THE DEVELOPMENT & USE OF HIGH GRADE CONTINUOUS CENTRIFUGALS

Dr. G. C. Grimwood, Mr. P. D. Thompson & Mr. M. J. Thewlis
Broadbent Ltd.

Introduction.

The desire to make the sugar process fully continuous has resulted in many advances in recent years most noticeably in the areas of diffusion and vacuum pans. However, batch centrifugals for the production of final quality sugars remain firmly entrenched as the preferred method of separation despite significant development in continuous processing.

Continuous processing of final quality sugars has been tried many times before with some limited success but in the mid 1980's the Australians made the largest effort to develop a genuine high grade continuous centrifugal.

The current generation of high grade continuous centrifugals available on the market stem from the extensive development and trials in Australia mostly on raw sugars. However, there has been ongoing development by others including Broadbents, to improve the separation performance of continuous centrifugals to allow high quality sugars to be processed continuously.

At this time, high grade continuous centrifugals (HGCC) are gradually becoming accepted as an alternative to batch centrifugals for specific applications and there are now installations in all the major sugar producing regions including Central America, Europe, Asia and Africa.

There are significant advantages to operating HGCC's in place of batch centrifugals especially in the areas of capital cost, installation and power usage. Already proven applications include raw, affination and VHP (very high pol) sugars although most of the sugars are for subsequent reprocessing. The continuous feeding & discharging characteristics of the HGCC also provide benefits in terms of simpler & smaller ancillary equipment, e.g. conveyors.

However there are also disadvantages with the use of an HGCC. This paper discusses the balance of these advantages and disadvantages.

Key Characteristics.

In many respects the design of HGCC's is similar to the standard low grade continuous centrifugal operating around the world and the HGCC's manufactured by Broadbent have parts common to both machines. There are, however, important differences that are key to the ability of the HGCC to produce sugar of a quality equivalent to that from a batch centrifugal for selected applications.

These key characteristics are based on work performed in the Australian sugar industry primarily by NQEA. Based on this foundation and subsequent work by Broadbent and other manufacturers,

the key factors which influence the ability of a HGCC to produce high quality sugar have been determined to be:

- **A basket angle close to 25 degrees**

A basket angle of 25 degrees reduces the forces transporting the crystal along the basket wall (see fig 1). The reduced transport forces mean that the sliding speed of the crystals up the screen is reduced and the residence time of the crystals in the centrifugal is therefore increased allowing the sugar to be washed and then dried as much as possible before discharge.

- **A relatively low separating force**

Adjusting the basket speed to produce a low level of separating force minimises crystal damage as the sugar passes through the centrifugal and further increases the residence time in the centrifugal. A separation effect at 300 - 500 x G is adequate as this corresponds to the early part of acceleration in a batch centrifugal which is when syrup purging occurs. The HGCC can not match the maximum 800 - 1200 x G of a batch centrifugal at full speed and consequently its drying performance is lower and the sugar moisture higher. A low basket speed also means that less energy is needed to accelerate the massecuite leading to a low power requirement for each tonne of massecuite processed.

- **Crystal protection baffles to control the trajectory of the sugar**

This feature is included to prevent the sugar crystals being damaged by impact with the centrifugal casing. Careful design of the crystal baffle is necessary to achieve good results.

