Control of Pulpers Beaters and Refiners

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Main Reasons for Instrumentation and Automatic Control

1. Objective control giving the maximum possible uniformity becomes more important with increased machine production, through higher speeds and wider deckles, and tighter paper specifications.
2. Reproduceability for repeat makings.
3. Eliminates or reduces the human element and the time lag in laboratory testing of process results.
4. Lower manpower requirement, although a greater load on, or need for, an instrument-section. The latter can be a difficulty in a small mill having insufficient work for a full time instrument mechanic.
5. Lower power consumption because more uniform and fuller utilisation of plant, and often higher production for the same reason.
6. Part of the trend towards full automation of the entire production line.

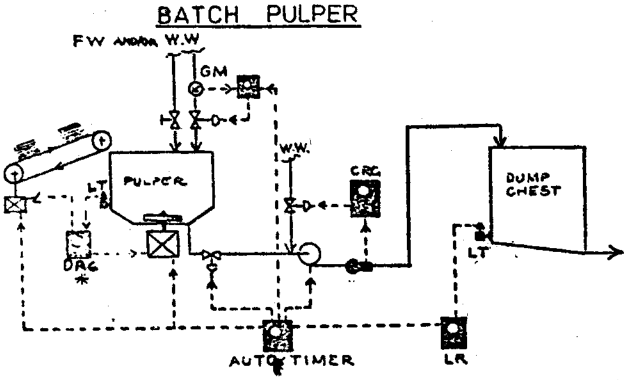
Main Drawbacks

1. Interdepandence of the variables measured : e.g. there is no effective automatic continuous fibre length test independent of freeness value.
2. Difficulties of eliminating, or allowing for variables other than the one being measured or controlled.
3. Great Difficulty in referring back significant paper or board properties basis to measureable and on a continuous controllable variables in stock preparation.

AUTOMATIC PULPER CONTROL

In continuous operation the degree of defiberisation is controlled by the screen hole size. In batch operation it is controlled by the time cycle, although a screen may be installed over the pulper dump valve to hold back very large unbroken pieces such as high wet strength or coating broke. Batch operation allows more complete treatment and greater flexibility (although lower throughput and higher specific power consumption).

AUTOMATIC PULPER CONTROL



The degree of defiberization may be tested in two ways :

(1) Handsheets from the pulper are compared visually with 'look-through' photographs of handsheets arranged in order, from barely slushed to completely difiberised, and each having an index number. These are supplied by certain manufacturers.

(2) An approximate guide is given to the absence of broke flakes or fibre clumps by progressively diluting a pulper sample until the individual components can be clearly seen.

Batch Pulper

The main aim is to add pulp and water in a predetermined ratio and pulp them for the optimum time in relation to work done on fibres and power usage. This time is determinet by trials.

Figure 1.

A fixed quantity of water, usually white water, is added to the pulper either controlled by a gallon age meter as in the illustration, or by a depth cell on the

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pulper. The depth cell actuates the roter and the conveyor, on which a fixed number of bales or weight or pulp has been placed. The moisture content of the pulp is not Critical. One man may service several conveyors or be given other duties.

The rotor is on for a fixed time, sufficient for slushing. The auto timer then stops the rotor, opens the dump valve and starts the pump. It also triggers the addition of wash-out water, the quantity controlled in the same way as the slushing water, when the pulper is almost emptied. Most pulpers can works to a ½ hour cycle, therefore emptying and washout must be very rapid, say 3-5 minutes.

The speed the process further, a vessel large enough to contain the pulper slushing charge plus washout water may be installed above the pulper. When the cycle is started, the charge is dumped rapidly into the pulper. A very large valve should be used to reduce filling time. The vessel is filled while pulper is operating, the amount of water being regulated by a depth cell on the vessel.

At the end of the cycle, when the pulper level has dropped to the appropriate point wash-out is added. The signal for this is given by the timer, measuring from when the pulper dump valve is opened, or by a depth cell on the pulper. The amount is controlled by the depth cell on the vessel, the level dropping from C to D. One mill-uses, a slushing charge of 19000 and washout charge of 13501.

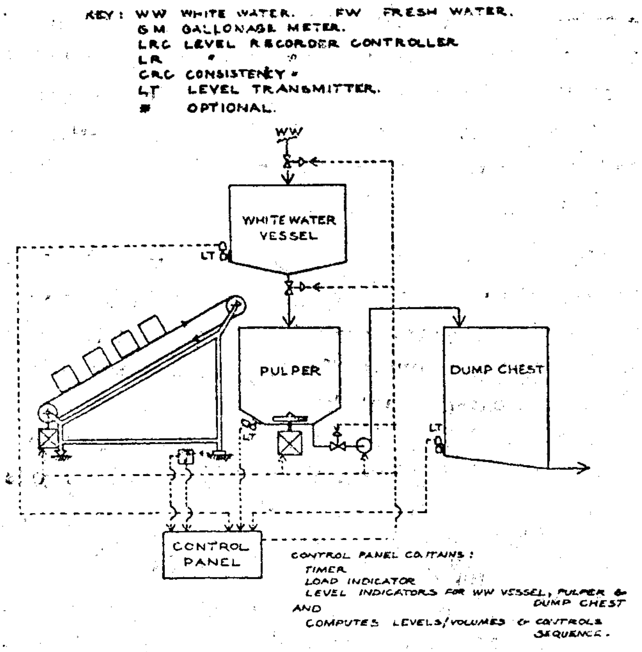
Alternatively a magnetic flow meter may be used to add white water, preferably servicing several pulpers when the cycles must be staggered. This is a very accurate method.

