Optimisation of paper machine broke handling

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The cost of production is increasing at a frightening rate. Everyday some cost factor shows a new increase. Inflation gets at all of us and causes us to take stock of what we are doing and look forward for ways to reduce or minimize its effects. The name of this game in most mills is to reduce costs. So every part and every operation must be given proper consideration.

Broke is a general term for the fraction of the web formed on the wire that is not turned into saleable paper aud therefore has to be reformed or technically broke is spoiled and damaged paper which may be produced when there are mechanical or other production difficulties on the paper making machine in particular when web breaks.

The term is very wide and includes a variety of broke grades, the most important being :

— Wet couch broke on (approx. 20% solids)
— Press brokes („ 20-40% solids)
— Dry broke
  — from dryers, size press, calenders area
  — from finishing hours winders,
  (app. 90-95% solids)

In the modern paper machine system the reuse of broke is must for economic reasons. So to accomplish this the system must have following attributes:

— They must be able to deliver the broke material to the processing equipment or pulper.
— Convert the material to a pumpable slurry.
— Remove the pumpable slush from the equipment faster than it is being introduced.
— Proper equipment has to be installed that may bring the broke back into optimal paper forming condition.
— Sufficient chest & silo capacity to accept the broke produced even during prolonged periods of operational trouble.
— (Thumb rule. Broke storage capacity should correspond to at least 2 hrs of full production).
— System for continuous, uniform feeding back of the broke into the main production stock line.

Figure (1) gives the content of fiber fines in the paper as a function of the volume of the broke silo. It shows larger the chests the longer the transition

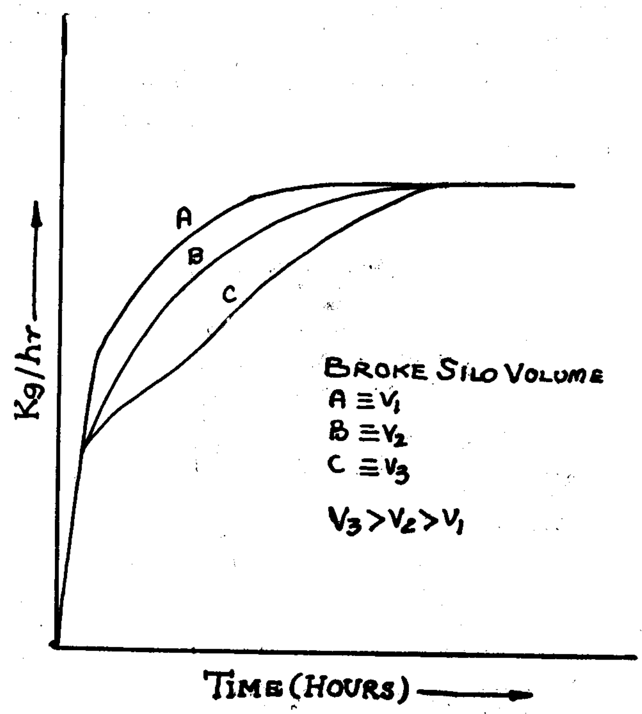

FIGURE- 1

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period for stock composition and consequently for paper properties of the other hand in-order to dampen process variations both as far as production volumes and production quality are concerned rather large volumes broke chests have to be included inside in the process run.

So optimization is to be done on this case.

The properties of various kinds of broke differ substantially. The wet broke essentially has the same properties as wet stock but dry broke differs a lot when repulped.

Substantial amounts of the stock passing over the wire ends up in the couch pit. 10-30% are normal figure in Indian mills depending on grades.