- **Effective sugar washing**

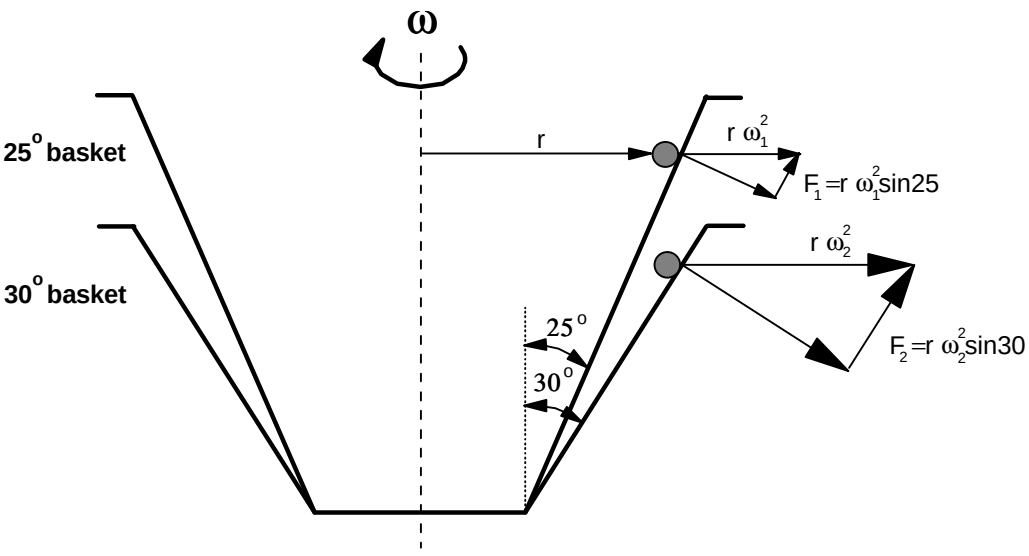
Effective washing is necessary to ensure the mother liquor is removed from the sugar crystal quickly. Although the velocity of crystals through the HGCC is slower than with a standard continuous centrifugal, it is still fast and hence wash must be applied precisely or the desired sugar quality will not be achieved.

- **Improved automation**

Since water consumption is important on all centrifugals, automation is used to ensure that the flow of wash water and/or steam is adjusted automatically to suit the massecuite flow preventing over and under washing and obtain consistent quality.

These key characteristics have been proven successful in operation although there are notable differences between the manufacturers on how these features are implemented. The basket angle and low basket speed both contribute to increasing the residence time of the sugar in the basket. In addition the basket angle of 25 degrees means that more screen area is available for the same overall basket diameter. These effect are compared for a 30 degree and 25 degree basket in Fig 1 for a particle of unit mass. More detailed information can be found in references 1 and 2.

Fig 1 : Standard and HGCC baskets compared.



Basket comparison for a standard 30 and an HGCC 25 degree conical centrifuges.

Basket Angle.	Typical basket speed. ω	Basket area ratio.	Ratio of transport force F.
25°	800 RPM	1	1
30°	2000 RPM	0.84	7.3

Note : Maximum basket radius = 550mms.

Comparison with Batch Centrifugals.

In raw, VHP and refinery affination applications the HGCC is capable of producing sugar of an equivalent quality to that produced by a batch centrifugal. However, there are distinct processing advantages of both types of centrifugal that must be considering before deciding which type is most suitable for a factory.

Tables 1 & 2 shows a comparison for an application to process 30 t/h of high quality cane A massecuite and produce a sugar greater than 99.0 purity. Two columns are shown for the batch centrifugal covering both an old existing batch centrifugal. The first covers a two speed motor and the second relates to a modern batch centrifugal with a energy efficient variable speed drive. Firstly the advantages:

Table 1 : HGCC advantages.

Requirement	Typical Old 48"x30" Batch Centrifugal	Typical New Energy Efficient Batch Centrifugal	High Grade Continuous Centrifugal
Throughput (t/h)	12	30	30
Power Consumption (kWhr/T of masse)	2.5	1	0.8
Drive Motor And Power	Two speed (75kW)	Variable speed (160kW)	Single speed (45 kW)
Power Demand	Variable	Variable	Constant
Maintenance/ Complexity	High/High	Low/High	Low/Low
Price Ratio	-	100%	65%

Of particular note are the following:

- The power consumption of the HGCC per tonne of massecuite processed is lower than both batch centrifugal options.
- The installed power of HGCC is also significantly lower than both batch centrifugals options with no power peaks other than in centrifugal start up.
- The HGCC is a less complex machine and easier to maintain than a batch centrifugal.
- The HGCC is significantly lower in cost than the modern batch centrifugal with a price ratio of typically 65%.

There are also disadvantages with operating HGCC's which are detailed below in table 2 :

Table 2 : HGCC disadvantages.

