Viscosity control - A new way to improve pressure screen performance

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Abstract
The effect of increasing the viscosity of the suspending liquid on reject thickening, screen capacity, fibre length fractionation, and specific energy consumption was investigated using carboxymethyl cellulose as the additive.

The throughput and therefore the capacity of a pressure screen can greatly be increased using a viscous liquid. Reject thickening decreases markedly due to increased fibre acceptance. The pumping energy per unit mass of accepted fibre is reduced because of reduced thickening and the pressure drop across the screen plate is also lowered. The effect of operating variables such as reject rate and rotor tip speed are less significant in viscous suspensions. The application of the commonly employed passage ratio model shows an increase of passage ratio with increasing viscosity. Fibre length fractionation is reduced which is an advantage when using the pressure screen for removing large contaminants but otherwise a disadvantage for long fibre fractionation. The screen aperture size could therefore be reduced to maximise contaminant removal efficiency while maintaining long fibre yield.

It is shown that the reduction of floc size in more viscous liquids produces a decrease in pressure loss across the screen plate. It is not the primary cause for increased fibre acceptance. The flow field in the vicinity of the screen aperture is responsible for more fibres passing the screen. The exit layer height as well as the maximum aperture velocity increase with increasing viscosity at constant average accept and rotor velocities. Higher fluid drag and more slippage between solid walls and fibres also contribute to the improvements.

Introduction
Flocculation is commonly recognised as a problem in most paper making processes. Fibres entangle and create flocs in zones of low shear intensity, thus reducing the efficiency of many operations in the pulp mill. This is of greatest concern when forming a sheet of paper where mass variations have a detrimental effect on final paper quality. Other operations also experience similar problems. The plugging of screen-basket apertures in pressure screening is one example where fibre networks reduce capacity and therefore process efficiency. In a pressure screening situation this problem is often resolved by using profiled surface screen baskets or by increasing the rotor speed. Generally, the most frequently used method to overcome the detrimental effects of flocculation is to decrease suspension consistency. This leads to higher water consumption and increased running costs.

A further option to reduce flocculation is to increase the viscosity of the suspending medium as this can profoundly reduce fibre network strength. Steenberg et al. [1] were the first to show that viscous sucrose solutions could significantly reduce the shear modulus of a Perlon fibre network. They explained this phenomenon with the dissipation of the elastic bending energy of the fibres before they came into contact and interlocked. The stored energy and therefore the resistance to deformation of the fibre network was reduced.

Wasser [2] thought that certain liquids, especially solutions of polymers of high molecular weights, form a liquid layer around the fibres that is difficult to remove. This layer would cover some of the irregularities on the fibre surface and thus reduce solid friction and 'hooking forces' between the fibres.

In a study carried out at the University of Auckland [3] it was shown that both factors are likely to contribute to a reduction in network strength depending on the type of additive / liquid used and the suspension consistency. The 'energy dissipation effect' is the predominant factor at relatively low consistencies where fibre crowding is minimal and fibres actually have the space to bend and straighten out. At higher consistencies however fibre lubrication becomes the main contributor to a weaker fibre network. This concept is supported by the measurement of the network strength of sugar-fibre and CMC- (carboxymethyl cellulose) fibre suspensions. At lower consistencies both types of suspensions displayed lower network strength at increased viscosities compared to a fibre-water suspension, whereas at higher consistencies only the CMC-solution was really effective.

Experimental

A study was performed with a Beloit MR8 (8 inch inner diameter) horizontal laboratory screen run in recycle mode. The laboratory plant equipment consisted of magnetic flow meters, pneumatic control valves, and electronic pressure transducers to monitor and control pressures and flow rates in feed, accept, and reject lines. All runs were carried out with a 1mm diameter smooth hole-screen basket and a hydrofoil shaped rotor. The screen rotor was driven by a variable-speed drive motor. Samples were taken from feed, accept, and reject lines to determine consistencies and fibre length distributions with a Kajaani FS-200 fibre analyser.

