EXPERIENCES WITH FLETCHER SMITH CONTINUOUS VACUUM PAN BOILING

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INTRODUCTION

The purpose of this paper is to state the merits of Continuous Vacuum Pan Systems, to indicate the parameters by which their performance can be judged and to give illustrations of how Fletcher Smith equipment meets these parameters.

Thanks are expressed to those companies, operating factories with FS equipment, who have agreed to the inclusion of their performance results in this paper.

MERITS OF CONTINUOUS VACUUM PAN SYSTEMS

The merits of continuous sugar boiling, relative to batch boiling are explained below and the parameters by which the performance of equipment can be technically assessed are given.

Why continuous boiling?

The main reasons why continuous rather than batch sugar boiling systems are chosen are :-

- high energy efficiency
- improved extraction
- reduced plant requirements
- reduced manpower requirements
- low levels of maintenance

Energy efficiency

For energy efficiency the continuous pan contributes by being able to operate on sub-atmospheric steam pressures and a steady steam load. Temperature differences as low as 20° can easily be achieved in the unstirred case and if the pan is stirred this can be reduced further.

For thermal performance to be optimum, the lowest temperature steam possible should be used at each stage of the pan. As massecuite passes through the pan its boiling point elevation is increased due to concentration and a higher vapour temperature may be needed to achieve a given heat transfer. Multiple heating chambers are therefore advantageous. When this is the case multiple effect evaporators can also be used to their optimum with the possibility of taking vapours from as low an effect as possible for each boiling stage. Evaporation rates in each part of the pan can also be balanced more easily with crystallization rates.

Steam usage is reduced as there is no longer a steam-out period as in the traditional batch pan operation. Evaporator systems can be balanced at very close to their optimum brix given steady demands of low temperature vapour. This makes high quantities of waste heat recovery possible and minimises energy usage.

At the boiler house, much steadier operation is achieved and where new installations or factory expansions are being considered, boilers no longer need to be sized to handle large surges in steam demand, nor is there such a variable syrup brix from the evaporators.

The steady vacuum load of a continuous pan also allows smaller vacuum pumps to be used further reducing electrical power consumption.

Overall power consumptions vary between continuous vacuum pan designs. In the case of the FS unstirred continuous pan, suitable for 2nd and 3rd product boilings, there is excellent mixing without any power usage, and with beet sugar massecuites no steam is used to create agitation. Where electrical energy is expensive this reduction in electrical demand cuts costs or enables other equipment to be run without the need for extra power generation equipment.

The low temperature differences with which continuous vacuum pans operate also enables the use of vapour recompression systems.

Extraction Performance/Crystal Quality

These two parameters are inextricably linked. For extraction of sugar to be optimum a number of factors need to be correct. The seed magma fed to the pan needs to contain sufficient crystal surface area to extract sugar from the mother liquor in tune with the rate of evaporation taking place in the pan. This ensures no production of false grain. Equally, a good quality CV is needed if centrifugation is subsequently to be efficient.

Good mixing in each pan compartment is vital to ensure rapid crystallization due to velocity effects. A large number of pan compartments and effective prevention of forward and back mixing of massecuite ensures near plug flow characteristics will occur.

Given this combination of factors, the crystal size variation (CV) will be reduced during the passage of massecuite through the pan. The more compartments exist, with short residence time in each, the better will be the effect. This is due to crystallization rate at a given supersaturation being proportional to surface area, the smaller the crystal the greater the ratio of surface to volume and therefore the size range of crystals reduces with time in a near plug flow situation.

At high purities where crystallization rates are fast, agglomeration will occur unless there is adequate, efficient mixing provided.

In this case the Fletcher Smith Seaford Stirred Continuous Pan provides an optimum solution giving good massecuite mixing with low power demand, and a multi compartment design with near plug flow characteristics for excellent crystal quality.

Extraction is enhanced as a function of installing a continuous vacuum pan as with production of good crystal quality purity rises at centrifugals are reduced. In addition, a levelling off of throughputs occurs, initially at the stage of boiling where the continuous pan is installed, but with quantities of sugars (and non-sugars) recirculated also becoming more constant the purity and brix profile of the complete sugar house becomes more stable. This in turn aids optimum use of all the equipment, and thus extraction.