Requirement	Typical Old 48"x30" Batch Centrifugal	Typical New Energy Efficient Batch Centrifugal	High Grade Continuous Centrifugal
Sugar Moisture (%)	~ 0.6	~ 0.6	~ 1.2
Wash Water (%)	~ 3.0 - 4.0	~ 2.0 - 3.0	~ 4.0 - 6.0
Purity Rise	~ 1.5	~ 1	~ 3.0
Mother Liquor brix less Molasses Brix	~ 2.5	~1.0	~ 5.0
Lump Formation	None	None	Some applications

Of particular interest are :

- The most noticeable difference is the higher moisture of sugar discharged by the HGCC which is typically double that from a batch centrifugal.
- HGCC's also tend to use more water to effect good washing of the crystals as the period of time which the water has contact with the sugar is very short. This is offset to some extent by the fact that the short contact time means less sugar is dissolved. The crystal yield from the HGCC is generally similar or slightly less than that of a batch centrifugal.
- As a result of the increased wash, the molasses brix is usually lower than that from a batch centrifugal.
- Lumps in the discharged sugar can also be found in some applications were the sugar size is small, has a large coefficient of variation in the crystal size or the massecuite is cold.

It is essential that potential users of HGCC's understand these advantages and disadvantages and make an informed decision on which is the best option for their application.

No reference has been made to the condition of the sugar crystals as in the majority of cases the difference between the sugar produced by both type of centrifugals, in terms of % fines, is negligible. In cases where it has been found that there has been an increase in the % of fines in the sugar produced by a HGCC, the total % of fines has still remained within the acceptable limits of the standards set by the factory's clients.

Suitability for Continuous Processing.

It is important for any centrifuge supplier to assess an application carefully before recommending the use of a HGCC. When assessing an application, Broadbent will normally review the following characteristics:

Table 3 : Important process parameters for successful processing by an HGCC.

Characteristics	Preferences
Massecuite purity, brix & temperature	Massecuites with lower brix and higher temperatures permit better separation of the mother liquor from the crystals. A brix of less than 92 and temperature of 55^{O}C or greater is preferred. Purities below 80 should also be avoided as often insufficient separating force can be generated to effect a
Massecuite & sugar colour	A low colour ratio between the massecuite and sugar is better for processing continuously. Ratios of approx. 100:1 are close to the maximum ability of the HGCC
Sugar MA, CV & purity	Larger crystal sizes with small CV's are better suited to continuous processing. A MA greater than 600 microns with a CV of less than 30 is preferred
Sugar moisture	For some applications this is irrelevant, e.g. affination, but for other applications reducing the capacity of the HGCC can improve the moisture of the discharged sugar to around 1%.

The ratio of colours is a good measure of the difficulty of separation in the centrifugal. The table below explains this point further:

Table 4 : The colour ration for typical applications.

Duty	Product Purity	Product Colour	Syrup Colour	Ratio
Cane A (VHP)	99.4	1,400	35,000	25:1
Refinery White (R1)	99.9	15	600	40:1
Beet White	99.9	25	8,000	320:1

As can be seen, the ratio of colour for the cane A application is lower than any of the other common applications. This indicates that the probability of successfully achieving the desired product colour by removal of the layer of mother liquor adhering to the surface of crystals is high. On the other hand Beet white sugar has a very high ratio such that very little residual syrup can be allowed to remain on the sugar crystals if the right sugar quality is to be achieved. This makes the task much more difficult and there may be insufficient time within the HGCC to effectively wash the sugar crystals.

As a consequence, most of the HGCC installations around the world are on raw, refinery affination and VHP applications with only a few producing sugar of purities greater than 99.4. Refined sugar, however, has been processed successfully by HGCC's in Australia and in the UK, white sugar of less than 40 colour has been produced from beet white massecuite.

