A NEW GENERATION OF BATCH CENTRIFUGALS FOR HIGH-PURITY MASSECUITE

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Abstract

To remain competitive, centrifugal manufacturers need to continuously review their designs. This results in ongoing incremental improvements. Occasionally, a more radical set of several improvements are simultaneously introduced to produce a significantly new machine.

The existing BMA G-series centrifugals were recently subjected to re-engineering to produce a new B-series. Aspects of the successful redesign are described.

Novel features of the re-engineered centrifugals are:

- a new plough of the same length as the full height of the basket, resulting in:
  - shorter discharging time
  - less residual sugar in the basket.
- a new syrup separator resulting in:
  - optimal separation of wash and green syrup due to the built-in separator
  - considerably improved sugar house work.
- all product-contacted components in stainless steel as standard
- an improved centering device for spindle during sugar discharge
- drive head bearing system with two bearings only
- new dampening device adjustable from outside the centrifugal
- an easily removable basket without the need for a split spindle
- a working screen without a lock-lap joint.

Introduction

Maximum efficiency in centrifuging work has occupied sugar technologists and engineers of centrifugal manufacturers ever since this machine for separation of the syrup/crystal mixture was first introduced to the sugar industry more than 100 years ago.

For high purity massecuites it is common practice to use pendulum-type centrifugals such as described in this paper.

Requirements

Requirements made on the manufacturer in the design and construction of such centrifugals include:

- safety
- technological efficiency
- high performance
- low maintenance cost
- price/performance ratio.

To remain successful, manufacturers and suppliers of centrifugal machines need to subject their designs to continuous improvement and development, always putting safety as the top priority.

Design details

Centrifugal basket

In the recent past, centrifugal basket volumes have been continuously increasing due to market requirements, resulting in volumes of 2,200 kg per charge and even more.

In general it can be said that in the purging of even sized crystals for both white and raw sugar a gravity factor of approximately 1 000 to 1 100 is sufficient. The layer thickness in the basket should not exceed 230 mm, especially for fine sugar having a crystal size of approximately 0,4 mm, since the smaller gaps between such crystals provide more resistance to molasses drainage.

The baskets described here are exclusively in stainless steel. A higher charge volume of the centrifugal basket (Figure 1) can be achieved by increasing:

- the height H of the basket and/or
- the diameter D of the basket and/or
- the thickness of the crystal layer H_K.

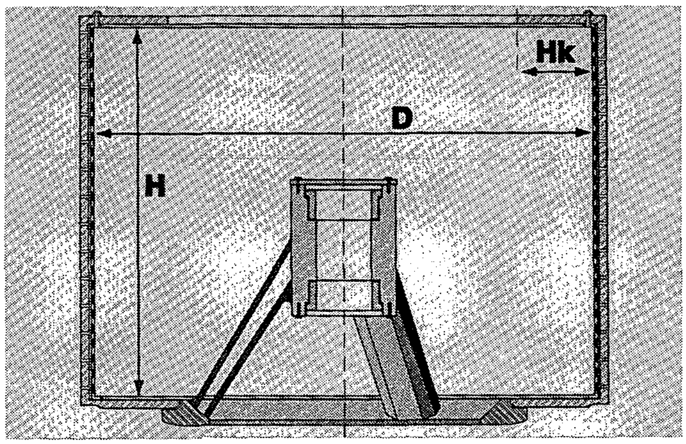

Figure 1. Centrifugal basket dimensions.

Basket height

Although the basket height H is a linear part of the mass moment of inertia, it can be used to increase the basket volume to a minor degree only, because there are important safety limits to the acceptable height/diameter ratio H/D.

The author's company decided not to exceed an H/D ratio of 0,76 (Table 1) because, in a rotationally stable centrifugal basket, the mass moment of inertia of the axis of rotation should be higher than that of the transverse axis extending through the centre of gravity of the basket

Some suppliers manufacture baskets with an H/D ratio of 0,8 and over and, in addition to that, make an attempt to provide the missing volume by thicker crystal layers H_K.