Fig. 2. shows how the continuous broke is generated. The wet end edge trim is continually flushed into the couch pit and entire sheet during breaks. When short-breaks at the open of wet end must be continued but by seen the couch pit level it must be closed. In this case optimization must be done between the energy consumption in M/c running and the couch broke handling system. So couch pit must be able to handle two steady state situations of very different capacity requirements :

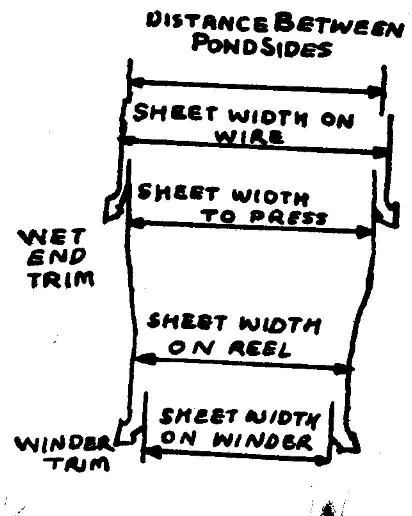

FIGURE: 2 THE EDGE TRIMMING OF THE WEB DURING PAPER PRODUCTION.

i) Edge trim during normal production periods.

ii) Full sheet width during breaks.

There are several steps in the broke handling and optimization must be done in each step. Every step is considered one by one.

Bringing broke to pulper

Broke may be produced at any time, anywhere in the paper machine system, after the wire section. Immediate removal arrangement must be done for broke otherwise it may cause severe trouble. If breaks occurs at dryer section it must not be given chance to get accumulated there. It must be broken ahead of at presses and sent to couch or press pit.

The pulper should be arranged under the paper machine. From dryers the belt conveyor may be made to convey to the pulp at reel. Winder trim and side rolls, offspec roll may also be carried to icel pulper.

Converting the broke into pumpable consistency :

Wet broke is easy to repulp and may be done by single propeller disintegration or by a cross shaft agitator. Cross shaft agitator is the best choice.

To repulp dry broke more energy and higher shear forces needed. Attrition type repulper must be used for the purpose. In mixing terminology it is a "high shear", radial flow impeller with single arial suction.

Generally, the harder the pulping job, the faster the rotor operates and the more attrition bars are present, both on the bottom of the impeller itself and the slotted deflaking rings. The units are designed to cause a high velocity radial flow due to centrifugal force which causes a massive vortex to form at the centre of rotor. This is the method of circulation and the method of pulling the broke sheet into the pulper.

High velocity, high throughout overhead showers must be arranged in the pulper to ensure submergence of the added broke. The other thing which may be done is the recirculation.

Proper control system must in some way contain a good, strategically located level senser, consistency controller, dilution value and a sufficient sized white water pump is also must to support the necessary white water.

Removal of repulped broke from Pulper

This is the most important step where proper control and optimization must be done.

In couch pit the not only the amount of solids vary severely but even the consistency and total volumes.

During normal operation both a wetting shower should be operating over the entire width and high volume edge trim showers on the edges. The web break detector must be installed so that it instantaneous without any timely trigger the knock off shower.

So in normal operation consistency will be pretty low in period of normal operation. There are two ways.

i) send to thickners

ii) sent to strainer so that the water may be used again in showers

But when the entire web passes into the couch pit both the consistency and the flow rate are raised dramatically so the operation must be able to face this extreme points.

Fig. shows that the broke is pumped to fiber recovery unit even during breaks but this process is trouble creating & not properly cotrollable.

Fig. 4. shows the other way in which stock thickness is separate. A fairly coarse filter is used as couch thickners and the filtrate is cleaned further in the fiber recovery.

Fig. 5 is the surity couch pit system, the edge trim is pumped to fiber recover unit during normal operation. At web breaks the flow is switched over to the broke chart. This may be attached to web break detector.

Fig. 6 shows the system for pick up process, the web can be carried to a separate press pit during breaks and pumped directly to broke chest at correct cansistency.

Fig. 7 present a optimum design of broke silo.

