Innovation and improvements in batch centrifugal designs.

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1. Summary.

Selected key batch centrifugal performance criteria and their impact on refinery operations are discussed. The design philosophy of a new range of batch centrifugals is presented and the effectiveness of this design is considered against the key performance criteria.

2. Introduction.

Important centrifugal performance criteria when viewed from the perspective of the refinery user include ...

- Reliability
- Utility consumption
- Cleanliness
- Yield

Good centrifugal design should be such as to maximise the overall refinery performance against these and any other criteria important to the end user. These four criteria are discussed below.

2.1 Reliability.

Many aspects of the centrifugal must be considered when assessing reliability. Reliability encompasses not only obvious mechanical aspects but also the ability to reliably process varying massecuites produced by the refinery. Generally speaking, for a given level of functionality, a simpler centrifugal design is a more reliable design often with a lower capital cost. Less parts, particularly moving parts, leads to greater mechanical reliability.

The ability to process varying massecuite also depends on many aspects of the centrifugal design. The most crucial are the ability of the feed system to distribute the massecuite within the basket and the tolerance of the centrifugal suspension to the inevitable out-of-balance massecuite loads. A greater ability to process such loads leads to greater availability and reliability.

2.2 Utility consumption.

All centrifugal users require the running costs of centrifugals to be as low as possible. Utilities that are normally considered are electrical power, compressed air, space, water and operators.

It is not uncommon for large amounts of effort and expense to be expended on minimising electrical power. However the largest energy usage is almost always associated with the use of water within the centrifugal for washing the sugar and the screen prior to feeding. Typically a modern inverter driven batch centrifugal will consume around 1 kWHour of electrical energy per tonne of massecuite processed whereas older simpler multi-speed motor driven batch centrifugals may consume 2.5 kWHours/Tonne or more. The use of a modern drive system will therefore save around 1.5kWh for every tonne processed. If however the wash water consumption is just 10% more than the minimum required to achieve the required process quality (e.g. 2.2% rather than 2.0% W/W on massecuite) then the additional thermal energy required to evaporate the excess water (approx. 1.5kWh/t of massecuite) is the same as the energy saved by using a modern drive system. Section 2.4 discusses the detrimental effects of excess wash water on centrifugal yield.

Space is a high cost utility. High throughputs from small volumes are beneficial in terms of installation costs and ancillary equipment such as mixers and conveyors. High throughputs require centrifugal designs capable of rapid acceleration, braking and ploughing. Maximum throughputs should always be assessed in terms of the basket capacity multiplied by the highest cycling rate giving the required quality, and not simply on basket capacity.

Centrifugal operators are an expensive resource. Advanced control schemes capable of adapting to varying feed conditions are needed to minimise operator intervention.

2.3 Cleanliness.

Customers of sugar refineries continue to increase the quality standards demanded from their suppliers. From the batch centrifugal design standpoint cleanliness and avoidance of contamination are central to achieving the highest quality standards. Designs should minimise the possibility of contamination from lubricants and other materials such as brake pads from entering the centrifugal. Complex mechanisms on the top of the centrifugal casing or close to inspection doors tend to increase the risk of contamination.

2.4 Yield.

Yield is defined as the proportion of sugar crystal that leaves the centrifugal expressed as a percentage of the crystal in incoming massecuite. The act of washing the sugar, either with water or unsaturated syrup always results in dissolution. All centrifugal designs must minimise this loss of crystal by ensuring a uniform layer of wash liquor is applied to the cake. Another cause of lower yields is the discharge mechanism used to remove the sugar from the centrifugal basket. It is often necessary to strike a balance between removing all the sugar (the ideal) and avoiding damage to the screens within the centrifugal basket. It is common for operators to run centrifugals with a residual sugar layer of between 2 to 3 mms to reduce the possibility of ploughing out the screen.

For a batch centrifugal with a basket diameter of 1.6M and a depth of 1.2M cycling at 20 charges per hour a residual layer of 2.5mms corresponds to 15kgs of lost sugar per charge or 300kgs/Hr. At least 200kgs/Hr of water will be required to remove this sugar at an evaporative energy cost of 120kWHrs. In this example the 2.5mm layer of sugar left in the basket corresponds to a yield loss of 1.5%. If a further 1.5% is lost through excess cake washing then a 1,000 tonne/day refinery requires an additional 18 tonnes/day of evaporation as a result of this 3% reduction in yield. Based on typical European energy costs of $0.012/kWh this equates to $130/day or $47,000 per annum for a continuously running refinery. Over the 20 year life of a typical centrifugal this cost would total around $950,000, which is comparable with the original capital cost of the centrifugal battery.