The (non-Newtonian) flow properties of the suspending liquid were determined with a rotary viscometer. The low CMC concentrations resulted in the CMC behaviour approaching that of a Newtonian liquid ie. the power law flow behaviour indices were near unity. Thus the viscosities indicated throughout this paper are equal to the consistency indices which are equivalent to the viscosity of a Newtonian fluid. The densities of the power law CMC solutions are also equal to water because the additive concentrations are very low.

Two bleached Kraft *pinus radiata* pulp types of different coarseness were used. The low coarseness pulp ('BKP Low') had an average length-weighted length of 2.08mm and an average coarseness of 0.2mg/m. The fibre length of the high coarseness pulp fibres ('BKP High') was 2.6mm long (length weighted average) and the coarseness was 0.25mg/m. Because of the pulps used and the small size of the screen, the feed consistency had to be limited to approximately 1.2%.

Results

The behaviour of viscous fibre suspensions in a pressure screen was examined with respect to the most important criteria in pressure screening: reject thickening behaviour, capacity, fibre separation efficiency, and energy consumption.

Reject thickening

Reject thickening is the term used to describe the increase of suspension consistency from the feed-to-reject side of the screen. It occurs because it is easier for the liquid to pass through the screen apertures than it is for the fibres resulting in a lower accept consistency compared to the feed. The reject thickening factor is the ratio of reject to feed consistencies. A decrease in volumetric reject rate normally results in an increase in reject thickening which can lead to screen aperture plugging because a large amount of fibres is being forced through the screen plate. If the consistency difference from feed to accept side becomes too large larger thickeners have to be employed to bring the mainstream consistency back to its normal operating level.

The reject thickening behaviour of a pulp screen was modelled by Gooding and Kerekes [4] by introducing the term passage ratio P to describe the probability of individual fibres passing through the screen plate. They developed two models for mixed and plug flow. In the case of the plug flow model, no axial mixing occurs but perfect radial mixing in the screening zone is required. In the case of the mixed flow model, perfect radial and axial mixing is assumed. The better fitting model is usually the ‘plug-flow’ model which relates the passage ratio to the reject thickening factor T and volumetric reject rate R_v in the following way:

$$T = R_v^{(P-1)} \text{ (plug)} \quad T = \frac{1}{R_v - P(R_v - 1)} \text{ (mixed)} \qquad (1)$$

Where T = Reject thickening factor (ratio of reject and feed consistencies)
R_v = Volumetric reject rate (ratio of reject and feed flow rates)
P = Passage ratio

The passage ratio is defined as the ratio of the consistency in a screen aperture to that upstream of the aperture and can be used as a single parameter to describe reject thickening as it is independent of reject rate. Wakelin [5], and Walmsley and Weeds [6] confirmed that the plug-flow model fitted their data well for different screening situations.

In **Figure 1** the thickening behaviour of a water-pulp suspension is compared to CMC-pulp suspensions of various viscosities (passage ratios P from plug flow model are indicated). It can be seen that the reject thickening curves become flatter and increasingly independent of reject rate with increasing viscosity (cP means centipoise). The reject thickening factors approach unity at high viscosity levels meaning there is almost no reject thickening taking place.

A comparison of plug flow and mixed flow passage ratios for the two pulp types as a function of viscosity can be seen in **Figure 2**. Both models fitted the data equally well (according to the R^2 values). This is somewhat surprising as both models are based on different mixing assumptions within the screen. It is apparent for both pulp types however that the passage ratios increase significantly with increasing viscosity and approach an asymptote above 20cP in case of the BKP Low pulp.

