OPERATING
AND
MAINTENANCE MANUAL

FOR

FS CONTINUOUS VACUUM PAN

Fletcher Smith Limited
Norman House Friar Gate
Derby DE1 1NU England

Telephone: +44 (0) 1331 636000
Telefax: +44 (0) 1332 636020
E-Mail Address :info@fletchersmith.co.uk
Website : http://www.fletchersmith.co.uk

CONTENTS

FOREWORD

This item of equipment has been manufactured by Fletcher Smith Ltd. It is of a rugged construction, using the best materials and workmanship. With proper care, a long trouble free life is ensured.

The correct application of the Operating and Maintenance Procedures in the manual will ensure the unit performs to the high standard for which it was designed.

It is important these instructions are thoroughly read and understood before operating the unit or its accessories.

Liability

Fletcher Smith's liability under the contract for the supply of this item of equipment is subject at all times to the correct application of the procedures set out in this manual. Fletcher Smith Limited can accept no liability for any loss resulting from any departure from the instructions contained in this manual. If in doubt the operator should contact Fletcher Smith Limited for advice and guidance.

Authority for Use and Reproduction

Copyright in this manual is vested in Fletcher Smith Limited. It must not be reproduced or copied other than with the written consent of Fletcher Smith Limited, and may be used only in connection with the item of equipment supplied with it.

Amendment Procedure

The information contained in the Manual may be amended from time to time in accordance with our policy for equipment development. However, manuals issued to clients will not normally be replaced by amended copies unless the amendment is to correct errors found in the issued document; in which case copies of the amended pages would be forwarded for insertion into the manual.

SAFETY INSTRUCTIONS FOR FLETCHER SMITH EQUIPMENT

The operation of the **Continuous Vacuum Pan**, like all Chemical plant used in Industry, must be operated in **accordance** with the **Factory's Safety Procedures**.

They should be incorporated into the Local Safety System and relevant Code by the Operating Factory Management. The Factory management are responsible for the provision of such safety notices as are required.

Certain areas need special consideration :

DANGER :

i) No person must enter the vessel, even when it is empty, until it has been totally vented. This should involve both manways being opened to allow venting of light and heavy gasses. If forced venting (fan or blower) is used, the flow must be through the whole vessel, including the lowest and highest points.

ii) No person must enter the vessel when it contains massecuite or molasses. These can generate Carbon Dioxide gas, which will collect in a heavy layer at the bottom of the air space. A **DANGER** of suffocation then exists.

iii) If the vessel is empty, it must be free of any residues, well rinsed and fully vented. Chemical cleaning may result in release of explosive vapours. If these vapours are ignited, there is **DANGER** of an explosion. Before opening or use of flames, sparks or welding arcs, the venting must be assured.

iv) The vacuum system can be used to draw fresh air through the Pan. However, if the vapour outlet is part of a common vacuum/condenser system, the system must be isolated in a secure manner.

v) Pressure relief must be provided on the Calandria. If there is a valve on the vapour outlet which can be closed, further pressure relief facilities should be provided, on the vessel Shell.

SAFETY INSTRUCTIONS (Cont.)

vi) The drain system can be used as a route for fresh air, provided drain valves are opened on **both sides** of the Pan, providing they are not sealed into another vessel such as a Receiver. In that case, the line must be broken to give access to fresh air. If the purging of the vessel is not easily checked and done, a gas test/check should be carried out before entry.

vii) The normal factory Permit to Work system should be applied to the equipment. The detailed isolation procedure and check list including : Steam, Vapour, Massecuite, Feedstock, Steaming out, Drains, Water, Instrument Air and Electrical connections.

viii) Normally the design is such that easy access is possible to all parts of the vessel from a comfortable position, however if a ladder is used, it must be securely fastened to prevent slippage. The heights involved should not require the use of a harness, unless the Factory/State code specify it.

ix) Lighting taken into the vessel should be of the correct standard. It must be protected from breakage. For inspection work, a hand held flashlight is normally sufficient.

x) In case of entry to the vessel, there must **always** be one person outside the vessel on duty in the event of a problem. He must not go into the vessel or leave his position without cover being arranged for him. As a rule, no single person should enter the vessel, it should be done in pairs.

xi) If the installation, at the construction stage is felt to be in any way unusual, a **HAZOP** exercise should be carried out. This involves the relevant P&ID details, Factory Permit to Work or Code of Practice, and a knowledge of the pertinent State regulations**.**

Caution/Danger

Electric motors and wiring should be carefully run so as not to be covered in any splashes or spillage of process liquids. Voltages used can be hazardous if installation is not correctly earthed, and with wet conditions.

SAFETY INSTRUCTIONS (Cont.)

Caution

On the station, there are several, relatively slow moving mechanical drive units. Normal guarding of these drive units, in accordance with the Factory and State Regulations, from risks to loose clothing, or mechanical “nip” conditions should be carried out.

Caution

Any spillage of oil, grease, massecuite, syrup water or molasses should be dealt with immediately, to prevent any danger of slipping.

NOTE :

The above notes do not take responsibility for safe working procedures away from the persons involved in operating and working on any vessel. Sensible working practices and adherence to correct safety regulations must be a normal working condition.