Even though it appears to be more expedient to use baskets with a relatively small diameter and to operate them at a large massecuite layer thickness, it should be borne in mind that purging constraints often only allow smaller layer thicknesses as mentioned before, in which case a basket with a larger diameter providing a larger area for the massecuite layer is the more economical solution.

Slim baskets with a high H/D ratio require less energy, but have a substantially inferior vibration stability and are therefore less reliable, particularly when the centrifugal operation is being monitored from a remote control centre. This disadvantage might be compensated for by moving the spider, i.e. the spindle connection, extremely deep into the basket.

These considerations led to the conviction that a basket providing a maximum H/D ratio of 0,76 and a layer thickness of 230 mm (9 inches) is optimum in terms of smooth and stable centrifugal operation.

Table 1. Height/diameter ratio of different centrifugal baskets.

Basket dimensions				
Type/capacity (kg)	Diameter (mm)	Height (mm)	Layer thickness (mm)	$\frac{H}{D}$
B 900/1000	1 200	900	200/230	0,750
B 1200/1300	1 350	1 025	200/230	0,759
B 1550/1750	1 540	1 170	200/230	0,760
B 1950/2200	1 700	1 290	200/230	0,759

Removal of basket

In this type of centrifugal the basket can be removed (Figure 2) without having a split spindle, the inherent advantages being:

- Removal of only a few components; for example, the front cover plate permits easy, thorough and quick inspection of the basket.
- The design of a two-part housing allows quick removal of the basket, dispensing with the very time consuming disassembly and re-assembly of bearing system and drive. Removal involves simply loosening the bolts of the upper bearing housing and the lower coupling half.

The headroom required for removal is easily accommodated at most factories.

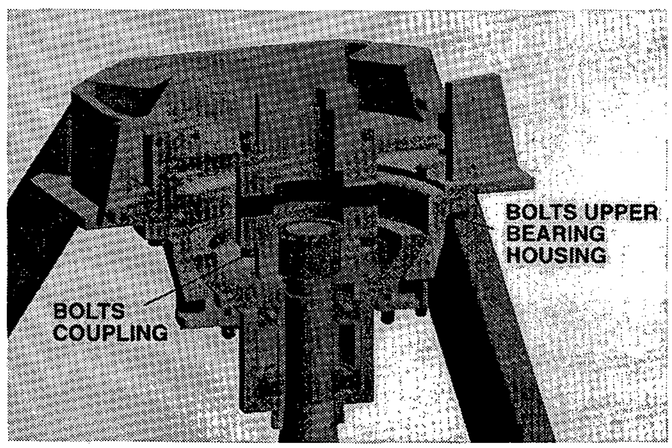

Figure 2. Removal of basket.

Centrifugal bearing system

Essential components of the new bearing system are a calotte, comprising a hemispherical plain bearing coated with a synthetic material, and a grease lubricated two antifriction bearing system, as shown in Figure 2, its duty being to dissipate energy in critical ranges and to cushion processional movements of the pendulum system.

Damping of oscillations by rubber buffers can easily be adjusted from outside without the need to dismantle other parts.

Screens

Another area of traditional centrifugal practice received recently was time consuming screen installation. In the new design, the long used lock-lap joint screens have been discarded and are substituted by a cover screen with a small overlap, the screen being held in place by thin clamp rings.

This design of the screens permits easy and quick replacement. The concept was introduced in the original G-series machines and has already proved successful in a number of centrifugals.

The cover screens, which are supported by a bridge-type backing screen providing a large clearance between the basket and the cover screen, have a thickness of 0,6 to 0,8 mm and either 0,55 mm holes or 0,35 to 0,40 mm slots, providing an open screen area of 19 or 20% to 23% respectively.