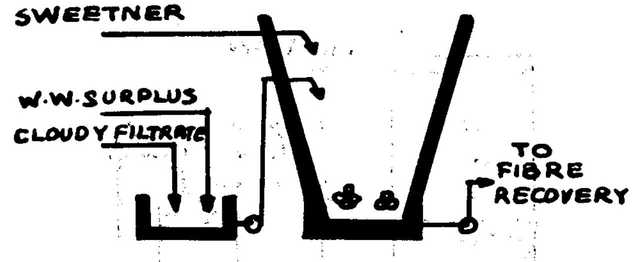

FIGURE 3: COUCH ALWAYS TO FIBRE RECOVERY

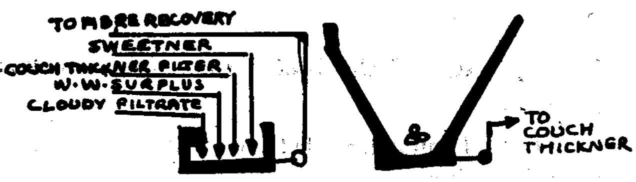

FIGURE 4: SEPARATE COUCH PIT THICKNER

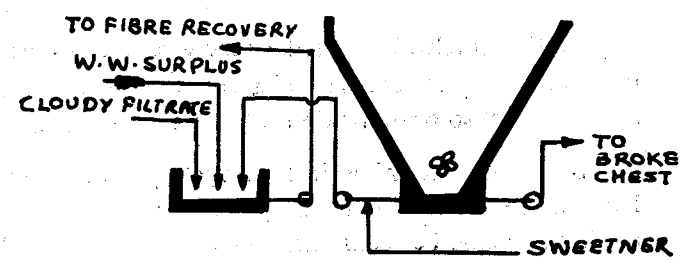

FIGURE 5: SWING COUCH PIT

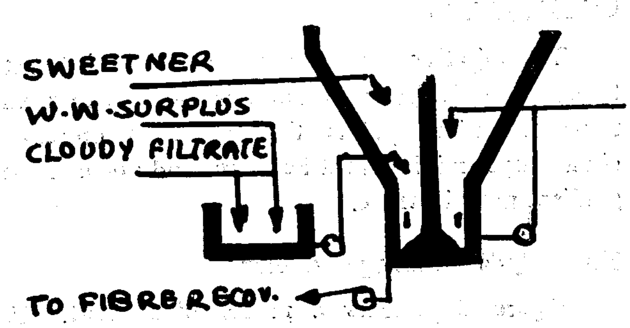

FIGURE 6 : COMBINED COUCH/PRESS PIT

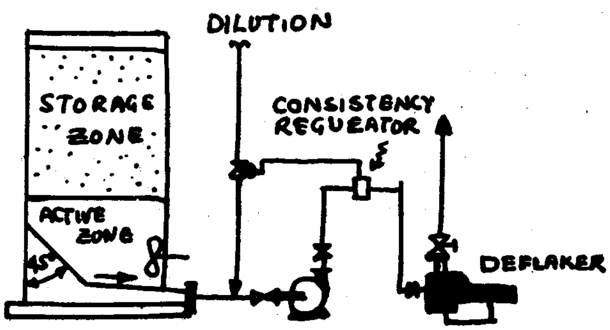

FIGURE 7: BROKE SILO SYSTEM

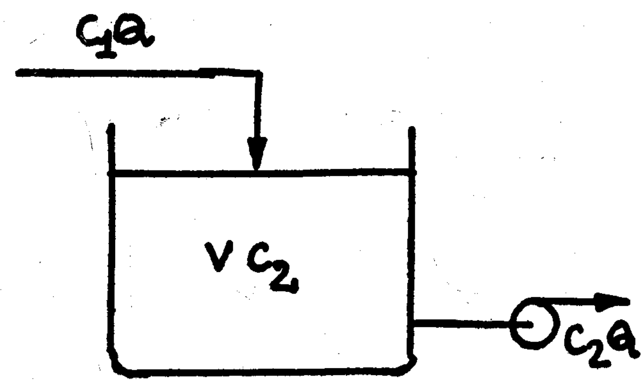

FIGURE : 8

Feeding back of the broke into the production process :

Typical difference between the stock and broke pulp is brokes.

- lower freeness for recovered broke,
- slower draining on the wire
- giving a moisture sheet having lower wet web strength.