Plant Requirements

One continuous pan can do the work of several batch pans. Because of the steady throughputs achieved there is no need for large quantities of syrup storage, or strike receivers after the pans.

Bottlenecks previously caused by dead time between batch pans are eliminated and where crystal quality is improved non-sugar recirculation, and thus load on the sugar house, is reduced.

Reduced Manpower Requirements/Controlability

To be an effective contributor to a modern sugar factory a continuous pan should be fully, remotely controlled and require no manual intervention to balance feeds between pan compartments when throughputs vary.

Full remote control also allows for the installation of the pan in a position away from an existing pan floor where it may be more convenient and cheaper to install.

The control of a brix profile through the pan is also a major contributor to optimum crystal quality and exhaustion of syrups.

When a continuous vacuum pan operates with fully automatic remote controls it leaves only residual requirements for overall supervision of it and its seeding system. Consistent quality of product massecuites removes the need for dedicated centrifugal station operators as throughput surges are virtually eliminated and differences in crystal quality between consecutive batch boilings no longer exist.

Maintenance Requirements

Maintenance can best be divided between on-line during the processing season and off-line during the off-season.

On-line

The pan should be so designed and integrated into the factory system that on line cleaning is a simple matter to undertake. This can be by boiling out compartments in turn as in the BMA design, or by ensuring a minimum time requirement for boiling out a single compartment pan, due to the method of integrating the pan into the factory process, or by liquidation of the massecuite in the pan followed by replacement with batch boiled crystal seed. In addition the internal design of the pan should be such that encrustation is minimised and the frequency of boilout reduced.

Off-line

Requirements vary between continuous pan designs. The number of powered stirrers and pumps should ideally be minimised to reduce the long term maintenance needs. In addition, the more complex the control scheme, the greater the on-going maintenance/replacement cost can be. The use of radio frequency brix measurement avoids the need for nucleonic devices with associated enviromental pressures whilst giving an accurate brix control.

Heating tubes may need replacement in the long term although choice of materials can greatly reduce this. There is every possibility that tube lives will be greater than for an equivalent batch pan system as, once full, the continuous pan is not subjected to regular steaming out with its corrosion potential on each occasion.

SUMMARY

By assessing the above parameters the benefits of a continuous pan installation can be determined and the merits of alternate pan designs assessed.
The following section gives performance results of the different Fletcher Smith products compared to these parameters.

FLETCHER SMITH CRYSTALLIZATION TECHNOLOGY

Finally, specific items of process plant within the Fletcher Smith product range are discussed and performance results given. These comprise stirred and unstirred continuous vacuum pans and radio frequency brix control probes.

FLETCHER SMITH UNSTIRRED CONTINUOUS VACUUM PAN

This pan is heart shaped in cross-section with a centrally mounted, vertical tubed calandria protruding through each end of the pan. The pan is divided into 10 or 12 compartments dependent on pan size which ranges from $50m^3$ to $145m^3$ and syrups are fed to each compartment under radio frequency brix control.

Seed magma or magmatised 3rd Product sugar is fed to Compartment 1 and product massecuite removed either by gravity or pump from the last compartment.

Pan absolute pressure is controlled at a steady level and the pan working level is also fixed. The massecuite temperature profile is therefore fixed so a steady state brix profile can be achieved.

Pan throughput is then the only parameter controlled by the operator which is achieved by varying the absolute pressure (i.e. temperature) in the pan calandria.

This type of pan is presently installed in 26 operating factories in 15 countries and 5 continents, 37 pans in total on cane sugar duties, 5 on beet sugar.

In beet it is suitable for the 2nd and 3rd product boilings giving excellent results as indicated below.

TABLE 1

CONTINUOUS VACUUM PAN OPERATING RESULTS

2nd Product Boiling

Factory	A	B
Masse Flow te/hr	25.4	48.5
Masse Brix	92.7	92.7
Masse Purity	86.4	83.0
Centrifugal Syrup Purity	72.6	70.1
Purity Drop Massecuite to Syrup	13.8	12.9
Heating steam pressure m bar A	780	700
Vapour space pressure m bar A	200	220
Approx. ΔT °C	21	18