The effect of rotor tip speed on the reject thickening behaviour can be seen in **Figure 3**. The data presented are for a volumetric reject rate of 10% as the rotor speed is assumed to have the greatest influence in this region. Rotor speed can have two opposing effects on fibre acceptance. In the case of long fibres a high level of rotor tip speed leads to reduced fibre acceptance because there is less of a chance for long fibres to turn into the hole or slot from their parallel alignment with the basket wall (fibre turning effect). However at higher rotor speeds suspension mixing intensity increases, producing more single fibres than flocs so that fibre-acceptance probability is increased (fibre mat effect). The results displayed in Figure 3 support the assumption that the latter effect is predominant as reject thickening decreases with increasing rotor speed. It is also evident that the influence of rotor speed on reject thickening is reduced with increasing viscosity. It was shown [3] that a pulp fibre suspension is generally better mixed (less flocculated) at higher viscosities so the increased rotor speed does not produce better mixing of an already well-mixed suspension.

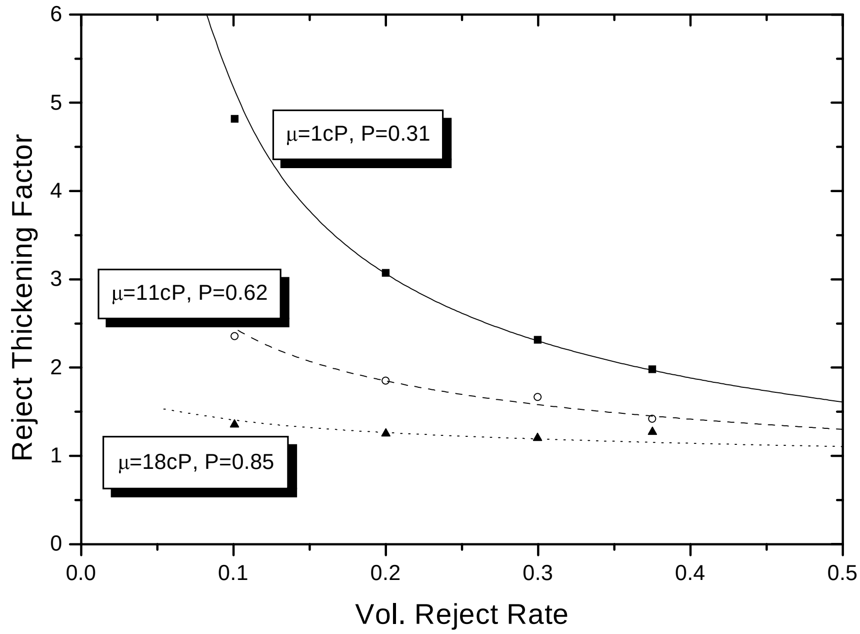

Figure 1. Reject thickening versus volumetric reject rate.

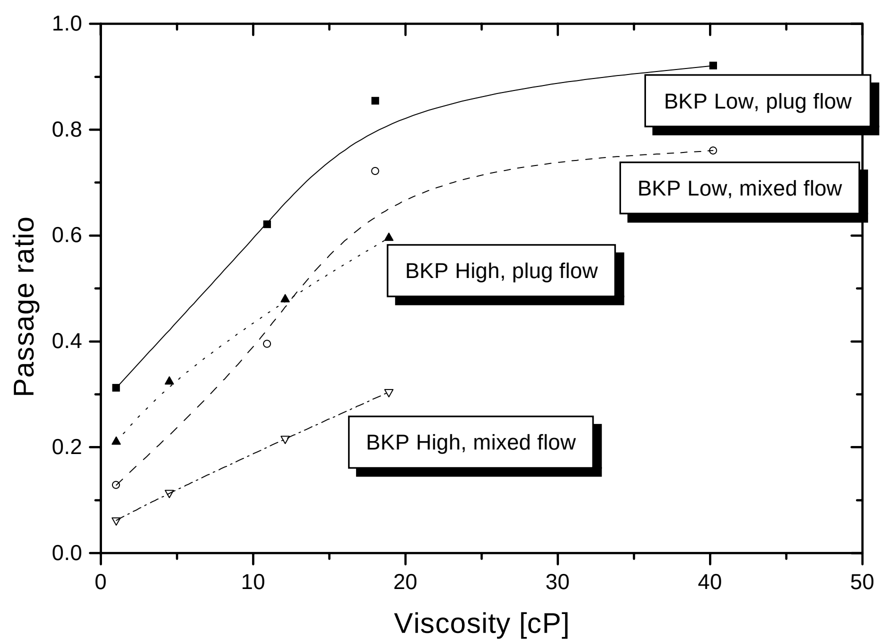

Figure 2. Passage ratios as a function of viscosity.