SECTION 1

UNIT DESCRIPTION

FACTORY	
COUNTRY	
FS ORDER NUMBER	
PAN DUTY	
H.S. / VOL. RATIO	
NUMBER OF CELLS	
MINOR DIAMETER	
MASSE VOLUME	
FS MODEL NUMBER	
NUMBER OF CALANDRIAS	

PROCESS DATA SHEET	
Output masse	
Massecuite Type	
Massecuite purity	
Massecuite Brix °(ref.)	
Crystal size	
Massecuite flow-rate	
Seed Massecuite / Magma	
Seed Brix °(ref.)	
Seed flow-rate	
Crystal size	
Feedstock	
Brix °(ref.)	
Nominal flow-rate	
Operating design	
Main shell working pressure	
Steam supply source	
Steam supply pressure / temperature	
Cell flow pattern / configuration	
Calandria hydraulic test pressure	

THE PAN

The FS continuous vacuum pan is a horizontal type unit, with a vertical tube calandria mounted along the shell axis.

Multiple units may be mounted in parallel or in series. A stacked configuration is also done.

Different feedstocks can be used, when "back-boiling", or "forward boiling" is required.

The calandria has a **single** or **double** chamber and is designed to work at various steam pressures.

Steam or vapour is fed into the calandria and condensate is drained out by a number of pipes fitted in the bottom tubeplate.

The pan is divided into 10 or 12 separate cells. These are arranged in various configurations of massecuite flow patterns.

Vapour boiled off from the massecuite is collected from the upper part of the pan shell, and removed to the condenser.

Boiling massecuite flows through each cell by gravity via a series of transfer ports. These are so designed as to prevent blockages and ensure a good masse plug flow. Each cell has its own feed manifold, agitating steam and control system.

By careful design, the pan shape provides a smooth massecuite flowpath, without stagnant areas or short circuits.

SEED PUMP

Seed masse, prepared in a batch pan or from a mingled lower grade sugar is pumped into the first cell using a variable speed, positive displacement, metering pump.

The pump speed used is dependent on the required crystal size and the masse flow-rate.

MASSECUITE DISCHARGE

Is by an outlet box with an adjustable weir height, via a barometric seal leg into a Receiver. Alternatively, the masse may be pumped with a level control and variable speed pump.

FEEDSTOCK SUPPLY

For good sugar boiling practice and feed control, the feedstock material should have a steady brix and temperature. It should be free of any crystals.

Ideally the tank Feedstock should be fitted at the same level or above the pan, with about 20 to 30 minutes retention time.

Multiple feedstocks can be connected to the feed valves, by appropriate piping and valve arrangements..

CONDENSER & VACUUM PUMP

As with traditional Batch pans, a condenser and vacuum source are needed to extract and condense the vapours from the pan.

These operations must be kept constant and free from interference by other users.

Devoted systems are strongly recommended.

SECTION 2

INSTALLATION

ERECTION

Depending on site conditions, the pan will be delivered in a number of pieces for welding together.

Where possible, the components will be as large as possible to suit transportation constraints and lifting capacity available.

FS standard welding procedures for weld types and preparation should be carefully followed. **Refer to "Welding terms and symbols for general fabrication."**

PIPEWORK

Massecuite piping should be run with good slopes and drainage. Outlet masse piping should be as steep as local conditions allow, with the minimum of bends, and no flat or horizontal lengths. Ample steaming facilities should be available. For high purity massecuites a minimum slope should be 45 °.

For an overflowing masse system, the height of seal leg must be at **least 6 metres, from the maximum possible height of the receiver / seal tank to the outlet overflow weir.**

Condensate piping is very sensitive to poor installation.

Careful attention should be given to these pipe-runs to prevent any vapour or air locks to occur. A slope of minimum 5% should be used, with long radius bends if possible.

Since the calandria will operate at **sub-atmospheric** pressures, the system is designed with a barometric seal. A simple inverted U-leg, with a 2.5 / 3 metre height is recommended to be fitted into the condensate outlet lines to prevent air being drawn into the calandria.

The top of this loop should be 7 metres below the bottom tubesheet of the calandria. This is a total height of 10 metres. If only a shorter height than 10 metres is available, FS can advise on the appropriate system to use.

Venting of the condensate collection system is ideally done to atmosphere. If venting to a flash vessel, or to the steam main, or to the calandria are used, it is important that at all times condensate must freely leave the calandria!

PIPEWORK (Cont.)

The 2.5 / 3 metre loop will allow up to 3 psig pressure to be used. If a higher pressure is desired, a conventional steam trap can be fitted.

The loop is also used to provide a flooded loop for the condensate flowmeter, which will improve the reliability of the flowmeter signal.

If the loop is not "simple", but incorporates long lengths of pipe to the condensate collecting system, it should have a small diameter air bleed at its highest point to prevent air locks. This bleed may be used as a "balance" line back to the Calandria.

A sight glass is fitted on the main condensate manifold under the pan. This should be clearly visible from a convenient point. It allows the condensate flow to be observed, and should run "empty", with the water cascading down through it. If the sight glass is mounted too low in the seal leg, it can be below the operating level and remain full of water in normal operation. A full and empty sight glass sometimes look the same! If water can be seen cascading, then the calandria is definitely free of any condensate build-up on the bottom tubesheet.