3rd Product Boiling

Factory	A	B
Masse Flow te/hr	13.5	35.0
Masse Brix	93.9	94.2
Masse Purity	76.4	78.1
Molasses purity	59.2	58.4
Purity drop Massecuite to Molasses	17.2	19.7
Heating steam pressure m bar A	690	700/780
Vapour steam pressure m bar A	135	160
Approx. ΔT °C	21	22

Key performance parameters

- Low temperature differences and excellent mixing without use of stirrers. No steam is added to mix massecuites.
- 10 or 12 pan compartments and near plug flow characteristics give excellent crystal quality (32 CV in the case of British Sugar - York). Little or no centrifugal wash is required to maintain previous cystal sugar colours.
- Fully automatic control - only throughput is manually adjusted.
- Fkexibility of throughput. The British Sugar - York installation has operated easily between 75% and 140% of design.
- Cleanouts during operation. The frequency of this varies with pan purity. Given a spray system to wash internal baffle surfaces above massecuite level 60 days is achieved on 2nd Product and up to 100 days on 3rd Product, without affecting extraction performance.

- Maintenance. With no mechanical moving parts, maintenance is minimal. With vertically positioned heating tubes no space needs to be allowed outside the vessel for tube removal as is the case with horizontally tubed designs.

Fletcher Smith Seaford Continuous Vacuum Pan

This pan has a similar cross section to the unstirred pan but is stirred by elements fixed to twin horizontal stirrer shafts. The heating surface is now provided by vertically mounted plate heating elements.

The pan is divided into a number of compartments and syrup is again fed to each compartment under brix control.

Two vessels of this type are presently installed at Zuckerfabrik e Raffinerie Aarberg in Switzerland. Each produces seed magma continuously for a continuous pan following it. The results from this are shown in Table 2 below.

TEST RESULTS ON SEED BOILING

TABLE 2

		PRODUCT REFINED	RAW	AFTER PRODUCT
Syrup Feed	Brix	73	81.6	78
	Purity	96	88.6	
Final (No. 5)	Cell			
Massecuite	Brix	87.53	91.8	92.3
	Purity	96	90.8	85.9
Mother Liquor Purity			80.2	76.9
Required Crystal Size Micron		350	250	170
Ratio of Syrup/Seed		7.6:1	5.0:1	5.0:1

Given the efficiency of stirring, agglomerated crystals are avoided and very low termperature steam can be used as the heat source.

At an early stage of the first installation at Aarberg the opportunity was taken to carry out a trial on product sugar production giving the results shown in Table 3.

Further long term trials will shortly occur on white sugar boiling at a Cane Sugar Refinery in UK.

TABLE 3

PRODUCT SUGAR BOILING TRIALS - OPERATING RESULTS

Pan volume m^3	11
Vapour space pressure m bar A	300
Heating steam pressure m bar A	850
Masse flow te/hr	8
Product CV (5 compartments)	36.5
ΔT at °C	17
Minimum ΔT achieved °C	10

Details worthy of mention are :

- very low ΔT, good mixing with nearly 100% swept volume, very low power stirrers
- compartment numbers can be optimised in larger vessels to further reduce CV
- fully automatic control
- wide range of throughputs varied by heating steam pressure.

Radio Frequency Brix Control

Fletcher Smith offers two types of Radio Frequency Brix Control instrument.

The FS Monotrac Probe covers lower purity duties, particularly in Cane Sugar applications.

The FS Duotrac Probe which is capable through calibraltion of operating across the complete range of purities from refinery to low purity duties. As the name Duotrac implies, two signals are produced being the series resistance and series capacitance of the massecuite.

In situations where ash content is high the series resistance signal correlates closely to massecuite brix whereas the series capacitance is influenced by mother liquor brix.

In situations of low ash content such as cane refinery applications, the series capacitance signal gives good results throughout the complete pan cycle.

The instrument can also be used for brix measurement and control on various liquors.

The benefits of these control probes are :-

- simple to install
- indirect measurement reduces scale and cleaning problems
- no environmental problems compared to nucleonic devices
- accurate and repeatable control of pan brix
- cost

CONCLUSIONS

Continuous vacuum pan technology offers a number of positive steps forward in terms of operational conditions and costs. These are particularly in the areas of energy saving, low grade energy usage and manpower requirements.

Fletcher Smith has a number of very cost effective products to offer in this area with a significant track record and will be pleased to discuss requirements with potential customers.