So the recycled broke reduce the wet web strength on the other more breaks and gives even lower web solids contact so optimization is to be done in addition.

So to avoid running in to severe operation problems and to maintain uniform quote the rate of broke addition should be constant. The broke should be added to stocks at a uniform rate in the component proportionary unit in stock unit. Wet web strength calculation directly gives the ratio.

CHESTS/SILOS

The objective of the chests and silos is to act as buffers in case of stock volumes or stock quality variations at various points thoughout the process. In chest proper mixing must be there and no consistency gradient must be there.

The analysis of mixing charactor

Figure 8 presents a model of a chest. Using notations of figure and an using ideal mixing following relationship holds by material balanee

$$\frac{dC_2}{dt}V = (C_1 - C_2)Q$$

at initial condition

$$C_2 = O \text{ at } t = O \text{ i.e.}$$

$$(C_1 - C_2)\,Q = O$$

So $(C_1 - C_1)\,Q - (C_2 - C_2)\,Q = \frac{d\,(C_2 - C_2)}{dt}$

Choosing derivation variable as

$$C_1 - C_1 = X,\ C_2 - C_2 = Y$$

$$XQ - YQ = \frac{dy}{dt}V$$

$$X - Y = \frac{dy}{dt}t$$

(taking $\frac{V}{Q} = T \pm$ Time constant)

taking laplace transfer

$$X(S) - Y(S) = SY(S)\,T$$

So $\frac{Y(S}{(S)} = \frac{1}{1 + TS}$

So it behaves like first order system so we get

$$\frac{C_2}{C_1} = 1 - e^{-Q/V^t} \text{ or}$$

$$(1 - \frac{C_2}{C_1}) = \frac{-Q}{V}t$$

Mathematically we devide the mixing process in a chest in to three separate components.

a. Volumes having ideal mixing

b. Volumes having plug flow

c. "Dead" volumes, not taking part in actual mixing.