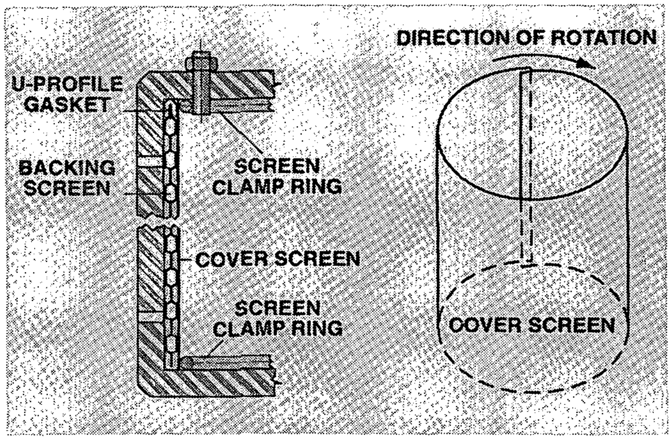

Figure 3. Cover screen installation.

Charging sensor

The charging sensor can either be a mechanical one or an electronic one using ultrasonic technology.

Practical experience shows that the latter is not yet 100% foolproof, but development is continuing and it is hoped that reliable performance will soon be achieved once additional experience has been accumulated.

Discharger

The discharger (Figure 4) is a complete innovation.

Its actuating and control elements for vertical and horizontal movement are provided outside the basket, protecting them from incrustations and resultant wear and making the discharger almost maintenance free, as those parts which require regreasing do not extend into the basket.

The vertical movement takes place in rail-bound carriers which allow an exact and easy adjustment of the discharger plough to the basket.

During the discharging process the basket spindle is held in place by a ring device provided with rollers which slide on a conical element attached to the spindle. An air cylinder moves this arrangement into position during the discharging process only; this prevents oscillations, ensures safe and gentle removal of the sugar from the basket and provides an almost completely clean screen after every cycle.

The plough has the same height as the basket, eliminating vertical movement within the basket and resulting in a considerable reduction of the discharging time. The plough moves into the sugar layer in the direction of basket rotation (Figure 5).

Results achieved by the trial machine proved that discharge time can be reduced by up to 20 sec/charge, which means an increase in the number of charges per hour from 20 to 22.

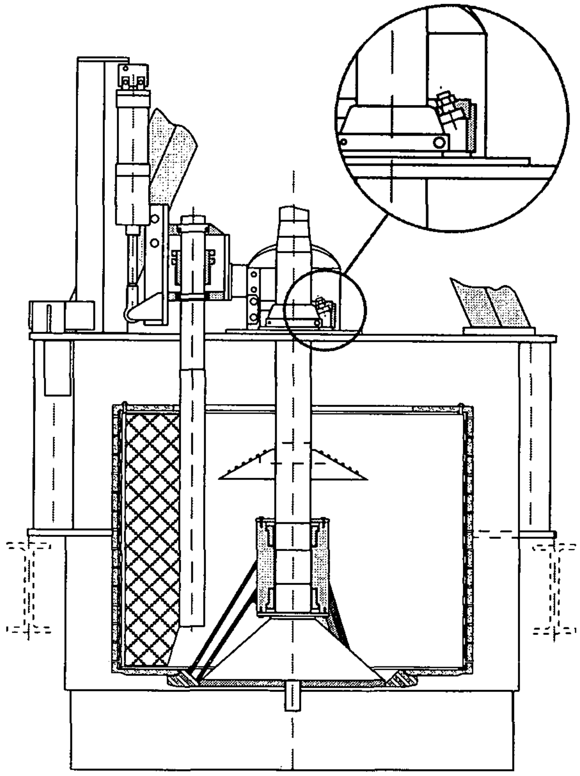

Figure 4. Discharger arrangement.