Many HGCC's operating around the world are producing sugars to be reprocessed. In these cases the higher discharged sugar moisture is not normally a problem. However, there are a significant number of installations where HGCC's are producing final quality sugars and the sugar is mixed with that from a battery of batch centrifugals to minimise any detrimental effects on moisture. For installations where final quality sugar is produced from HGCC's alone then it is probable that additional dryer capacity will be required to condition the sugar adequately.

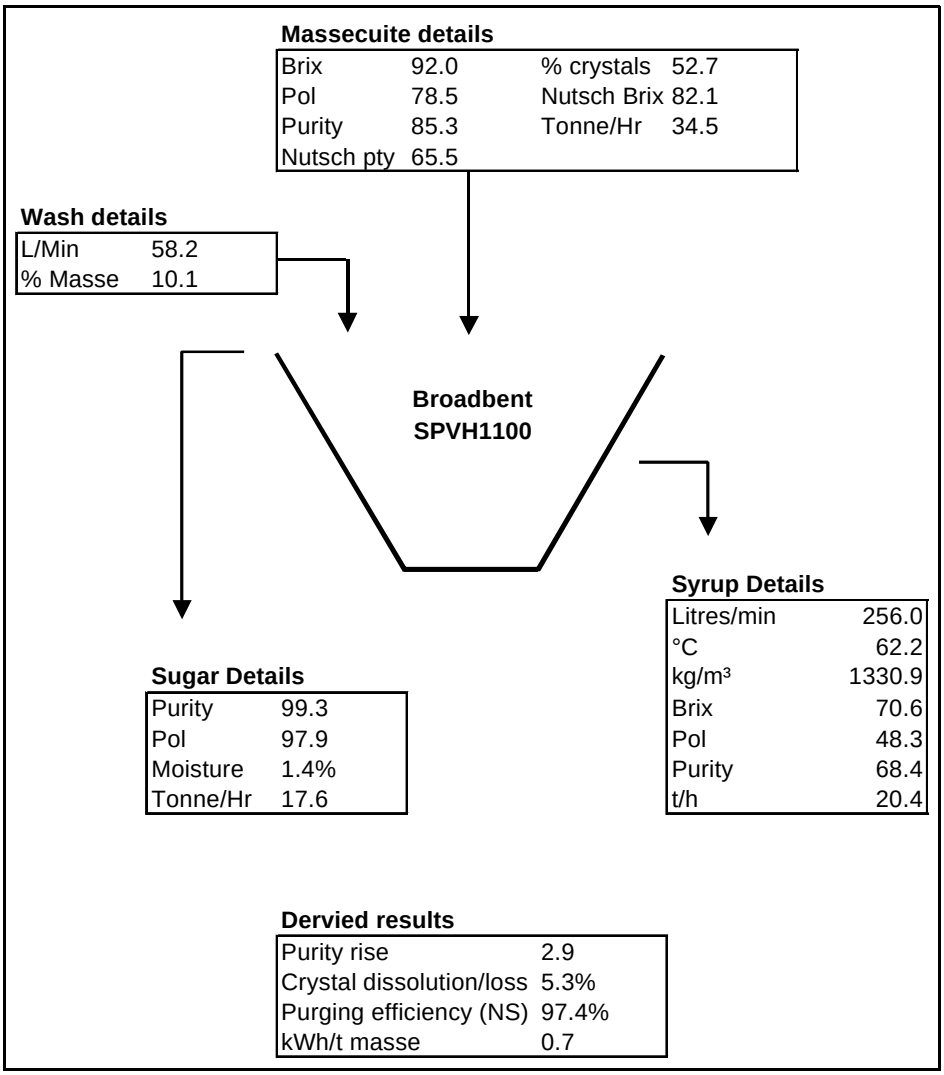
An unexpected benefit of processing sugar through HGCC's is the ability of the centrifugals to handle bad massecuites with small crystals. These massecuites can often prove difficult to process in batch centrifugals and take a long time to clear out of the system. HGCC's on the other hand can process these difficult massecuite effortlessly, often with good results.

.Fig 2. View of High Grade Continuous Centrifugal installation in Europe.

Process Results.