The relative sizes of a, b, c may be calculated by plotting

$(1-C_2/C_1)$ vs time unit V/Q

as shown in figure 9,10,11

From figure 11

a) Ideal mixing component $= \frac{X}{Y}$

b) Plug flow component $= z$

c) Dead volume $= 1 - Z - \frac{X}{Y}$

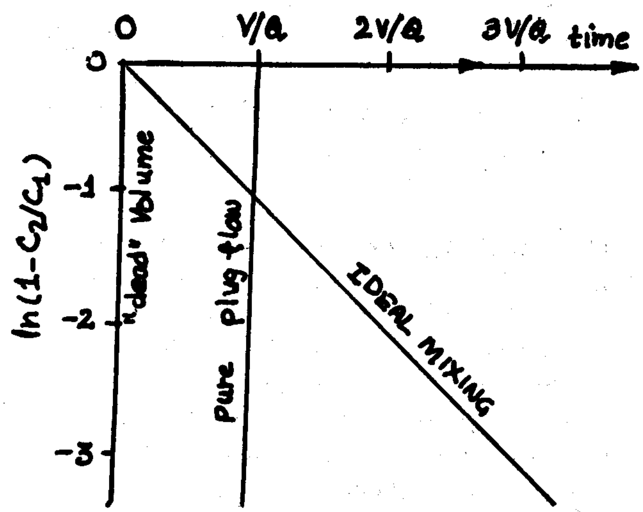

FIGURE 9: MODEL GRAPH FOR CALCULATING THE MIXING CHARACTERSTICS FOR STOCK CHESTS

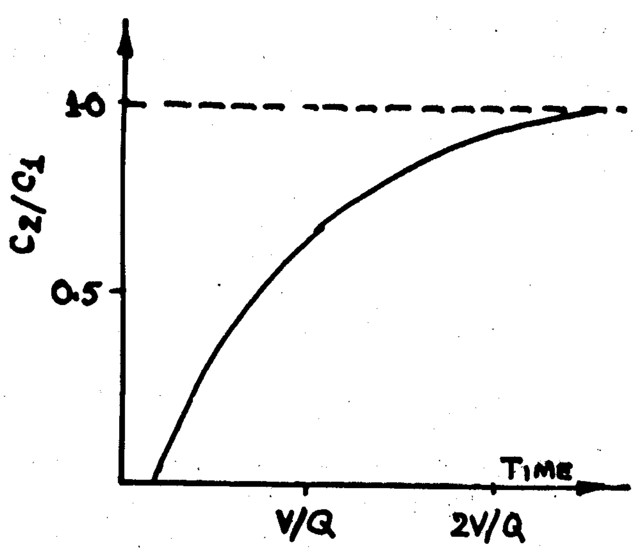

FIGURE : 10: Ratio C_2/C_1 vs mixingtime V/Q

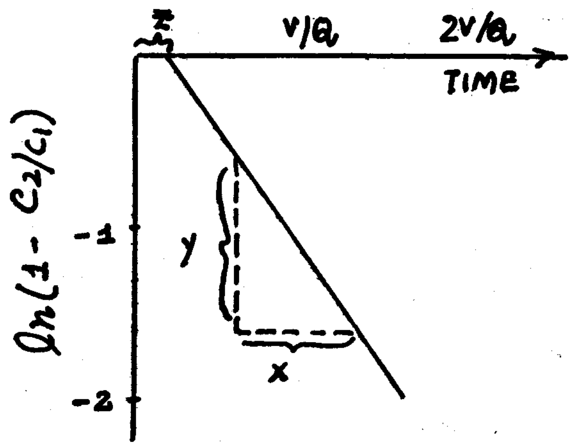

FIGURE 11 : ln $(1-C_2/C_1)$ vs mixingtime as read from side by figure.

For a newtarian fluid like water there will be no dead volume but for pseudo plastic type pulp suspension, b), c) vary greatly on consistency.

The ability of chests to dampen volume and quality variations of stock

To meet the stock volume levelling function, the shear size of the chest is of prime importance.

The stock quality levelling abilty of a chest is often a very important characteristic. It is usually reported as the *dampening curve* of the chest.

Figure 12 shows the curve, which gives the ability of the chest to dampen rectangular stock quality disturbances of varying durations.

Graphs in figure 12 give some examples if the ability of some chests N (A,B,C,D) to dampen a rectangular disturbance pulse of some property X, having an intensity Xy and duration ty.

In the stock leaving the chests there will be a disturbance of maximum intensity Xn and duration t_n.

For uniformity of the Process characteristic

$$d_n = \frac{X_n}{X_y}$$

is important. It is called the 'dampenity factor of chest'.

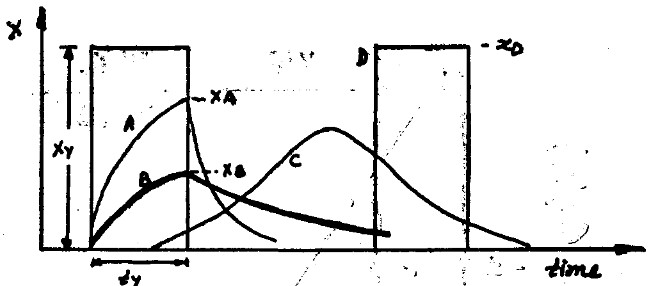

FIGURE: 12: The dampening ability of some chests A–D on an incoming disturbance of intensity Xy and distribution ty.

Curves A-D give the disturbance response curves for different chest types and sizes. The maximum disturbance intensities are ^{x}A-D.

A and B both represent chests having ideal mixing, B however being a larger chest than A. The dampening factor for a chest having ideal mixing can be calculated by

$$^{d}Ni = 1 - {}^{-t_y/{}^{t}Ni}$$

^{t}Ni being the time of the chest in question.

Curve 'C' represents a chest having some plug flow and some 'dead' volume.

Curve 'D' gives the response of a chest having Pure plug flow. No dampening just a time delay.