Agitation steam (Jigger) pipes are installed to each cell. The manual stop valve should be mounted as close as practicable to the pan shell. The non return valve on each line, is mounted on the vertical line below this manual valve.

The non return valves are only a protection in case a manual stop valve is left open, when the steam pressure falls or the pan is shut down. They should be carefully checked on installation for correct fitting direction (as arrowed), and that the flaps are free to move and return to their seats under gravity.

IF PROBLEMS ARE EXPERIENCED WITH MASSECUITE BEING DRAWN INTO THE JIGGER STEAM SYSTEM, a small diameter air line with a manual valve is fitted to the main. Before a stop, opening this valve allows checking that all the stop valves are closed, not passing, and allows air to be drawn into the piping. This air will prevent massecuite being sucked into the lines due to steam condensing on cooling.

Massecuite sampling lines should be fitted as close to the pan shell as practicable to reduce blockages. A small steaming out line should also be fitted to this to displace the old massecuite and clean out the pipe before a new sample is taken.

INSTRUMENTATION AND ELECTRICS

Instrumentation is usually based on electronic control signals to air actuated control valves. The electronic signals being converted as required by I/P Convertors**.**

Pressure control loops, for vacuum and steam use modulating Controllers and valves.

Feed Control loops and valves may be modulating, or time proportional control.

Installation may be based on a free standing, discrete panel, fully tropicalised for external mounting. Other options using PLC control as part of an integrated distribution control system are also used.

FS strongly recommend internal mounting in an air conditioned, pressurised control room.

A voltage regulator to provide protection to the system is recommended.

An ample air pressure, of clean air, with suitable regulators is basic.

Pressure Transmitters, Flow meters, should be correctly mounted in accordance with the Manufacturers recommended instructions. Correct piping with "wet legs" should be fitted to the pressure sensors.

Correct upstream / downstream straight pipelengths of the correct diameter are essential for Condensate flowmeters.

FS Probes should be lightly greased with Silicone grease on the fitting collar, (well away from the probe tip), to ensure ease of removal.

Installation of Instrumentation should only be done **after** the major construction stage is complete. If the Instruments are mounted too early, they can be easily damaged. Electric "spikes" from welding power surges may damage the wiring and cable runs, no matter how well the welding systems are "grounded".

ELECTRICS

Design is based on the frequency and voltage of the factory involved.

Illumination of Light Glasses should be of not less than 100 watts, preferably more.

Light glass switches may not be permanently lit. They can be on a timer, set for 5 minutes which switches off after use.

Ample illumination of the whole area of the pan is strongly advised, and good general lighting to allow Feed sight glass flow to be easily observed.

Invertor control of Seed pump is normally controlled from the Control room, with local stop / start buttons at the pump itself if desired.

TEST PROCEDURES

A **Vacuum test** is advised **before** any insulating materials are applied.

The test is done on a cold, empty pan. The installation should raise vacuum to 25" Hg (150 mbars abs), at sea level within 30 minutes. With a good installation, a final figure higher than this can be achieved.

At high altitudes, the absolute pressure should only be used, since the "vacuum" if read in " Hg, will be misleading.

If desired a vacuum decay test can be done, where the minimum decay rate acceptable is 1" Hg per minute. A figure of 1 " Hg in 5 minutes is very good.

A **Pressure Test** is done on completion of erection.

The pan shell is filled with water for a static water test. The water should fill up to and over to the Condenser.

The Calandria is filled with water and pressure tested to 2.0 bar g, or to Data Sheet hydraulic test pressure if higher.

Local pressure vessel test procedures and regulations may apply.

Where the vacuum is controlled by a valve on the vapour line, the pan shell should be protected from pressure by a relief valve or bursting disc. This can be mounted on the piping going into the vapour space. This would normally be to Client Supply.

The calandria is protected similarly. In this case the relief valve is usually in FS Supply.

INSULATION

Insulation of all hot surfaces above 50°C should be done for personnel protection, to the required local standards.

The pan shell and steam mains should be lagged with a minimum of 50 mm thickness material.

SECTION 3

COMMISSIONING

PRE START-UP TEST

i) If any leaks occurred in the calandria with the hydraulic test after erection, the calandria should be subjected to a second hydraulic leakage test.

ii) The body of the pan, all feed tanks, all piping, the seed receive and the seed pump should be cleaned and free of all debris.

Checks are made for welding rod stubs, welding slag, nuts, bolts, washers, pieces of wood, gravel etc., etc.

If screens have been installed for clean-out purposes they can now be cleaned and / or removed.

Before final closure of the manway, all ladders, planks and suchlike must be removed.