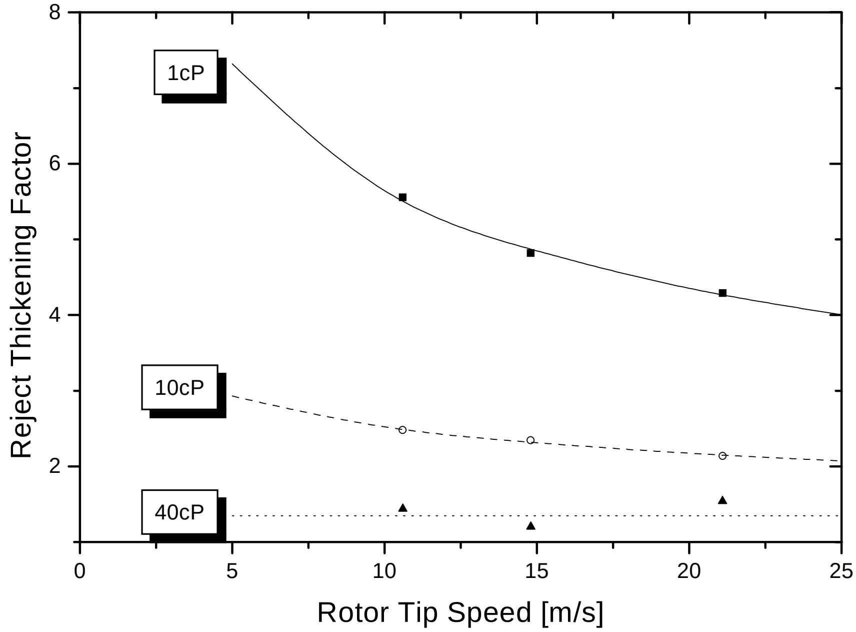

Figure 3. Reject thickening versus rotor tip speed.

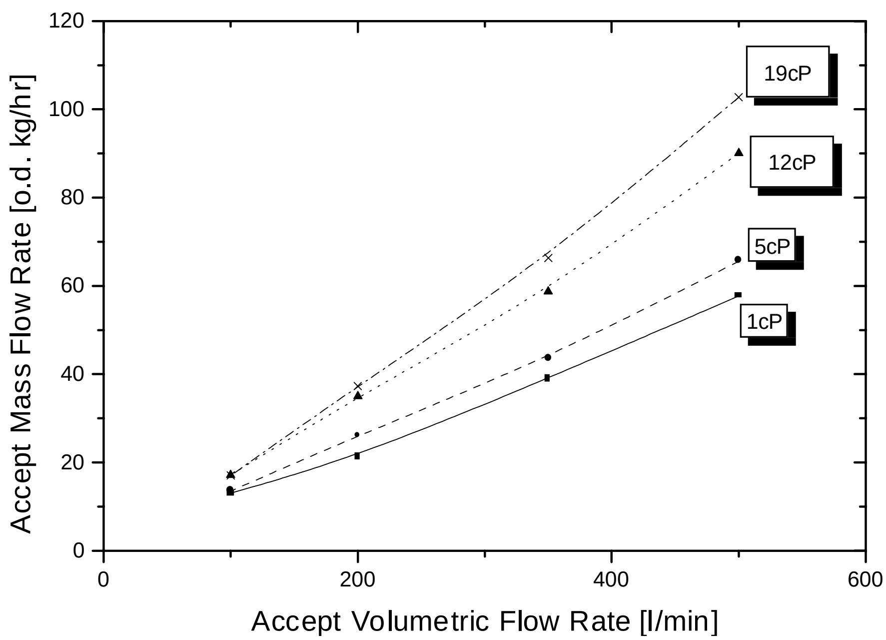

Figure 4. Screen capacity versus accept volumetric flow rate.

