (3,990)	2,240 (4,938)
(e.g. white sugar, raw sugar)**	Batches/h***		28	28	28
	Throughput up to	mt/h (sht/h)***	39 (43.0)	51 (56.2)	63 (69.4)
Not easily centrifuged	Quantity per batch	kg (lbs)	1,190 (2,624)	1,540 (3,395)	1,900 (4,189)
(e.g. raw sugar)**	Batches/h***		26	26	26
	Throughput up to	mt/h (sht/h)***	31 (34.2)	40 (44.1)	49 (54.0)

* *model to be launched soon*
** *subject to factors such as massecuite purity and crystal size*
*** *subject to product quality and drive motor*

Fig. 13: Overview of the new E-Series

3 Summary

With the development of the new series of batch centrifugals, essential new structural features have been introduced, and the performance of the machine has been increased. Because of the elliptical shape of the openings, the basket has a much longer service life. The new syrup separation system does not need any internal mechanical parts and separates the mother syrup and the wash syrups, which are produced in the water and screen washing phases, at a very low level of back mixing. Maintenance requirements and downtimes were reduced significantly. Even with varying massecuite qualities the machine operates reliably. Furthermore, the new control system contributes to a much higher operational safety.