A final check should be scrupulously carried out, with all loose change, pencils etc. removed from the pockets of those who enter the pan.

iii) All piping is checked for correct installation.

iv) Instruments and electrics are checked for correct installation, zeroed if needed, and pre-set to approximate start-up settings.

v) The air operated valves are checked for correct action, and response to air failure. The steam valve **closes** on air failure, the condenser injection water valve opens on air failure.

vi) Modulating valves should be "stroked" and on / off valves actuated a number of times to verify their operation. This should be done remotely from the panel, **and the actuation confirmed at the valve !**

vii) A full vacuum test should be done on the empty, closed pan, using the vacuum pump. Rate of increase should be noted every 5 minutes. Check for leaks and repair if necessary. A vacuum decay test can be done if desired.

A good vacuum test is proof of a sound installation!

BOIL OUT

i) Close pan for start-up. All stop valves should be closed.

ii) Fill pan with hot / warm water to just cover the top tubesheet. If possible use the feed lines and valves for this operation. Some vacuum may be needed for this operation.

iii) Check all pipes, welds. flanges etc., for leaks. If any are found, fix them!

iv) Start up the vacuum system. If the water is hot, it will start to boil when the vacuum reaches the pressure at which the water's temperature is the boiling point. Set vacuum control to operate at 15 / 20" Hg or 300-500 mbar abs.

v) Slowly open the steam valve to the calandria about 10 / 20 %. A pressure setting of 1.1 -1.2 barg (1100-1200 mbar abs) can be used instead. But since the heating surface is very large, a fixed opening from a source of low pressure (1.1/1.2 barg) steam is best.

vi) Check that a slight flow of condensate is dripping down through the condensate sight glass. The condensate seal leg should be filled, if need be prior to the boiling out. Alternatively it can be sealed with the first runnings.

vii) The air in the calandria may be forced out through the condensate system. Since the incondensible gas valves are still closed. Steam is thus prevented from entering the calandria.

Slowly open the incondensible gas valves. The air will now evacuate to the vacuum space, or to atmosphere. As it does so, it will be replaced by condensible steam. Condensate will flow down the sight glass. The water will start to boil vigorously only where steam is in contact with the heating surface.

When the whole tubesheet is covered with boiling water, the incondensible gas lines will get hot, condensate water will be gushing down the sight glass. The pan is now boiled out! Make-up water should not be needed. If the pressure in the calandria is sub atmospheric, the incondensible gas valves should be set to vent to the vacuum space.

BOIL OUT (Cont.)

viii) After a suitable time, say 30-45 minutes, close the steam valve, break the vacuum, allow the pressure in the pan to drop to atmospheric, check again for leaks. If satisfactory, drain out the water, close all valves when pan is empty and drained.

INITIAL START-UP

Before the pan can be started, sufficient seed magma or massecuite, with feedstock must be readily available.

Depending on equipment available, the initial fill is usually boiled in a conventional Batch pan. This is normally boiled to give a crystal size of about 75 % of the desired final crystal size.

The Seed Pump, is checked before starting to fill the pan. It should be checked for lubrication fill, and direction.

This Pump may be a metering pump to measure a fixed volume / hr, from a receiver, or a level controlled pump supplied from a magma mingler.

These Pumps may be bi-lobe or tri-lobe, depending on size and duty. Bi-lobe is normally preferred.

The variable speed control should also be checked, with the pump running.

Special checks should be made to prevent any debris or foreign material jamming between the rotor and casing.

A recirculation back to the receiver or mingler is opened when the pan is shut down for a short stop.

To **Fill the Pan,** by cutting over from a batch pan.

a) Prepare the fill masse in Batch pan(s). If practicable, a larger crystal can be prepared for the last cells, and a smaller crystal for the early cells.

b) Close up the Continuous pan and raise vacuum.

INITIAL START-UP (Cont.)

c) Run some feedstock into each cell, to check that all feeds are clear and operating. When the fill masse is ready, at about 90 °Brix, close off steam to the batch pan, then break the vacuum.

d) Open the cut-over connections to the Continuous pan and the massecuite will be drawn across to the Continuous pan.

If desired, it is possible to preferentially put a large crystal masse into the final cells, and smaller, more normal size crystal masse into the earlier cells.

e) When the batch pan is empty, some air is drawn through to clear the lines, and the cut-over line is closed, drained and steamed out if needed.

Normally 2 or 3 Batch pans are used to fill the CVP. When the tubeplates are covered, the CVP can be brought onto boiling.

An alternative to using a cut-over system and batch pans, is to simply fill the CVP using the seed pump. Even running this at a high speed however will be slow in filling the CVP.

f) If a masse seal leg is used, this can be filled before or after the CVP is boiled for the first time. Pumped extraction is primed after the unit is boiling.

BOILING THE PAN

The CVP is now full of masse.

The Vacuum is set to about 150 mbar abs (ca 25" Hg). The Condenser water stop valve is open, the air to the pneumatically operated control valve is open. At this point since vapour is not yet boiling off, the vacuum may be higher than set point.

The Incondensible gas valves are all **closed**.

The Steam pressure set point is set to say 1,000 mbar abs. (atmospheric). The manual stop valve is now opened slowly, to about 25% open. The air trapped in the calandria will have been warmed by the hot masse and be at an elevated pressure, so the automatic control valve will be closed.

BOILING THE PAN (Cont.)