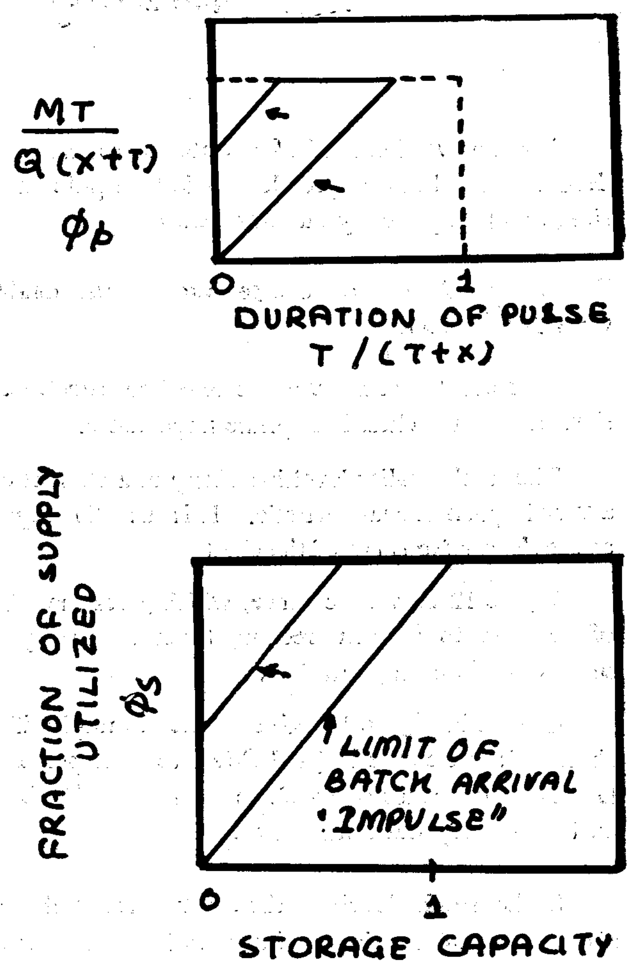

FIGURE: 13.

Effect of variations of supply of broke and way to handle it.

If suppose paper breaks at a duration of T hours at a rate of M Kgs per hour during the break and let in rest of the period there is continuous supply at the rate of Q Kgs/hr, or less and excess material that cannot be stored must be shunted for use in another facility, the overflow. Now if the supply of broke is too much it may be more due to more rejects from finishing house or may be due to sudden break in paper and the rate of reuse of this is also at constant rate in the Process of paper making. The fibers being too costly can't be drained away but are to be used so this is to be stored for certain period of time. The problem comes how much optimized capacity of the storage system be. If $M<Q$ than there is no problem since the system can handle the broke as it comes. However, when H Q the process cannot handle the instantaneous arrival rate during the break and with no storage (M-Q) T Kgs of material must be shunted to the over-flow during every break.

So we may define the 'supply utilization factor' Ø as the fraction of supply that can be used by the system. In the case of no storage.

$$Ø = \frac{MT-(M-Q)\,T}{MT} = \frac{Q}{M} \geq 1 \; \ldots \ldots \text{(i)}$$

That is, with no storage only a fraction Q/M of the arriving feed can be utilized be our system and the remaining fraction (1-Q/M) must by shunted to overflow or to drain.

Now we may do the broke storage capacity optimization. Suppose that a storage tank is present with capacity G Kgs of material. During an arrival pulps $O \leqslant Q \leqslant T$ minutes, the amount of the material stored in the tank, S Kgs will increase until the tank is full, at which time the tanks will remain full as the excess arrivals are shunted to the overflow. Thus in the period $O \leqslant Q \leqslant T$, a transient material balance over the storage gives.

$$\frac{dS}{dQ} = \begin{matrix} (H\text{-}Q) & \text{for } S \leqslant C \\ (Q) & \text{for } S \approx C \text{ .... (ii)} \end{matrix}$$

(O) =O, since any material in the tanks at that time can never be processed in this mode of operation and could be removed without changing the operation of the system. We may say this amount to be 'dead' amount.