An alternative way of looking at the benefits of a high yield is to consider the quantity of massecuite processed. If a vacuum pan achieves 55% crystal content and the centrifugal yield is 90% the overall yield is 49.5%, requiring 2020 t of massecuite to make 1000 t of sugar. At 93% centrifugal yield the overall yield increases to 51.15% and the amount of massecuite required to make 1000t of sugar falls to 1955t. This reduction could allow an increase in throughput from a given set of vacuum pans amounting to 30 t/d or 11,000 t/y with little or no energy increase.

In practice centrifugal yields vary from the low 80% to above 95% and it is therefore clear that maximising yield during ploughing and washing can give major cost savings.

3. Review of new Broadbent batch centrifugal design.

Fig 1 - Sectional view of Batch centrifugal.

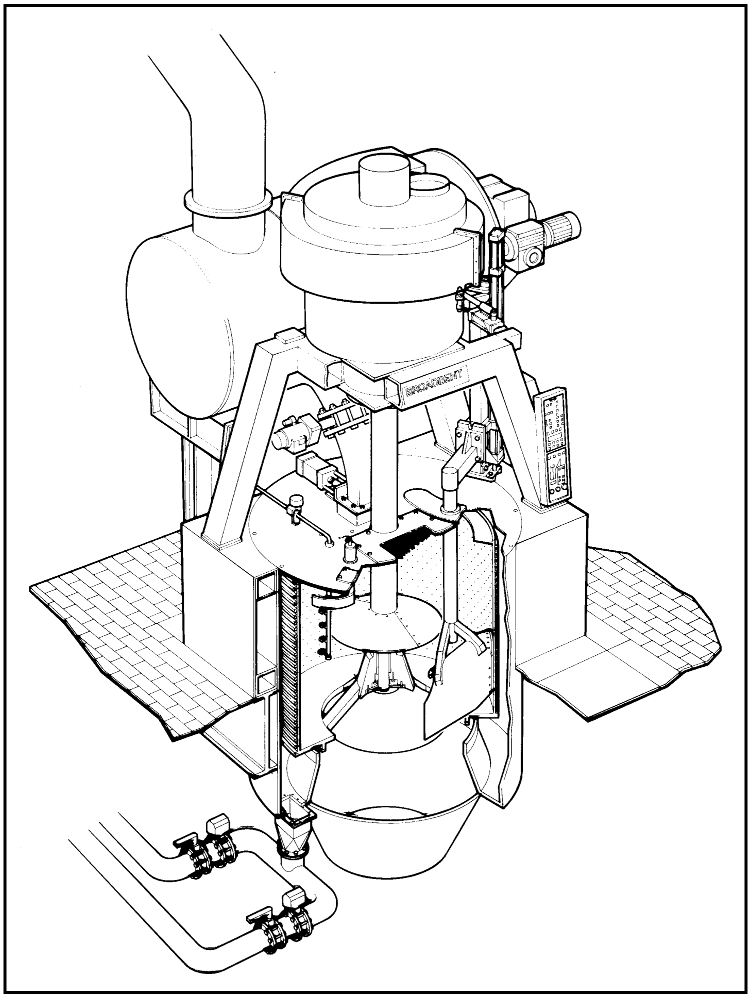
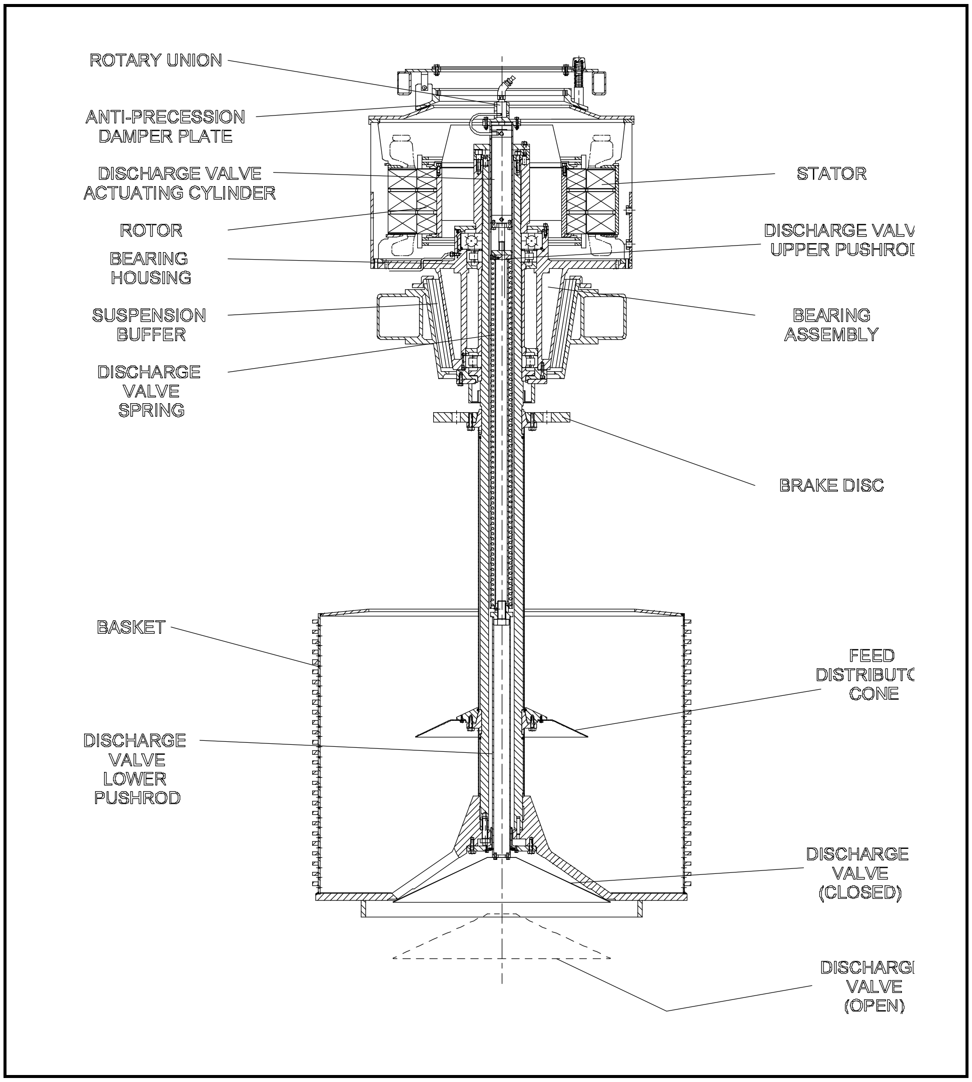