When the pulper is emptied, the pump is stopped, the dump valve closed and the cycle repeated.

The pulper may be flowed by a rough consistency control to 4-5% if the expense is felt to be justified. A drawback to this is that the regulator does not operate when the more dilute washout charge is passing through. Washout water is sometimes dispensed with, but one advantage is that it should speed dumping by reducing consistency. The consistency regulator is better installed after the pulper dump chest, when it operates on more regular stock. The mill may prefer simply to rely on attaining a given consistency by a controlled water addition to a known amount of pulp.

The number of dump chests depends on the furnish and if separate beating/refining of different pulps is to be carried out. An alarm bell can be made to ring if the chest(s) is, or are, too full or depth cell(s) fitted to override the pulper discharge.

A cheaper alternative to having a depth cell on the pulper is to have the operation sequenced by timer only. A part from cost, a depth cell on a pulper has the drawback that it might be damaged, specially with waste paper furnishes, and may be influenced by pressure water from the rotor. It can be fitted in a pocket, but there is a risk of this filling with dead stock.



FIG—2

This illustrates a system used by the Taylor Company, The conveyor, which is continuously weighed by hydraulic load cell with a pneumatic transmitter, is loadad with the approxinately correct weight of pulp (this should appear between the upper and lower limits marked on the load indicator). The pulping time and consistency in the dump chest are sent on the control panel.

When the cycle is started, a pneumatic computing relay, using the weight of pulp, calculates the volume of water necessary to attain the present pulping consistency. This value is fed into the water metering circuit. Another relay computes the volume of washout water necessary to obtain the final desired consistency in the dump chest.

The water metering circuit is called a no datum batching system. It reads the original level in the white water tank and thereafter computes the fall in level necessary to provide the required volumes. The only requirements are that there should be sufficient water in the tank at the beginning of a cycle and the white water consistency must be reasonably uniform.

The pulper then starts to fill and at a predetermined level the agitator and conveyor start up. The whitewater dump valve is closed when the correct pulper level is reached, the agitator runs for a preset time and, provided the dump chest has the capacity, the pulper empties itself with the correct amount of washout water. When the pulper is empty, provided the conveyor has been reloaded, the cycle automatically restarts. A depth cell in the dump chest can stop the cycle at any time if there is insufficient chest capacity.

No consistency measurement is involved. The average moisture content of the pulp should be known but normal variations are said not to be significant compared to the amounts of water added to the pulper and allowances need not be made. An accuracy of approximately 0.25% consistency is claimed and has been quoted as being better than 0.5% in at least one installation.

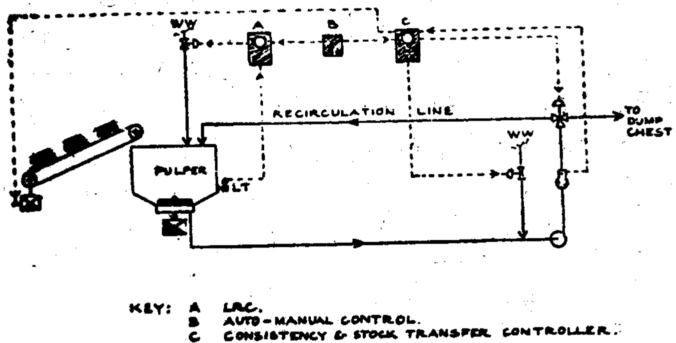
Advantages of Automatic Batch Pulper Control

1. Variations in work done and consistency are minimised between batches and production is increased. Pulper control gives first stage consistency control.
2. Water addition time can be very greatly reduced by filling the pulper just as the cycle is ending: very important when pulping capacity is limited.
3. Recorders may be used to keep a record of the work done.
4. Labour saving if more than one pulper (or if attendant can be given other duties).

Continuous Pulper

Pulper level is continually maintained by depth cell. Controller 'C' (proportional+integral,) coupled to an in-line consistency regulator, controls consistency in the pulper between upper and lower limits by recirculating stock and by addition of dilution water. It can also be used to activate the pulp conveyor for fixed periods of time when the consistency falls below the lower limit, though this is sometimes done by time delays.

CONTINUOUS PULPER



KEY: A LRC.
B AUTO-MANUAL CONTROL.
C CONSISTENCY & STOCK TRANSFER CONTROLLER.