The equation (ii) can then be integrated to give

$$S\ (O) = \begin{matrix} (M\text{-}Q)\ Q \text{ for } (M\text{-}Q)\ Q \leqslant G \\ (G) \quad \text{otherwise} \end{matrix}$$

valid when $O \leqslant Q \leqslant T$

The time at which over-flow first occurs, Q_o is obtained thus

$$S\ (Q_o) = (M\text{-}Q)\ Q_o = G$$

$$\text{or } Q_o = \frac{G}{M\text{-}Q} \leqslant T$$

That is, overflow must occur before time T if it is to occur at all since after time 'T' the supply pulse stops.

Now, we might say that storage capacity greater than (M-Q) T Kgs would never be used and hence that capacity can be thought of as the upper limit of optimal capacities, the supremum of the economically optimal capacity G*.

$$G^* \leqslant (M\text{-}Q)\ T$$

The amount of material that must be routed to over flow while the storage facility is full is (M-Q) $(T\text{-}Q_o)$

Thus the supply utilization factor in the presence of storage is

$$\varnothing^* = \frac{MT\text{-}(M\text{-}Q)\ (T\text{-}Q_o)}{MT}$$

$$= \frac{Q}{M} + \frac{G}{MT} \leqslant 1$$

Now the main problem comes in the pump selection for the pit. Generally a pump with a fixed speed electric motor drive and to instal a control valve to reduce the flow during lower handling periods of in the system the pressure drop is a significant part of total head requirement a variable-speed drive merits consideration. If we take the example of the normal capacity of 500 gpm but it may as high as 1000 gpm. Obviously a 1000 gpm pump with an electric motor and a control valve can handle the 500 gpm demand. But if you notice that at this rating such a pump efficiency is only 65% as compared with 83% at the 1000gpm level.

The head developed by a centrifugal pump varies as the square of the rpm ratio. Its capacity varies directly with the rpm ratio. Thus it can "track" the system pressure drop curve very nicely, while keeping at or near its best efficiency point if the rpm can be varied. If we go through the pressure drop in the system, keeping in mind the affinity laws concerning pumps head and capacity versus rpm of demand is equally divided between 500 and 1000gpm with no in between requirements than a two speed motor having rpm twice the lower rpm would be the best choice (this is generally the case). So one important conclusion may be drawn from concent for variable speed drives for capacity control of centrifugal pumps. They can be used to vary the flow exclusive of a control valve and can reduce horse power requirement as much as 50% or more. So one of the first analysis to be made in pump selection for the variable volume is the balance between a low first cost of small piping vs a higher operating cost caused by high dynamic doses. After that, a choice of reasonable margin of safety and control valve sizing criteria should bring some significant power savings because the dynamic loss over the control valve may become more than five times all other dynamic losses at that flow-rate.

where

$$G < (M - Q)\ T$$

Figure shows this supply utilisation factor as a function of storage provided. An impulse supply, which occurs during break. is one in which MT kgs of material arrive in single batches $(T =_o)$ every X hrs.

Now we might define the process utilization factor $\emptyset$ as the fraction of the possible production capacity per cycle, Q (T+X), that is actually utilized. This possible production capacity might not be realized for Want of feed during the feed when no supply of material is entring the system should the storage be empty.

The total amount of feed that appears for processing per cycle is MT kgs and the $\emptyset$ (MT) Kgs remain to be processed, the remainder over-flows. Thus the process utilization factor is

$$\emptyset_p = \frac{(\phi)\ MT}{Q(X+T)}$$

$$= \frac{T}{T+X} + \frac{G}{Q(T+X)}$$

We may see from above, how a semi-continuous supply results in a greater utilization of the process than a batch supply.

In this way we call that, this part which is not given much consideration is a very important point for energy conservation, which may lead to too much cost saving. The design of the whole system must be optimized upto as much extent as possible. By having optimum design the most important point of fiber loss will be eliminated.