Screen capacity

The use of a viscous liquid as the suspending medium clearly produces increased screen capacity as displayed in **Figure 4**. Here the accept mass flow rate is plotted as a function of accept volumetric flow rate which is directly related to average aperture velocity. It can be seen that the accept mass flow rate increases as aperture velocity increases which can be explained by higher drag forces acting on the fibres. The rate of increase in mass flow rate with increasing aperture velocity is greater as the suspending medium viscosity increases. This can partially be explained by the overlaying effect of better mixing and higher drag forces. However at low accept volumetric flow rates the viscous nature of the suspending medium does not appear to make a large difference.

Fibre separation

Screening can be used to remove contaminants as well as to fractionate different fibre types. In the case of contaminant removal it is desirable to retain as many of the contaminants in the reject screen outlet as possible and have as many of the 'good' quality fibres including the long ones pass through the screen plate as possible. In the case of fibre fractionation however it is desirable to keep a certain fibre fraction such as (long or thick-walled fibres) in the reject portion of the screen and ideally send all the short or thin-walled fibres to the accept fraction.

The fibre separation efficiency in this work was evaluated using a Kajaani FS200 analyser and the Nelson's *Q*-index equation [7]:

$$Q_{long} = 1 - \frac{X_{i,accept}}{X_{i,reject}} \quad \text{or} \quad \mathrm{Q}_{\mathrm{short}} = \frac{X_{i,reject}}{X_{i,accept}} - 1 \tag{2}$$

There are many equations available to describe screening efficiency. The *Q*-index has an advantage that it is largely independent of reject rate. For graphing purposes two definitions are used, one for long fibres (Q_{long}) with Q varying from positive unity to zero, and a separate one (Q_{short}) for short fibres with Q varying from zero to negative unity.

The number of fibres present in a certain fibre length class can be determined with a Kajaani analyser. The width of each class in the FS200 is 0.05mm and the total length range is 0 to 7.2mm so that 144 classes are available all together. The length-weighted percentage of fibres existing in a specific class is calculated by dividing the number of fibres in that class by the total number of fibres analysed:

$$X_i = \frac{n_i L_i}{\sum_{i=1}^{144} n_i L_i} \tag{3}$$

The letter 'X' normally refers to a mass fraction. In this case the length-weighted fraction was chosen to be an estimator of mass fraction. The length-weighted fraction would be equal to mass fraction if all fibres had the same cross-sectional dimensions. The index 'i' now refers to a particular fibre length class. The efficiency index is obtained using the length-weighted fractions in Equation (2).

The effect of viscosity on the Q-index can be seen in **Figure 5**. By increasing the viscosity, the *Q*-index for small fibre lengths increases and the curves become flatter (approach zero). The concentration of short fibres in the accept fraction becomes smaller compared to their concentration in the reject stream as viscosity is increased. A similar effect is obtained for long fibres. This phenomenon is seen more clearly if *Q* is plotted against viscosity for different fibre length fractions (**Figure 6**). The *Q*-index value for the long fibre fraction decreases from approximately 80% to 0 as more long fibres are being accepted with increasing viscosity. It is interesting to note that the short fibres approach the zero *Q*-index value as well. In a water suspension the short fibres have a strong tendency to go to the accept side of the screen. At high viscosities they are not automatically accepted even though it is easier for the long fibres to pass the screen plate. Obviously the accept and reject pulp compositions approach those of the feed pulp which is equivalent to the flow through a T-junction where no separation takes place. Even though this trend defeats the purpose of fractionation it could be used as to advantage if the solids needing to be removed from the suspension are larger than the screen aperture (barrier screening). In this case the capacity of the screen can be greatly increased and increasing fluid viscosity would be a distinct advantage.