Alternatively, the LRC output can pass through a ratio controller to a variable speed conveyor motor. The bales are equally spaced on the conveyor. This eliminates the lag caused by the capacity of the pulper and the time taken for slushing before the effect of added pulp is read by the consistency measurement. But it is still preferable to have a consistency regulator on the pulper outlet.

When the consistency reaches the correct value the 3-way transfer valve is automatically altered by controller 'C' diverting the pump discharge to the dump chest (s). Controller 'A' then opens the fill water valve, maintaining pulper level.

If the supply of pulp stops or falls behind, consistency drops below the lower limit and the stock is recirculated to the pulper. When the supply is resumed, consistency rises and the cycle is repeated.

Controller 'B' allows manual control for startups, washups or for batch operation (e.g. when heavier disintegration is required.).

If the consistency builds up to a point where the water dilution valve is fully open, i.e. out of control, a signal can be made to flash a warning light or stop the conveyor if activated by e.g. auto-timer.

If the dump chest is full, a depth cell can be used to override 'C' stop the convayor and recirculate the stock.

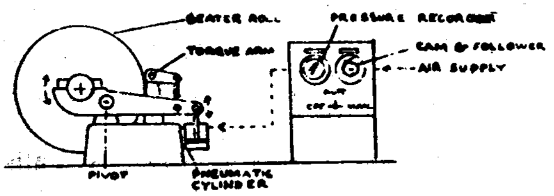
Similar systems can be used under the dry end of the machine to handle breaks with the scquence, which is continuous, being started by a break detecting device, e.g. photo-electric cell and light source on opposite sides of the web. Automatic conveyors can be used to transport broke from under the drying cylinders and size press. It can also be used on a periodic time cycle to slush accumulated trim during normal machine running.

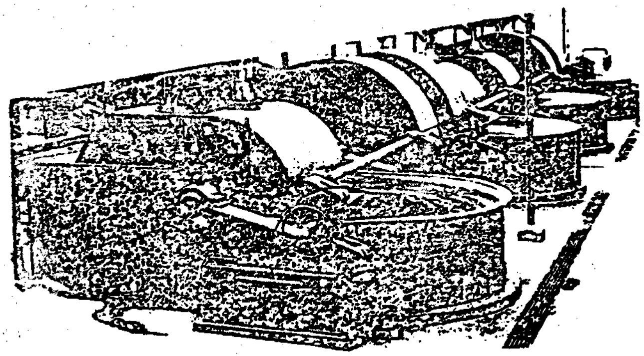
Control of continuous pulpers is much more difficult than pulpers. As already mentioned, there is far less control of defibring degree and accurate consistency control is also much more difficult. A great problem lies in pulp being added in given periods of time but taking time to break down and raise consistency. Limits must be introduced to prevent the consistency regulator asking for more pulp before the pulper charge has been slushed.

BEATER CONTROL

Beating action for a given beater & stock depends on the following variables: the gap and pressure between the roll and bedplate, the total time of treatment and the sequence of altering gap and pressure. All this is called the beating schedule and must be determined by trial for the different pulps and end products. It is important to realise that paper quality depends on when different pressures have been applied and for how long.

AUTOMATIC BEATER CONTROL





There is, however, no completely effective control available and tests, e.g. measurement of wetness or freeness, must be carried out at least at the end of the treatment.

Before attempting any control, it is eseential above all that consistency is kept uniform. Three ways in which consistency can be tested are:

(a) Dewatering a weighed sample of stock in a centrifuge takes about 2 minutes to obtain a moist sample from which B.D. equivalent can be calculated with a probability of error of less than $\pm 0.5\%$.

(b) Depth to which a calibrated rod (6″ long × $\frac{1}{4}$″ square) sinks, corrected for temperature.

(c) Measuring fluidity, which is inversely proportional to consistency, by deflection of a streamlined bulb set at a fixed depth, due to the friction of the stock in the beater.

These can be used as occasional checks, but better is to ensure a constant value by adding a weighed amount of pulp to a measured volume of water.

Methods

1. Manual Adjustment

The being subjective and, in the main, non numerical gives very variable results. The severity of the action can be judged using a beating stick one end held just in front of the ear, the other near the bedplate. Some beatermen find a foot encased in a wellington boot just as sensitive. A micrometer gap indicator can be fitted, preferably with zero compensation for bar wear.

Altering the gap by hand means that after each adjustment roll preassure gradually decreases as the fibres are beaten. The gap remains constant but the work done continually grows less. This means the quality of the work and the time taken depends to a large extent on how often the beaterman can be persuaded to adjust the gap-an unsatisfactory situation.

A subjective estimate of the progress of the treatment can be mad by judging the feel of the stock by hand, in various ways described later.

2. Power Consumption

Measured by recording wattmeter (AC)or ammeters (DC), preferably with individual beater motors.

As fibre flexibiltty increases and length decreases with treatment, the roll is lowered to keep power consumption constant: either continuously by auxiliary motor, or manually in stages. The latter leads to less uniform treatment and higher power consumption.

As the pulp becomes able to withstand progressively more work being done on it without fibre damage, the roll may be lowered so as to give increasing power consumption thus shortening the beating cycle.