Slowly open slightly the incondensible gas valves. As the air evacuates, steam will be drawn into the calandria, condense, and the masse will start to bubble, then boil **at the points where there is steam, not air.**

If foaming occurs, the boiling rate is controlled along the calandria, until a rolling boil is achieved at the hot part of the calandria. This is controlled by throttling or closing the incondensible gas lines. Once part is boiling, the foam will subside in that part. The boiling zone is then slowly extended across the full pan and the foaming is controlled until boiling is achieved.

At this point, the condensate system will be primed, and the steam set point dropped to say 700 mbar abs, then the manual steam valve is fully opened.

If the outlet masse seal leg is filled, the outlet valve is opened slowly, once the last cell reaches the brix desired, and the seed pump is run at a convenient speed to give the crystal size wanted.

If the seal leg has to be filled, the level in the CVP is built up until there is sufficient above the top tubeplate. The Pan is stopped, by closing the steam off, then breaking the vacuum. When the pressure is at atmospheric, the masse outlet valve is opened and the surplus masse overflows the weir to fill the seal leg. If the piping allows, the drain system can be connected to the seal leg and this can be used instead. Another alternative is to be able to pump seed directly into the seal leg for priming and by-pass purposes**.**

PROBE SETTING

When the masse seal leg is made, the Pan is brought back on-line, and the probes set.

These should be set when the pan is boiling, and the masse is rolling over the probes. Readings are observed as soon as the probes are covered when filling the Pan, but these are not consistent enough for control purposes.

i) The output signal from each probe is checked to confirm it is calibrated within the operating range. If not within the range, the probe is re-calibrated.

ii) Move each cell controller set point, stroking the feed valves. These controllers and feed valves may be time proportional or modulating control. The set points are set to give the desired settings for automatic control to the profile across the CVP.

When all the Control loops are on automatic control, the CVP is "commissioned"!

SECTION 4

OPERATION

NORMAL START-UP PROCEDURE (Pan empty and clean)

1) Check the masse seal leg and make-up if needed.

2) Give the pan a short steaming, this will displace air from the body and warm the pan. Use some of the jigger steams for this. The drain valves can be opened, but if they are closed, the steam / air will blow through the vapour line to the condenser.

3) With all the drain valves closed, raise vacuum.

4) Check there is enough seed and feedstock before starting the CVP.

5) Fill CVP with massecuite, by cutting across from batch units and/or pumping seed fast.

6) Set points for vacuum, steam pressure, should be at normal operating set points.

7) Condensate system should be checked to confirm that valves are open, the seal leg is made or the trap is opened.

8) Open the manual steam valve, the automatic valve will stay closed because the air in the Calandria will be at a higher pressure than set point.

9) **Slowly** open the incondensible gas vents, to control the boiling pattern. Stop foaming if it occurs, by use of these valves.

10) Set / check the seed pumping rate.

11) Set / check Steam pressure.

12) Set / check Vacuum.

13) Set / check Probes, and Controller set points.

14) Open feed valves.

15) Set / check massecuite boiling level, adjust if needed.

16) Check condensate is flowing away freely at the correct rate.

17) Check outlet masse brix, feed controller set points as needed.

SHORT STOP AND/OR HOLD PROCEDURE

To **Slow** the Pan down, the simplest thing to do is to reduce the steam pressure. Where possible this should be done instead of stopping the pan. Water can be added to several cells, if there is a shortage of feedstock, or if there is a problem with outlet masse receiver level.

Steam pressure should always be reduced over a period, by small steps or by "ramping" if available. An increased steam pressure can be done without ramping.

If the Pan must be stopped for less than 12 hours;

Vacuum can be maintained, the last 3 cells are made slack.

The Seed inlet valve is closed and seed pump put into recirculation. Note this usually requires the pump to be stopped / started in order to close the valve and to open the recirculation valve without disturbing the vacuum.

All manual feed stop valves are closed, after drawing in some water to keep lines clear for restarting.

Shut the manual steam valve.

Shut the massecuite outlet valve only after the masse stops overflowing.

If the jigger system has been in use, close off all manual stop valves, then draw air into the jigger header.

Leave those incondensible gas vent valves which are "set", but shut the main stop valve.

To re-start the Pan;

Restore all the above which were done. If the stoppage is only a very short one, the restart will be easy. If it was longer than anticipated, jigger steam may be needed to re-start the circulation.

When the Pan is boiling, open the feedvalves. Check that all the probes are working properly, since they may require cleaning immediately after such a stop.

SHORT STOP AND/OR HOLD PROCEDURE (Cont.)

For a stop in excess of 24 hours;

Depending on the massecuite duty, and circumstances, it is advisable to empty the Pan and start afresh with the normal start-up procedure as above.

The Seed system should be shut down, and the pump, lines drained and steamed out thoroughly.

All drain lines should be empty and steamed out.

Before commencing to empty the Pan, all the drain lines should be clear and checked by drawing air into the Pan through them, with the Pan still under vacuum.

NORMAL OPERATION & TROUBLESHOOTING

There are a number of factors to consider when operating the continuous Pan, but probably the three most important are :-

i) Masse quality in cells 5 / 6,

ii) Massecuite crystal content,

iii) Ensuring constant running of the pan.