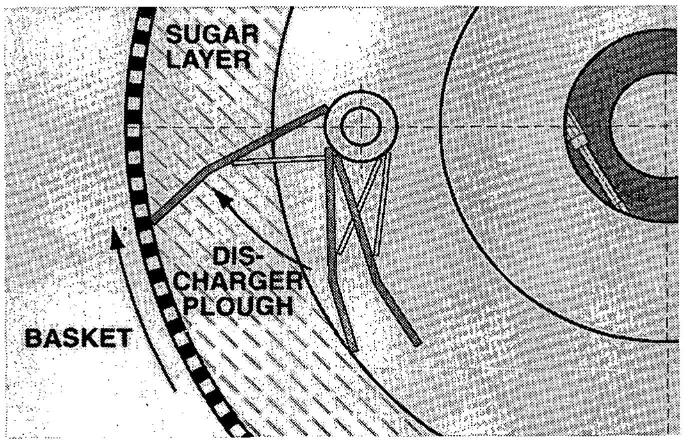

Figure 5. Movement of plough in direction of basket rotation.

An alternative design in which the plough moves into the sugar layer against the direction of basket rotation (Figure 6), similar to that of the previous G machines, is also available. This is intended for those customers who prefer this system over a plough moving in the direction of basket rotation.

Discharge valve

The novel discharge valve lowering device (Figure 7) consists of an air cylinder attached to the spider and a stainless-steel hood attached to the piston rod. The compressed air used has a pressure of approximately 6 bar. The rotatable grommet of the air cylinder has a minimum service life of 350 000 cycles and therefore should not give any problems in operation. However, if it should have to be replaced, this takes a very short time.

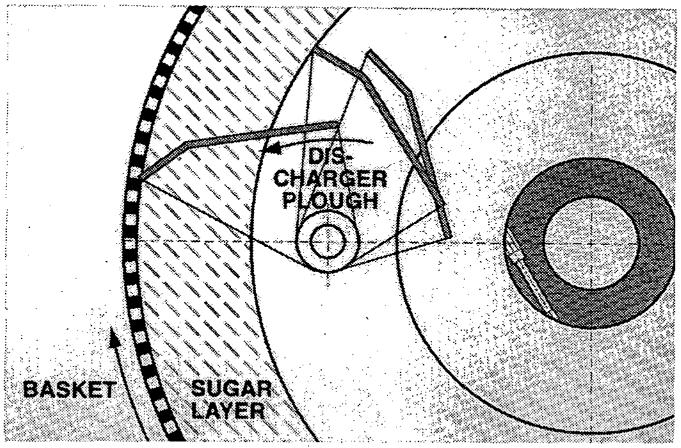

Figure 6. Movement of plough against direction of basket rotation.

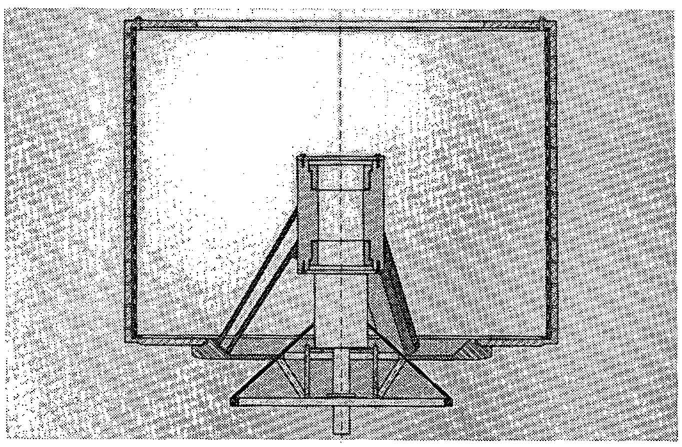

Figure 7. Operation of discharge valve (open position).