Since consistency affects the proportion of power used for circulation and churning in front of the roll, it must be kept constant for reproduceability. It also affects the quality of the work done in both beating, and refining e g. the ratio of cutting to fibrillation.

3. Beater Rool Pressure

3.1. The system illustrated is that installed by the Foxboro company. A pneumatic cylinder action on the end of the lighter arm holding the roll counterbalances part of all of the roll weight. Supply of air to the cylinder, and therefore also the pressure applied to the stock between the roll and bedplate, is controlled by a clockwork-driven cam and follower.

The cam is cut to the desired shape and any predetermined beating schedule (up to 4 hours) may be automatically maintained, a different cam being used for each schedule. The follower has a small microscrew adjustment, equivalent to a travel difference of approximately ± 1%. This is used to give small adjustments to the cycle without cutting a new cam, or to adjust for cam wear.

A record is kept, of applied pressure against time and the roll is automatically lifted at the end of the cycle. The pressure can be held constant by stopping the cam for any set period (or by having a prefectly circular profile on part of the cam). Alternatively, the pressure may be altered manually using a record chart as a guide.

The controller is normally narrow band proportional. Offset should not be a problem, since furnish and consistency ought to be constant for any cam.

One mill has used this system to automate the process. This includes filling which slused stock from the pulps; the beating schedule, and emptying to the beater dump chest.

3.2. A mercury filled load sensing element, which supports one end of one of the lighter bars, is used by the Taylor Instrument Companies. This records beater roll pressure and can be connected via a controller to an electric motor raising and lowering the roll.

As in the previous method, the controller can be fitted with a cam to give any desired beating schedule. Both these systems can be used to duplicate previous treatment and ensure reasonable reproduceability, although beaters generally are less amenable to fine control than refiners.

3.3. An older method is to have a moveable weight on a lever connected to the lighter arm, which can be used to counterbalance any desired fraction of the roll weight.

The Bertrams system incorporates a stepped pulley, belt-driven from the roller spindle. This pulley operates a worm and thread whicd moves the weight anywhere within the range fully counterbalanced to full roll weight. The rate at which the weight is moved depends on the effective pulley diameter chosen. The system can be set up to disengage and run continuously at any given pressure. The weight can also be moved manually if preferred to any one position, and this is the usual method now in mills.

There are severe practical limitations in use due to the mechanical inertia and stiffness of the system.

4. Viscosity

Viscosity changes as pulp is beaten and can therefore be used as an indication of the treatment the pulp has received up to any one time. Viscosity curves-Values on a time scale can be produced as a guide to the beating schedule for each paper. The beaterman periodically measures the viscosity of beater samples and adjusts the roll to keep to the appropriate curve, as best he can.

Viscosity is dependent on friction within the pulp and of pulp with solid surfaces and is measued by beater drag (suspending an object within the pulp flow) or dynamometer. In the latter the drag of small disc drive at fixed depth in the sample is measured.

It also varies with consistency (and is in fact the usual measurement made by consistency regulators) and additives, e.g. rosin size reduces consistency.

REFINER CONTROL

Refiner elements were first adjusted by hand wheel through gear reducers. For remote operation the hand wheel is replaced by a reversing motor. For automatic operation the motor is controlled by one or more measurements related in some way to the work done by the refiner.

The choice of automatic operation must depend on the stock system i.e. it is useless to apply complicated and expensive control if the system is basically unstable. The most important are flow, pressure, temperature, additives, furnish blend, PH and above all, consistency. If these are not kept reasonably uniform then control of refiners cannot be precise, though their relative importance depends on the method used.

Effect of Gap on Motor Load

As the gap in figure 1 is decreased there is at first little effect on power consumption. Above approximately 60% available horse power, consumption increases rapidly, and most rapidly for discs. The latter point illustrates the need for more accurate control of disc refiners.

AUTOMATIC REFINER CONTROL

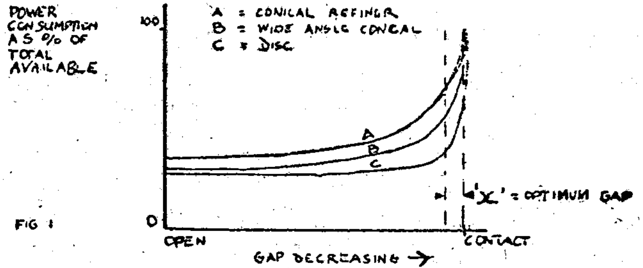
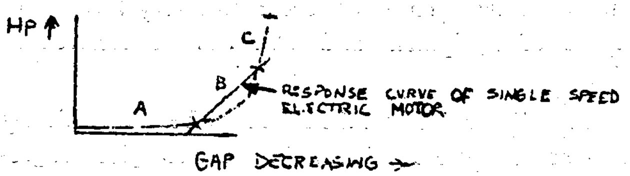


FIG 1

EFFECT OF GAP ON MOTOR LOAD (1)

In the optimum gap opening X a very small movement has a large effect on power consumption and therefore on work carried out on the fibres. Gear reduction allows the extremely small element changes necessary, where the element is adjusted by electric motor. A two speed motor drive allows the refiner to be brought quickly to the loading position and retracted quickly in an emergency. Vernier (slow spped) drive is then used for the final accurate adjustment. An electric motor may overshoot and black Clawson for example use an air motor giving an infinitely variable speed control. Hydraulic and pneumatic actuation are also used.