For good massecuite boiling and circulation, a high crystal content is needed to reduce the danger of introducing fines, and to ensure an adequate surface area for sugar deposition. This may require water to be fed into the first cell to increase the crystal content.

It is important that care and attention is given to the first part of the Pan. Any errors occurring at the beginning cannot simply be cured in the last few cells. if fines do appear, it is better to wash them out by putting one of the cells onto a water feed.

SEED MASSECUITE QUALITY

It is important to ensure the quality of the seed massecuite is good. If it is poor, the continuous pan will not correct it. The seed crystal should therefore be a consistent size and free from false grain.

SEED MASSECUITE QUALITY (Cont.)

In order to keep a standard seed / masse volume ratio, the crystal content of the seed should also be constant.

MASSECUITE BRIX

Once the desired boiling profile has been determined, the pan operator should ensure that is obtainable at all times.

The brix may become reduced for the following reasons:

a) Too low a probe setting, this is corrected by increasing the set point.

b) Sugar scale on the probes. This is corrected by cleaning the probes. It will be observable on the cell recorder, when a cell is seen to drift away from the set-point.

c) Loss of vacuum. As the pressure in the pan rises, the masse boiling temperature will rise, slackening off the massecuite.

d) A leaking feed valve.

The masse brix may become too high for the following reasons:-

i) Too high a cell probe setting. This is corrected by dropping the set point.

ii) Partial blockage in the feed line or valve.

POOR BOILING

If the molasses flowrate to the pan reduces it may be due to a drop in the evaporation rate. The reasons may be one or more of the following:-

a) Poor heat transfer through the tubes due to encrustation. Temporary relief may be obtained by using Jigger steam, but eventually the pan will have to be boiled out.

b) Low calandria steam pressure or high shell pressure (low vacuum).

c) A build up of incondensible gases in the calandria.

POOR BOILING (Cont.)

d) A build up of condensate in the calandria.

e) Too low a crystal content.

f) Operating the pan at too low a throughput. To overcome this, put some cells on water feed.

g) Massecuite brix is too high in the early and middle parts of the pan. This will be seen with a steep gradient of the boiling masse level across the pan.

LARGE VARIATION IN CRYSTAL SIZE

A large variation in crystal size may be caused by the following:-

1) A high coefficient of variation (CV) in the seed masse / magma.

2) Erratic feed control.

3) Poor vacuum control.

4) Incorrect boiling profile. The profile should always be increasing in brix across the pan. No cell should be lower in brix than its predecessor!

5) Low crystal content.

6) Lots of stop / start operations.

TO ALTER THE MASSECUITE FLOWRATE

The massecuite flow through the pan is basically controlled by two functions. The first is the seed masse / magma flow rate into the pan, and the second is the calandria steam pressure. This latter is the main rate control variable! The Vacuum and seed flowrate rate should be constant.

As the steam pressure changes, the evaporation rate changes, which in turn draws more or less feedstock into the pan. This in turn deposits sugar onto the crystals as the water is evaporated.

TO ALTER THE MASSECUITE FLOWRATE (Cont.)

If water is fed instead of feedstock, the massecuite flowrate for the same steam pressure will be reduced. The correct thing to do is to lower the steam pressure in the calandria. Ideally this should be ramped down over a short period to prevent the masse going "off the Boil".

The FS pan should not require water to maintain its circulation. If water is used then a higher steam pressure is maintained.

To raise the masse flowrate, the steam pressure is increased. This need not be ramped, since the step change is upwards.

For the best results from any continuous operation, it is important that the feeds into the system are as constant as possible, e.g. brix, flows and temperatures of feed, steady seed masse flow and quality, constant vacuum, steady steam pressure.

As any changes in flow rates take time to settle, the operator should be wary of too many changes being made too often!

There should always be ample Seed Masse and Feedstock available.

Steam pressure setting changes should be infrequent and related to the level of the main feedstock storage vessel. A practical suggestion is that if this level is between 25% and 75% full, no change is called for.

If the level hits either of these "trigger" points, then a change should be CONSIDERED. Only after consideration of the general process surrounding the pan, should a change be made.

SHUTDOWN CLEANING AND BOIL-OUTS

In addition to the Short and Long stops above, at the end of the operating period, or should the internal surfaces become encrusted with sugar, it will be necessary to empty out and clean the pan.

Depending on the circumstances, if the material in the pan has to be made the same as the normal output (e.g. for centrifuging), before discharging it will be necessary to increase the crystal size in the first few cells. Thus:-

1) Stop the seed masse / magma flow to the pan.

2) Increase the brix in the first cells of the pans to make the crystals grow, by moving the feed set points.

SHUTDOWN CLEANING AND BOIL-OUTS (Cont.)

3) When the crystals are sufficiently large to be easily handled in the centrifugals, close off the steam to the calandria and isolate all the feed lines. Shut all jigger steam lines and the main steam isolating valves.

4) Shut down the vacuum system and open the vacuum breaker.

5) When pan shell pressure reaches atmospheric, open up the drain valves and drain out massecuite.