Fig 1 shows a schematic view of a typical centrifugal from the new Broadbent large batch machine range. The new design builds upon the proven approach used by Broadbent for many years. Central to the design is the single piece rotating assembly comprising basket, spindle, bearings, drive motor and suspension. Fig 2 shows these elements in more detail.

3.1 Design of the rotating parts.

Fig 2 - Simple G/A of rotating assembly.



There are several important points to note in Fig 2. Firstly the spindle connecting the basket and motor is a single component and without any form of flexible coupling. This approach allows the basket discharge valve to be operated via a push rod running down the centre of the single piece spindle.

Secondly the drive motor is a ‘special’ motor designed specifically for drives in sugar centrifugals. The motor design is optimised for a centrifugal duty cycle comprising regular high torque acceleration & deceleration periods followed by periods at full speed with very low torque requirements (windage and friction at spinning). In addition the design goals of the centrifugal as a whole such as easy disassembly and a low headroom requirement influence the design of the motor. The result is a short large diameter motor with a high torque overload capacity and thermal capacity which has no bearings of its own but utilises the main bearings of the centrifuge.

This design allows easy independent access to the stator and rotor of the motor without disturbing the bearings.

Depending on the drive selection cycling rates in excess of 22.5 charges per hour are possible with spin times of 60 seconds. Faster cycling rates are achievable with lower spin times and it is always important to consider the achievable cycling rate when assessing real centrifugal capacity. Large baskets and low cycling rates may produce less sugar and use more space than smaller baskets and a faster cycling rate.