In figure 2 the single speed motor has good response at B but hunts at C and A. The good response at B is where it most nearly matches the refiner gradient of figure one. It is most suitable with conicals which have the shallowest curve most like the response curve of the single speed motor (N.B. only one speed is used for fine gap adjustment.).



EFFECT OF GAP ON MOTOR LOAD (2)

Methods

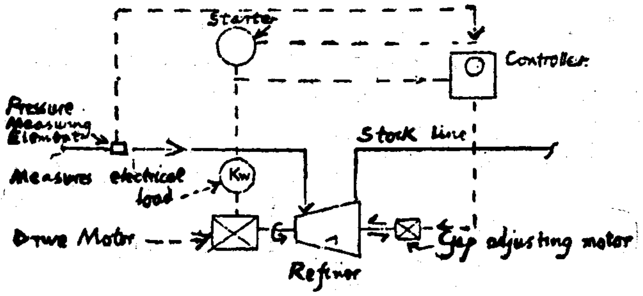
(1) Power Demand.

The element is moved in and out by a motor actuated by an ampere or watt sensitive control, maintaining constant power load and therefore on the fibre. Simplest method and fast response. Disadvantages :—

From the grraph showing the effect of gap on motor load (fig. 1) it can be seen that a dead band is necessary at the bottom of the curve to make the system stable. (because such large changes in gap are possible with very little corresponding change in power demand). At a wide gap, movement of the element does not affect power demand to any significant degree. The works is only constant when incoming stock conditions are stable. Used alone, it is not entirely satisfactory e.g. if flow is increased there is less work per uniti weight of fibre Actually more power input would be required to keep the work done per unit weight of fibre constant.

The scale of current used is so wide that it appears not to be precise enough; however it should be suitable on long runs under stable conditions and with little variation in the product.

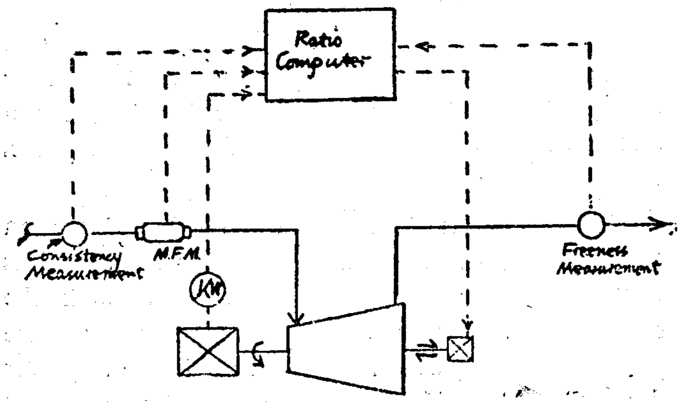
Fig. 1.1.



POWER DEMAND

The electric load on the drive motor is compared to a difference value and a difference signal used to actuate the gap adjusting motor. The plug (or disc) is automatically retracted when for example, stock supply pressure drops below a specified figure. Aelrtnatives are if the drive motor stops, or sealing water or lubrication fails. These are common safety features in all types of equipment and will not be referred to again.

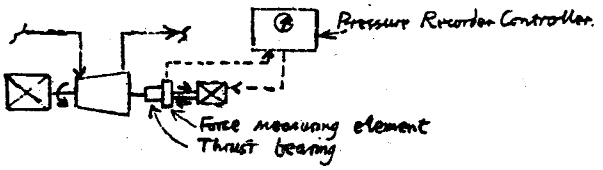
In recyling operation the load may be automatically altered as the cycle continues in order to give progressive treatment. As the system makes no allowance for changes in stock conditions (supply) periodic freeness tests may be carried out.



POWER DEMAND + CASCADE CONTROL

Fig. 1.2.

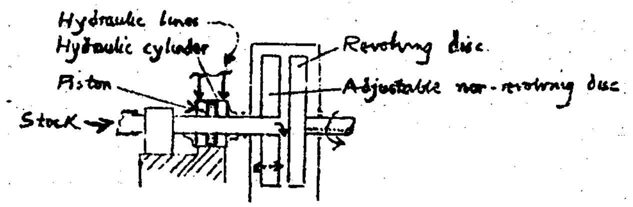
Signals from a digital flow meter and a kilowatt hour motor and also from a consistency measurement are fed into a ratio computer. Consistency may be measured in-line or dialled in following laboratory tests. The electrical eneryg per ton of pulp (Kwh./ton) is computed and a signal produced for the control of the gap adjusting motor. This gives the spacific energy consumption i.e. per unit mass of dry fibre in unit time. A signal from a continuous freeness tester may be used for set point adjutsment by cascade control. It may be better however to use the freeness signal for manual adjustment of the set point, or as a help in eliminating freeness instability further back in the system. Fully automatic control as in the diagram wolud mask the latter. The dead load of the refiner may be subtracted electronically to allow recording of the actual energy consumption on the pulp.