Depending on the degree of encrustation, time available or other circumstances, the pan can now be:-

a) steamed out (similarly to a batch pan), using the jigger system and steam-out connection.

b) boiled out fully with top tubesheet covered, using the main steam with help from the jigger system, similarly to the initial Boil-out as above, or

c) cleaned out with only the bottom tubesheet covered and using the jigger system to provide the agitation through the small volume of water in the bottom of the pan.

It is good practise to keep a record of any blocked tubes by filling in a blank form showing the tube and cell pattern. This is a direct indication of the degree of encrustation and how well the pan has been cleaned out. If some cells are more prone to blockages, the reason should be checked. The Jigger steam can be preferentially applied to problem cells.

The division plate sprays, on high purity massecuites, are a very good source of water and vigourous washing. They can also be used as a venting route for the incondensible gases by suitably cross connecting. This suppresses any encrustation build up above the massecuite level continually.

At the end of the cleaning period, the pan should be completely free of any encrustation and blocked tubes.

SHUTDOWN CLEANING AND BOIL-OUTS (Cont.)

Depending on the method used to clean there may be no liquid left in the pan (if only steamed out), about 70 % of the nominal volume (full boil-out) or about 25% of the nominal volume (if only the bottom tube sheet was covered). The brix of this material should be recorded, since it is a direct indication of how badly fouled the pan was.

If the volume is large, the contents are dropped into a "washings" tank for subsequent reprocessing. If the brix is below 45 °Bx, the norm is to reprocess via the evaporator station. Above 45°Bx, it is usually reprocessed with the pan feedstock.

If the volume is low, the material can be kept in the pan itself. Fresh seed masse, or the previous contents of the pan, is pumped or transferred into the pan at the first cell.

The pan is put on the boil. The light material is pushed along the pan to the last cells, and the extra water is boiled off. Only when the last cell is at its proper brix and level, is the outlet opened. The brix profile will then be checked for normal operation.

In the event an "acid" boil-out is needed, the relevant procedure above can be used, followed by ample rinsing.

When the pan has been cleaned for the end of the operating period, it is recommended that all valves and lines be carefully drained, particularly the massecuite and feedstock lines.

ON-THE-RUN STEAM-OUTS

The so-called on-the-run steam-out, of a continuous vacuum pan, is a process which can assist in both removing accumulated encrustation and also in retarding its subsequent growth. This operation is quick and easy to carry-out, should only have a minimal impact on operations, and is effective on exposed surfaces above the massecuite boiling level and is also believed to assist with controlling encrustation that occurs below the liquid level.

Regular application of this procedure will significantly prolong the periods that a CVP can run before having to stop it for a boil-out to remove the encrustation. In certain cases it may allow a CVP to be run through a whole season or campaign without having to shut it down for a boil-out.

ON-THE-RUN STEAM-OUTS (Cont.)

The operation of a batch pan incorporates a routine of regular steaming-out of the pan, after discharging the massecuite, to remove any build-up of sugar layers and encrustation. The operation of continuous pans does not provide the same opportunity and encrustation build-up can then cause problems due to two factors**:-**

(a). Sugar build up on exposed surfaces of the pan reaching a level where lumps break off. These may then cause blockages in tubes, pipes or outlets.

(b). Progressive scaling of the heating surface reducing the heat transfer and consequently requiring the calandria steam pressure to be increased. When the limit of this adjustment is reached, cleaning of the heating surface is required in order to maintain production levels.

Encrustation is highly dependant on massecuite purity, with that formed by cane B- and C-massecuites being the least serious allowing CVP's to be run for long periods of time without having to empty and boil-out the pan with water. For example, CVP's in cane raw sugar factories boiling C-massecuites with purities of around 52, routinely operate for a full season of around 38 weeks without having to have any stops to clean out the pans. On the other hand, rates of encrustation in A-massecuite pans are far more severe, requiring boil-outs to be carried out at intervals of between 2 and 4 weeks.

The mechanism of encrustation proceeds in three steps:-

(a). Formation of encrustation islands;

(b). Growth of the encrustation islands or crystals along the surface of the wall to which they are attached until they touch against each other, thus forming a crust.

(c). Growth of the crust.

The growth rate of encrustation on a surface is much higher than the growth rate of a crystal in suspension. This is because there is a higher relative velocity between crystal/encrustation and the solution, increasing the mass flux for diffusion controlled crystal growth and because of the additional attachment of small crystal that takes place.

ON-THE-RUN STEAM-OUTS (Cont.)

It is the intention of this operation to heat the vapour space to a temperature of between 90 and 100 EC. This results in the exposed metal plates also being heated to higher than normal temperatures, which causes the encrustation islands and crusts to loosen and to break off when the agitation caused by boiling restarts.

With the calandria also being heated to around the same temperature during this operation a similar effect is also achieved on the heating surface. That is, with the massecuite not boiling the heating surface temperature will rise causing localised reduction in supersaturation. Just a small increase in the wall temperature above the saturation temperature is sufficient to remove encrustation.

PROCEDURE

Shut-off the CVP condenser by isolating the appropriate valves. This could involve either shutting of the isolating valve in the vapour line or closing the condenser's water valve and stopping the vacuum pump.