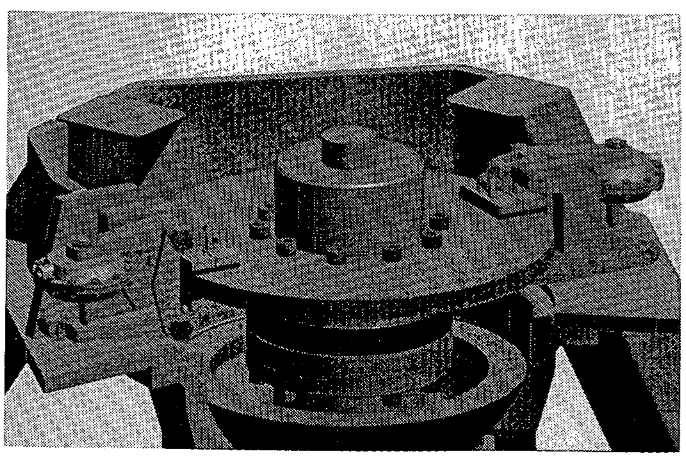

Figure 8. Disk brake.

Brake system

The air-operated disk brake (Figure 8) serves as an emergency brake or for shut-downs only, as the machine does not stop during operation. It is fitted above the bearing system and the coupling within the upper centrifugal frame, identical with the G-centrifugal design, preventing dust from falling down on the centrifugal cover.

Syrup separator

Syrup separation can have a significant impact on the efficiency of the sugar house, therefore it is common practice at many sugar factories to separate the syrup into two fractions, green syrup and wash syrup. The green syrup mainly consists of the mother liquor from the massecuite and the wash syrup results from washing the sugar layer and from basket screen washing. Therefore, the separation process comprises two phases:

- syrup separation for quick quantitative removal of the syrup from the massecuite
- washing following directly after syrup separation with water wash alone or a syrup wash followed by a light water wash.

To improve the separating process, especially when viscous syrups are concerned, it is advisable to carry out 'intermediate' spinning for 10 to 20 seconds at a speed of approximately 500 rpm.

Separation of 'green' and 'wash' syrup should of course be as complete as possible: the mother syrup of the massecuite should be nothing but green syrup and the enriched wash water should be nothing but wash syrup to avoid purity and colour overlaps.

Hitherto, syrup separation (or rather the changeover from green to wash syrup) after the centrifugal was chiefly done by valves fitted in the syrup outlet pipes. One must bear in mind, however, that after centrifuging off the green syrup and at the beginning of water washing there are still considerable quantities of green syrup left on the lower wall of the centrifugal housing, on the bottom plate and in the pipes to the shutoff valve, which are prevented from flowing off quickly due to the turbulences inside the machine. For this reason there always remains a certain quantity of mixed green and wash syrups.

To reduce this mixed syrup quantity, the new centrifugal is equipped with a syrup separator (Figure 9) which allows changeover from green to wash syrup at the lower end of the centrifugal housing wall.

The essential component of this facility is a ring plate inside the housing, which when closed directs the green syrup into an inner outlet duct and when lifted up (pneumatically) conveys the wash syrup into an outer duct.

Assuming this reduces the so-called mixed syrup, i.e. the mixture of green and wash syrup, by half the quantity produced before, the overall sugar house balance will show a higher sugar yield, a reduced molasses output, and energy saved due to reduced mass flow in the crystallisation of raw (middle-product) massecuite. It is known that most refineries and a number of other sugar factories do not practise syrup separation; but nevertheless this improvement in sugar house work is certainly of importance to the factories that do.

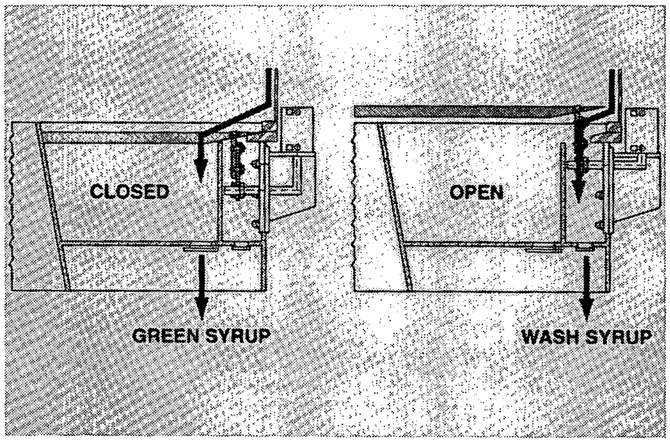

Figure 9. Syrup separator.