Pressure Regulation

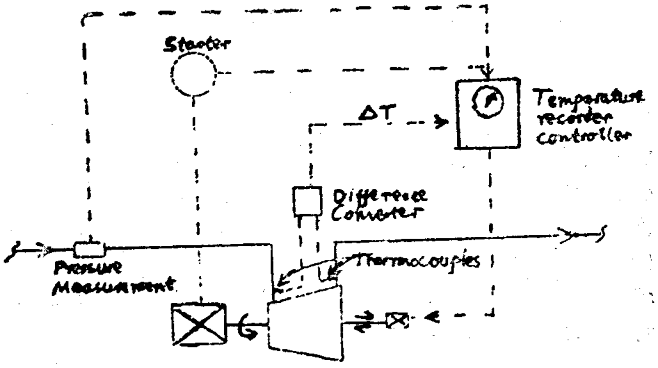
2.1 Conical Refiners

A jordan plug. creates considerable hydraulic pressure. A force measuring element between the thrust bearing and the gap adjustment sends an impulse to the controller. There, the desired pressure for a particular paper is set on and maintained by an air or electric motor automatically advancing or retracting the plug. This compensates for minor changes in stock supply and bar wear. Alternatively the readings can be used as a guide for manual gap adjustment. The system installed by the Taylor company uses a proportional+integral controller.



2.2. Hydraulic Disc Adjustment

The gap is adjusted by moving the non-rotating disc by means of the two way piston. The desired setting is maintained by constant hydraulic pressure, set on the control panel. It maintains constant pressure on the stock giving, as in 2.1., uniform and reproduceable refining action within certain limits of incoming stock variation. The gap alters automatically with changing conditions. The pressure is released if the stock supply fails. The big disadvantage with 2.1. and 2.2 is that if, for example, mass flow increases, pressure on the refining element should also be increased not kept constant, to ensure the same specific energy input.



TEMPERATURE RISE ~ ΔT

FIG—3.1 .TEMPERATURE RISE ΔT

Control by temperature rise across the refiner, which is a measure of the work done on the fibre, is more sensitive than an ammeter or wattmeter reading. ΔT is measured by thermocouples set in the stock lines as close as possible to the refiner inlet and outlet. If ΔT is kept constant by altering the gap, more or less the same amount of work is done. It is essential that incoming stock characteristics are kept constant but if, for example, flow increases, ΔT falls and the gap is adjusted to compensate to some extent.

After the refiner is adjusted to give the stocks the desired freeness, the plates are controlled as a function of ΔT. Desired ΔT readings are logged for the various papers made.

It may well be sufficient to apply the system to the last refiner only of several in series.

Power input to the refiner is distributed in three main forms :

(a) Energy to overcome hydraulic, friction and motor losses.

(b) The encrgy absorbed by the stock (ΔT)

(c) The energy to expose new fibre surface or otherwise change the state of the fibrous material.

(b) Absorbs approximately 90% of the total energy, input, whllst c) is negligible.

(a) is assumed to remain more or less constant.

Drawbacks

(1) Time to settle down after start-up because of heat absorbed by the refiner (e.g. Star Mills up to 6 hours in winter and 3 hours in summer). Therfore it is preferable to start up on power demand and use ΔT for steady running. For the same reason it is more suitable for longer runs. Thought is being given to lagging refiners to reduce time taken to reach steady temperature but if this is not removeable the higher running temperatures could reduce refining effect. A water jacket using initially hot water might be worthwhile.

(2) Slow response, but see method 3.2.

(3) As elements wear out the groove volume decreases more energy is absorbed and heat produced to fibrillate and cut to the same extent; therefore; a higher ΔT is required. More work is necessary to force the stock through the refiner.

See method 3.3.

(4) Operates over a very small temperature range, usually approximately 20°C. However temperature changes as small as 0.3°C have proved useable for control.

(5) In at least one installation the electric bi-directional gap adjusting or regularly burned out after only 2-3 months use, motor becasue of the continual hunting in and out. An air is now used successfully.

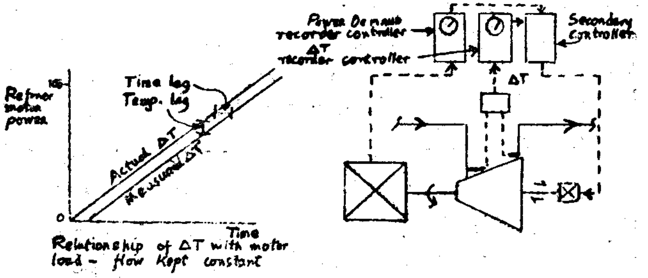
Other Uses

(1) For a constant power imput ΔT can be used for throughput control.