Broadbent has a number of installations throughout the world including Central America. Two typical cane applications are reviewed below. The first of the installations is in South Africa where a Broadbent HGCC is working on VHP sugar of approx. 99.4 purity.

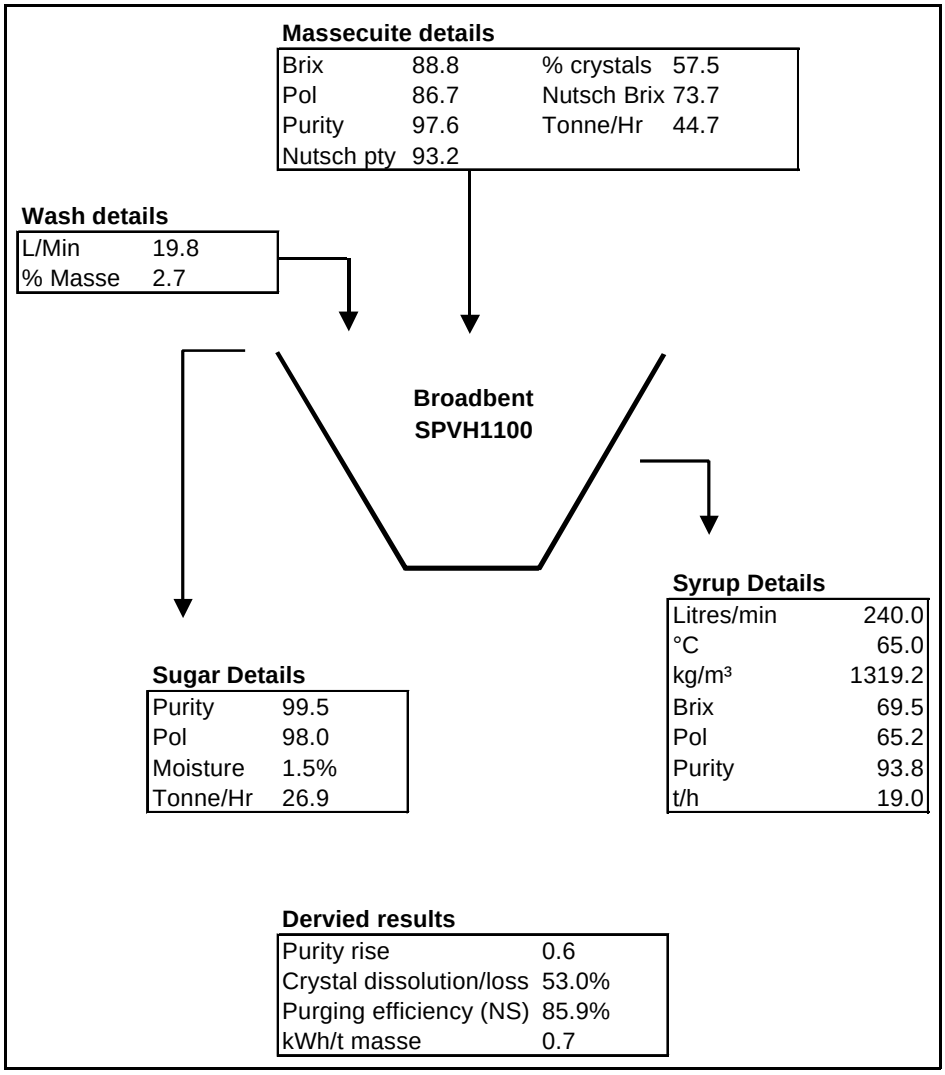
Fig 3 : Mass balance for A raw sugar production.



These figures represent the peak performance of the centrifugal and the HGCC is normally operated at lower throughputs to obtain a slightly lower purity and drier sugar using less water.

The second installation considered is for affination based on trials performed at a refinery in the USA.

Fig 4 : Mass balance for a refinery affination application.



As can be seen from the above information, the throughput of the Broadbent HGCC is large being capable of performing the work of 3 - 4 old 48" diameter batch centrifugals. When processing affination sugars it is important to avoid lumps and tramp material in the magma feeding the centrifugal as this can causing blocking.