Proceeding from this basis, the mass balance of the sugar house shows a better purity drop because of the better separation of green from wash syrup, the result being a lower molasses purity and, consequently, extra sugar recovery of 0,02% o.b. and substantial relief for the raw sugar (hi-remelt) station.

This in turn leads, for a 10 000 t/day beet sugar factory operating 100 days per campaign, to more sugar in the bag, less molasses, and primary energy savings of approximately DM 150,000 (approximately US$ 83,000) per campaign. Tests and experiments to verify these correlations will be continued next campaign.

Drives

Motors/frequency converters

The area of centrifugal technology which has probably seen the most rapid and radical development in recent decades is the drive units.

Today, AC motors of the TEFC (IP 55) type, in connection with appropriate frequency converters, are used to drive centrifugal machines. Subject to the size of the centrifugal concerned, the motor powers range from 110 to 355 kW (preferably 8-pole). These modified standard motors equipped with an additional separately driven fan do not require any maintenance, except for relubrication of their antifriction bearings.

Both CSI and PWM frequency converters using the four-quadrant technology and 100% energy recovery during the braking process, and PWM frequency converter units with a common DC bus, can be employed for frequency control. For larger centrifugal stations, frequency converters using a DC bus involve the advantage of lower costs and also certain technical advantages such as more uniform motor/rectifier currents within the DC bus system.

Insulated gate bipolar transistor (IGBT) converters, active line compensating filters, surge suppressors and power failure protection units are components which various manufacturers can supply for their frequency converters.

As a major manufacturer of centrifugals, our company co-operates with all reputable makers of centrifugal drives. At the time of commissioning it is therefore necessary in most cases that a drive specialist be present as well as a centrifugal specialist.

To reduce the costs involved in such assignments, BMA has decided to offer both services from one single source. For this purpose, the company has established its own electrical engineering service department that handles everything from projecting to commissioning and after-sales service. Until quite recently, the sub-suppliers still had most of the know-how, but now BMA has established its own competency in these details.

Control system

Another major advance on the new 'B' centrifugal is the use of the most modern innovative control technologies. Carefully thought-out operating philosophies open up new monitoring and diagnosing methods.

The 'intelligence' of a machine will be directly accommodated in the lower bus level, abolishing the conventional programmable control systems with their notoriously large number of varieties.

From the outside, every machine is an intelligence of its own in the bus system. A master which manages all intelligences and is responsible for both the inter-communication of the machines and their connection to the process control system. This means, for example, that whereas in the past it was necessary to provide for extensive wiring and cabling from the system in the control room to the machine, followed by corrections, adjustments and optimisations, these will no longer be necessary.

After their completion at the manufacturer's workshops, the machines will be in an operative condition, allowing them to be subjected to functional tests as part of the manufacturer's quality control. What is left to be done at the customer's site is only to install the power cables and make a few control connections.

The advantages of this new drive/control system concept can be summarised as follows:

1. New operating philosophy:
   - status of inputs and outputs is obvious, without the need to interfere with the program
   - operator-friendly input of technical and technological parameters
   - detailed diagnosis and fault display.
2. Transparency of control system, hence
   - fail-safety
   - reduced number of components
   - less space.
3. Improved interlocking.

4. Easy incorporation of process control system interface.
5. Easy commissioning.
6. Substantially less cabling, hence
   - less costs
   - shorter commissioning time.
7. Manufacturer's shop testing possible – without motor.

Conclusions

The following is a summary of the main features and advantages incorporated in the new line of BMA B-series centrifugals (Figure 10).