(2) Solely as a record of the work done by the refiner, i.e. a check. It can be incorpoated later in a closd loop if required.

3 1. ΔT.

Two temperature readings are sent to a difference converter which produces a direct current proportional ΔT. The signal is recorded at the controller and its to deviation from the set point actuates the gap adjuating motor (i.e. maintains the desired ΔT). For greater accuracy a magnetic flow meter can be incorporated. Stock flow is computed to give a mass heat rise. It makes no allowance for freeness variation in stock supply.



ΔT AND POWER DEMAND

3.2 ΔT Plus Power Input

The measured ΔT shows a time lag because of the delayed response of the temperature measuring system and capacity lag. This lag can give control instabilities e.g. hunting, but combined in cascade with the fast response of power demand, the control can be stabilised.

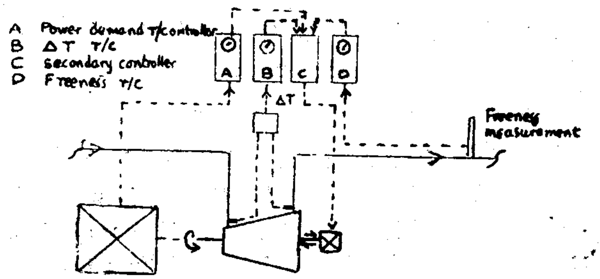


Fig. 3.3 ΔT + POWER DEMAND+FREENESS MESUREMENT

3.3 Freeness correction to ΔT

Freeness measurement can be used to adjust the set point of the secondary controller shown in the previous example. It gives back-up control and also allows maintenance of one system if required.

4. Freeness/Drainage Measurment

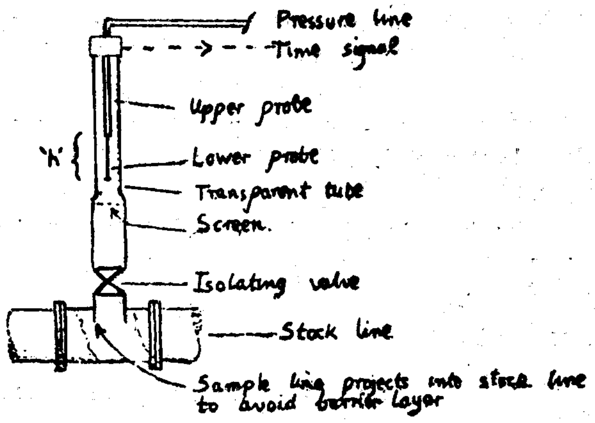
Freeness is part dependent on the length and physical state of the fibres (both determined by refining) and therefore gives an indication of paper properties. In addition, it simulates drainage and formation conditions on the machine wire which also affect paper properties. This makes it a practical parameter to use for refiner control. However it is also very dependent on stock variables other than refining, such as consistency, temperature and additives.

Pressure drop across the pressure screens, if they are operating efficiently, has been correlated with freeness and can be used for control. The usual method however is to test a stock sample following the refiner(s): either continuously, by measuring drainage rate through the mould of a small vat machine; or cyclically, by measuring the time taken for a given volume of filtrate to pass through a standard screen plate. The reading is compared to set point and a corrective signal sent to refiner if necessary.

An example of the first type is the BCM-Freecon Freeness Controller. A sheet is formed on the mould, then couched off and returned to the stock line. The filtrate passing through the mould enters a standpipe with a standard orifice measured by a bubble tube and gives an indication of freeness.

The Krofta Freeness Controller is an example of the second. A diluted stock sample is passed upwards through a fine wire screen set in a container. After a preset time the container is automatically weighed. The reading indicates the volume of filtrate which has passd through the fibre mat on the screen and therefore also the freeness. The container and mesh are then flusded clean by water and compressed air and the cycle repeated.

The best known system is the Drainer Tester (Drainage Rate Indication and Control shown in fig. 4.1. The measuring element is a 100 mm diameter tube set vertically in the stock line downstream from the refiner. An isolating valve allows maintenance and the pressure sensing device continuously monitors pressure in the tube and in the stock line. The screen, of Canadian Standard Freeness mesh, can be slid out for cleaning.



"DRAINAGE" FREENESS TESTER

At the start of the cycle, tube pressure is reduced approximately 50KN/m^2 below stock line pressure (via pressure line at the top of the transparent tube). Stock rises up into the tube and a fibre pad forms on the lower side of the screen, through which water passes into the transparent filtrate chamber above. Two concentric conductance probes are used to measure the time for the filtrate to cover the distance 'h'. The freer beaten the stock, the shorter the time. Pressure is then increased above that in the stock line and the filtrate forced out of the tube, flushing the mat off the screen. The cycle lasts approximately 60 seconds and is automatically repeated.

The results are roughly equivalent to C S.F. and the instrument can in some cases be calibrated directly, although mill reports differ on this point. The relationship is claimed linear for practical purposes. The drainage figure is theoretically nearer to that on the machine wire than any laboratory test, becasuse a constant head is maintained compared to the C.S.F, or °SR Testers and the human element eliminated. It has the additional advantage of being much faster than sampling and laboratory testing.