Within Central America, Broadbent has installations in Mexico at Groupo Piasa's Tres Valles and Adolfo Lopez Mateos factories. Both of the installations are processing A massecuite. These HGCC's have a pre-dissolving facility built in to the centrifugals and produce a liquid discharge.

An installation in Central America at Belize Sugar Industries Tower Hill factory uses the three Broadbent HGCC's to produce A sugar. In this case the HGCC's have a crystal discharge in to the same conveyor as the batch centrifugals.

In all cases, once installed and commissioned the associated factories have continued enhancing the performance of the centrifugals to suit their individual requirements. This has been easily achieved as the more sophisticated controls used by HGCC's allow full flexibility of all the process parameters. In the case of Broadbent's HGCC, a touch screen is used to monitor and change the centrifugals settings. In some cases variable speed drives have also been used to allow the easily basket speed to be adjusted to suit processing conditions.

Broadbent and its partner NQEA also have other HGCC installations in Australia, Mauritius, Philippines, South Africa, Vietnam, Thailand and the UK. Broadbent will also be installing our first HGCC in Thailand later this year.

Overall Impact.

It is not always enough to look at the characteristics of a centrifugal and it sometimes helps to review the overall impact of operating a centrifugal by considering the upstream and downstream effects. This is best considered by looking at a new centrifugal battery of HGCC's and assessing how it would differ against an installation of new batch centrifugals.

Table 5 : Effect on ancillary equipment.

Feature	Batch Centrifugal	HGCC
Feeding	From crystaliser to massecuite mixer tank to centrifugals	Direct from crystaliser
Supporting Steel Work	Steel work must be designed to handle heavy centrifugals and high out of balance forces that may be generated	Steel work can be designed to handle less weight and light out of balance forces that may be generated
Electrical Cabling	Heavy duty cabling from mains supply to drive system and motor.	Light duty cabling from mains supply to drive system and motor. Cabling for the controls is also simpler
Liquor Flows	Both pipe work of services to and from the centrifugals are larger to cope with large sudden flows	Service pipe work can be sized for constant flows hence be smaller
Sugar Conveyer	Conveyor designed to accept large peak loads	Conveyor sized to receive continuous flow of sugar
Sugar Dryer	Dryer designed to handle varying loads of low moisture sugar	Dryer designed to handle continuous load of moist sugar

HGCC's are generally smaller than batch centrifugals and are often designed to fit on standard centres where batch centrifugals were previously installed. This makes the whole installation process far simpler and can often be completed in a few days.

Conclusion.

The benefits of operating HGCC's where the factory can accommodate the consequences of continuous processing are clear:

- Lower capital cost
- Lower power demand
- Lower operational costs

A battery of HGCC's are also simpler and cheaper to install than a battery of batch centrifugal installation due to:

- Lighter steelwork
- Less cabling
- Smaller physical size
- No mixer feed tank
- Smaller sugar conveyor

These benefits must be consider against the disadvantages of using HGCC's which are:

- Higher moisture sugar
- Higher wash consumption
- Larger load on dryer

Despite these disadvantages, the low capital cost and the advantages above means that HGCC are being serious considered for more applications by more sugar factories.

Although many HGCC's are being used on sugars which are going to be reprocessed, they are also ideal for low cost expansions of existing batch centrifugal stations on final quality sugars where the sugar is blended with sugar from batch centrifugals. It is recognised that HGCC's may not suit every application or factory but we are convinced that they are a viable alternative to batch centrifugals and they will become more common in sugar factories around the world.

Research and development of the HGCC continues to obtain a better understanding of the separation characteristics of continuous centrifugals and it is expected that more final quality products will also be processed continuously in the future as their performance improves.

References:

1) Developments with high grade continuous centrifugals. Zuckerindustrie Vol. 122 (1997), pages 777 - 780. P. D. Thompson & G. C. Grimwood.
2) Handbook of Sugar Refining. 2000 John Wiley. Editor Dr. Chou, Chapter 14 Centrifugation, Page 203 G. C. Grimwood.