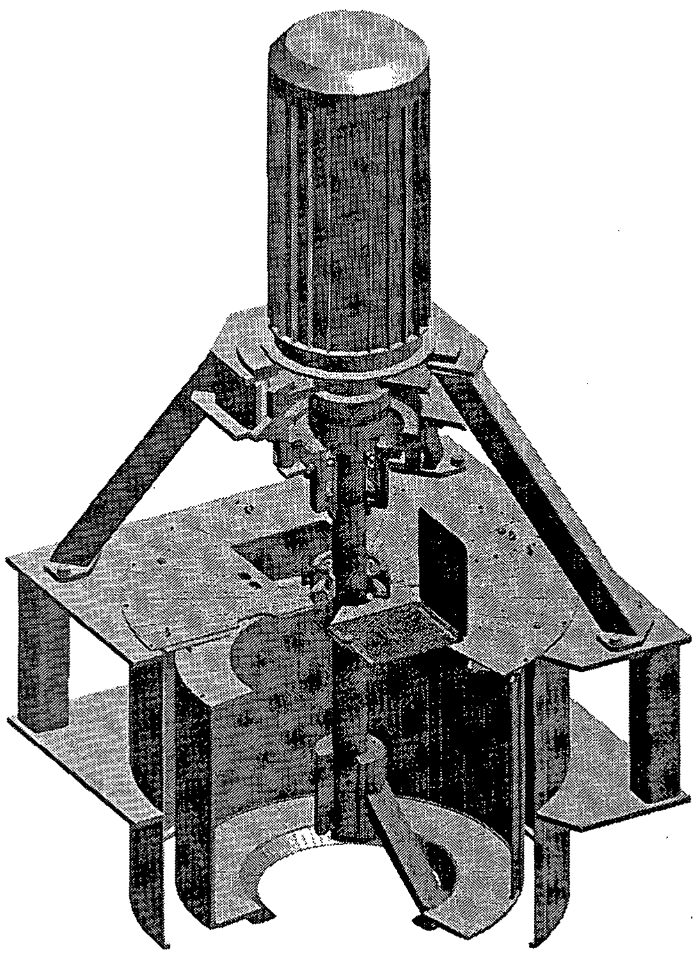

Figure 10. General arrangement of B-series centrifugal.

- Normal charge mass of up to 2,200 kg charges.
- High throughputs at a small layer thickness (230 mm), providing excellent performance under a wide variety of operating conditions.
- Novel discharger – minimised maintenance, no contamination of product by lubricating grease and short discharge period.
- Spindle (basket) fixed during discharging for smooth and gentle discharge.
- Cover screen without lock-lap joint.
- Downward opening closing valve equipped with novel, almost wear-free actuator.
- Design and construction complying with the world's most stringent safety regulations.
- Optimised basket diameter to height ratio for extremely smooth operation.
- Grease lubrication and pneumatic actuation eliminate the need for separate oiling and hydraulic systems.
- Individual installation, avoiding direct influence on adjacent machines.
- Machines completely shop-assembled and tested to save time and cost for installation at site.
- Enclosed disk-type emergency brake.
- Competitive price/performance ratio.

The first trial centrifugal was tested in the autumn of 1997. A further 17 machines of this type will be put into operation in the forthcoming campaign (1998).

The extent of the re-engineering and advances in the B-series centrifugal are illustrated by comparison with the manufacturer's own existing G-series machine. The new B-series shows the following improvements.

- Discharge time up to 20 seconds shorter than that of the G machine, resulting in approximately two more charges/h.
- Less residual sugar in the basket after discharging.
- Syrup separator as an optional item for improved separation and sugar house work.
- Syrup discharge at 180° opposite direction possible.
- All product-contacted parts in stainless steel as standard (for G machines on request only) .
- Bearing system with only two antifriction bearings (G machine: three).
- Oscillation dampening system easily adjustable from outside (G machine: motor must be dismantled).
- No split spindle required for basket removal.
- Easy removal and installation of basket.
- Lower mass moment of inertia of basket.

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