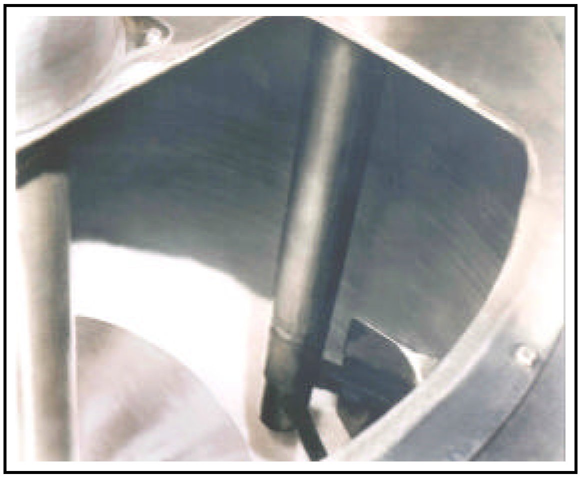
A third feature of the design is the ability to optimise the processing of difficult massecuites by adjusting the damping mechanism to control unwanted gyrations (e.g. those caused by out of balance loads). This is done via an easily accessible adjustable friction damper mounted above the drive motor.

Finally it is clear from the basic schematic of Fig 2 that the mechanical design of the rotating assembly is inherently simple using just two bearing sets carried by a resilient rubber conical buffer attached to the centrifugal support frame. This simplicity contributes directly to improved reliability.

3.2 Design of the ploughing mechanism.

Another key design feature of the new centrifugal is the improved ploughing mechanism which is mounted on the right hand side of the centrifuge support structure - see Fig 1. During the ploughing operation no attempt is made to centralise the basket to give a close plough to screen clearance. An alternative approach is used whereby the plough blade gently touches the screen and floats in and out to accommodate any eccentricity in the motion of the basket. A low contact force is maintained between the plough blade and the screen by careful choice of the plough geometry. Once the plough blade enters the sugar cake the geometry dictates that the equilibrium position is midway through the cake thickness. The plough blade is made to move away from the equilibrium position into light contact with the screen by the application of a small externally applied force. This system maintains a light contact between the plough blade and the screen even if the basket swings from side to side during the ploughing operation. Fig 3 shows the complete removal of the sugar by this self adjusting plough mechanism.

Fig 3 - Plough in operation showing cleaning of the screen.

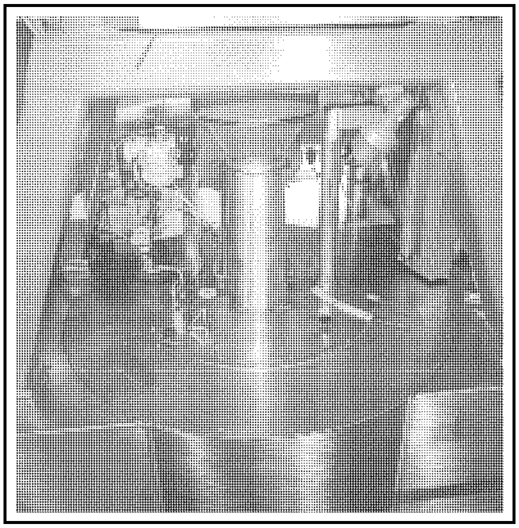


This plough design together with the efficient static wash pipe used on the new centrifugal range and the absence of a feed chute wash leads to excellent yields with low water consumption. Extensive site proving tests have confirmed yields in excess of 95% in beet operations (Ref 1).

3.3 Cleanliness.

Many of the design features discussed above have an impact on the level of cleanliness of the overall design. The result is illustrated by Fig 4 which shows the case top of the prototype centrifugal free from complex mechanisms.

Fig 4 - Centrifugal casing top - Prototype machine.



An independent assessment of the design of the centrifugal against the UK food hygiene regulations has been undertaken as part of the design process.

4. Conclusion.

Some key criteria for the assessment of batch centrifugal performance have been discussed and reviewed against the design of a new range of batch centrifugals. Table 1 indicates those design features which are considered to enhance the performance of a batch centrifugal against the key criteria listed in (2) above.

Table 1.

Summary of centrifugal design features and their effect on performance criteria.

	Reliability & Simplicity	Utility consumption	Cleanliness	Yield
Single piece spindle	✓		✓	
Motor designed for a cyclic centrifugal duty.	✓	✓		
Remote actuation of the discharge valve	✓		✓	
Adjustable damping	✓			
Floating full sugar removal plough system		✓	✓	✓
Static wash system	✓			✓

Additional process data on the performance of the centrifugal in beet application can be found in Refs 1 & 2.

5. References.

1) Process performance of a modern batch sugar centrifugal.
International Sugar Journal. Dec-96. P.D.Thompson, G.C.Grimwood.

2) Process performance of high capacity centrifugals.
International Sugar Journal. Oct-99. P.D.Thompson, G.C.Grimwood.

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