A 180 mm filtrate head prior to measurement reduces the effect of consistency variation and up to ±4.5°C are claimed not to be significant. The correction curve for temperature variation is linear so a simple circuit to compensate can be incorporated (if stock temperature is measured.). In practice, difficulties from temperature and consistency variations have been reported.

Because of this and the somewhat expensive and sophisticated equipment involved it is perhaps best employed at the last refiner stage to control final freeness going on to the machine. The initial stages can be controlled by the simpler and more conventional power demand and or △T. The readings can be used as a guide to hand adjustment, for full automatic control, or as a final check on any other control method by adjusting a secondary controller set-point in cascade. Certain of the early applications in full control have been reported as only moderately successful.

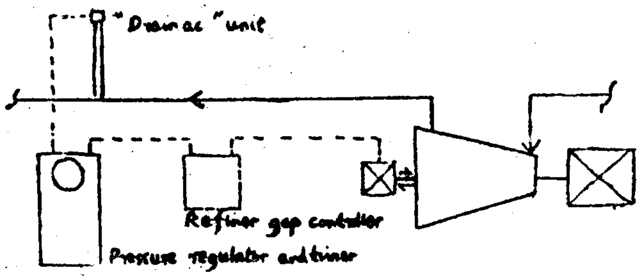


Fig 4.2 CONTROL BY FREENESS

Fig. 4.2. illustrates an installation. The time signal is sent to the Drainage Cabinet which records it, compares it to set-point and sends a corrective signal if necessary to the refiner gap controller. The latter adjusts the refining element to maintain the drainage rate within the desired limits. Within the Drainage Cabinet are also housed the timing and pressure regulating equipment.

In later installations refiner motor load rather than gap is adjusted and, in one mill, controls the drainage rate within a band approximately equivalent to 10 to 20 cc. C.SF.

(5) Control from the Machine

Using a measurement of drainage on the wire instead of the various freeness tests, which may not accurately predict drainage, is the most common. Other direct measurements on the web are being tried. Using direct measurement of machine conditions or, even better, of paper properties is theoretically desirable, The nearer the measurement is to the end product the more directly the control can be related to the use to which the paper or board is put.

Disadvantages :—

(1) Variables measured such as drainage on the wire, porosity or formation do not themselves depend solely on refining degree. Conditions on the wire do not remain constant; the wire makes up and wears; different wires require different settings; free water flow-rates from different furnishes may not be comparable and drainage is affected also by machine speed, shake, and stock consistency, temperature, PH, Additives, efflux ratio.

(2) Because it exerts control later than a cantinuous control in the stock preparation system, it is normally used at the final refining stage only, i.e. just before the machine. Otherwise there is excessive lag between control and measurement.

(3) There are a large number of uncontrolled variables on the wire.

(4) There are no continous in-line tests of paper/board strength properties which can be used.

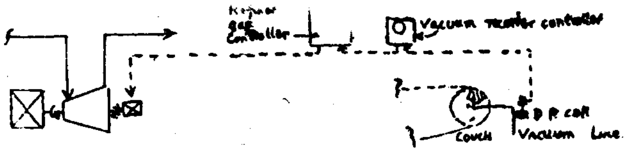


Fig. 5 CONTROL BY SUCTION COUCH VACUUM

5.1. Suction Couch Vacuum

Change in formation, which is a function of fibre length and stock freeness, when machine conditions are constant, alters the drainage rate and thus the vacuum at the couch.

This is used as a feedback control to the refiner. The desired vacuum reading is determined by trial. Deviations from this figure are measured by a d.p. cell on the couch vacuum line and registered on a vacuum recorder/controller. This sends a signal to the refiner controller which adjusts the refining element as required. A timer delay allows for the distance velocity lag between the refiner and couch before a further change is made.

The value of the system depends on other conditions being held constant and a manual overriding control is normally fitted.

Furnish mix and particularly grammage must be kept constant. The former because different species react differently to refining in respect to freeness changes; the letter because the amount of fibre on the wire effects couch vacuum. Changing angles or numbers of foils whilst running could present a problem. This system might also interact with a Broughton system.

5.2. Water Flow from individual Suction Boxes

Measured by M.F.M.S and gives an indication of the position of the dryline. Pneumatic signals are sent to a recorder/controller which alters the power input to machine jordans to keep freeness within present limits. As described above, machine conditions must again be kept constant.

Similarly drainage from subdivided trays below the table rolls or foils may be used.

Flow rate from the flat box sealpit has also been used.

5.3. Porosity or Formation Measurement at the Reel-Up.

Here a continuous in-line measurement of a paper property is used to provide the feed back signal to the refiners. Again, a time delay allows for distance velocity lag.

Drawbacks to the method include this lag and the consequent amount of offspecification paper which might be in line; the fact that both properties can be greatly affected by factors other than refining such as conditions on the wire and in the flow box, and the robustness and reliability required of the equipment, at the dry end.