For a CVP operating on a predictive control system; shut off the syrup/molasses feed valves to all cells. This is an optional step for a CVP utilising RF probe controls, since with this system the RF control loops will soon close the automatic feed valves to each cell, as the combined effect of the feed itself and massecuite temperature increase will cause the cell RF signals to drop below the set-points.

Where a pump is being used to remove massecuite from the last cell, either stop the pump or put the speed setting on manual and minimum output. This is to prevent the massecuite level being run too low; for a CVP utilising an overflow weir no action is needed since the massecuite will only drain out to level with the top of the weir. The seed pump can be left running.

Open up the steaming-out valve into the vapour space and allow the pressure to rise to around atmospheric.

There is no need to close the steam valve/s to the calandria/s since the controller/s will cause this to happen when, in the first instance, the CVP stops boiling and, secondly, vapour is pushed back through the incondensible gas vents causing the pressure in the calandria to rise above the set point/s.

ON-THE-RUN STEAM-OUTS (Cont.)

Control the steaming-out valve opening so as to maintain the pressure in the vapour space at around atmospheric pressure for a period of around 10 minutes. This period of time is recommended for routine operations. If the encrustation build up is severe then this period can be extended to around 15 minutes, however periods longer than this produce very little extra increase in encrustation removal.

Close the steaming out valve and raise vacuum and put the control onto automatic.

If the CVP syrup/molasses feed valves have been closed, re-open them once the pan starts boiling again. If the massecuite pump has been stopped start it, or else put it back onto automatic control.

OPERATION GENERAL

Note: At no time should steam be fed to a pan calandria, if there is no masse or water in it.

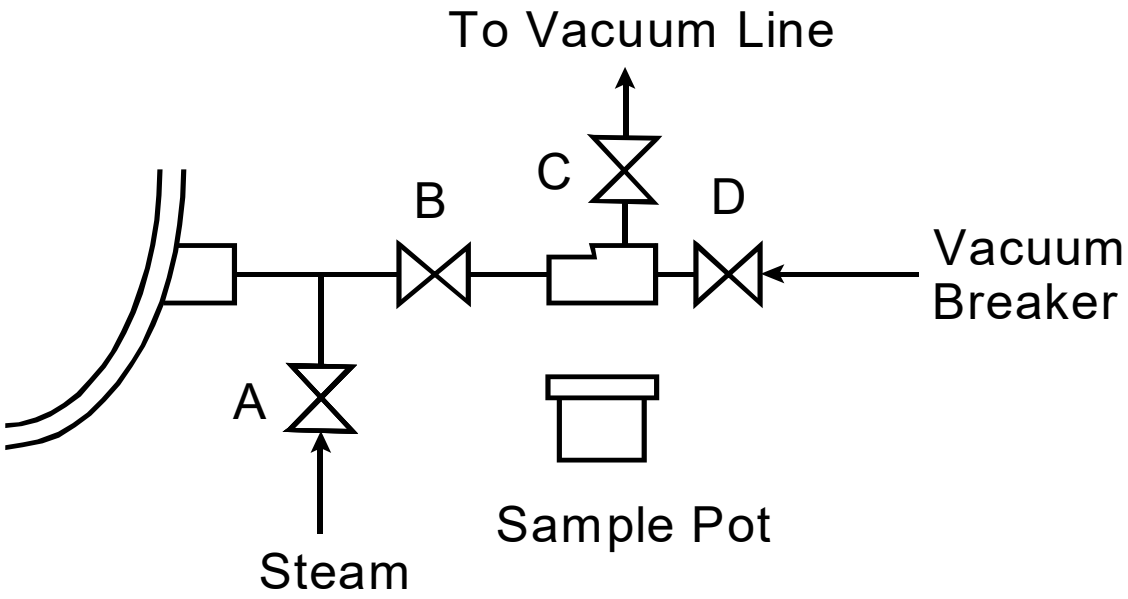
SECTION 5

GENERAL INFORMATION

PROCEDURE FOR MASSECUITE SAMPLING

Under normal conditions all valves are closed. To take a sample:-

1. Open steaming out line valve 'A' to clean out sample line.
2. Close valve 'A' after steaming line, open and close valve 'B' to check line is clear (i.e. Air is drawn into pan).
3. Wet seal with water, lift sample pot onto seal of sampler top and open equalising valve 'C'. Sample pot will be held onto sampler by pan vacuum.
4. Open valve 'B' to fill sample pot. When sample pot is 75% full, close valve 'B'. Do not over fill sample pot.
5. Close valve 'C'.
6. Hold sample pot, open valve 'D' to break vacuum. Slide sample pot off seal.
7. Open valve 'C' for a few seconds to check line is clear.
8. Open valve 'B' for a few seconds to clean out valve 'B'.



ESTIMATE OF MASSECUITE/SEED VOLUME RATIO

If the crystal content of the seed and discharge massecuite are approximately the same, then the ratio of the flow rates is proportional to the ratio of the cube of the crystal size.

$$\frac{Qm}{Qs} = \frac{dm^3}{ds^3}$$

where Qm is massecuite flowrate (m^3/hr)
Qs is seed magma flowrate (m^3/hr)
dm is massecuite crystal size (mm)
ds is seed magma crystal size (mm)