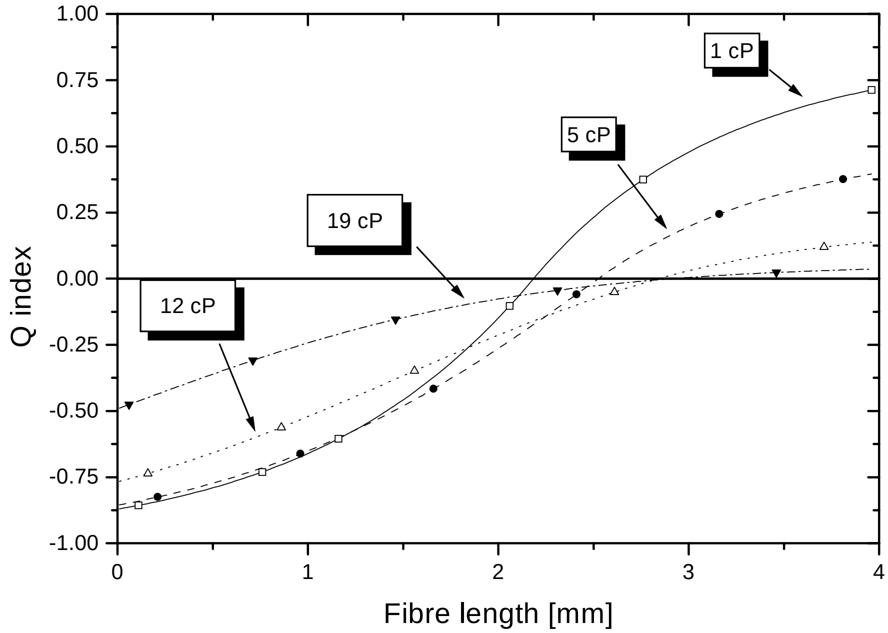

Figure 5. Q-index versus fibre length.

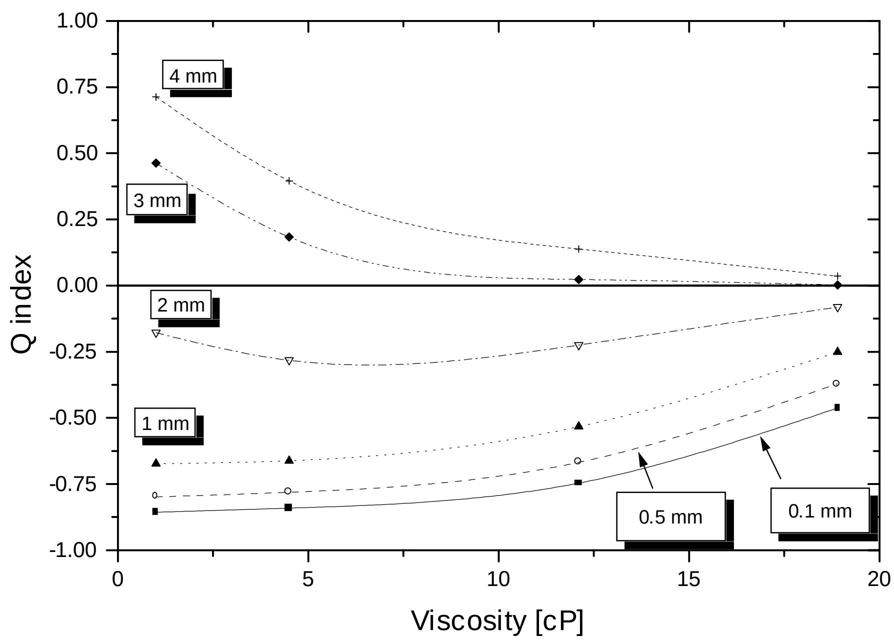

Figure 6. Q-index as a function of viscosity for various fibre length fractions.

Specific pumping energy

The energy required to pump a pulp suspension through and across a screen, and maintain a fixed rotor speed is an important consideration if viscosity enhancement is to be of industrial value. Higher consistencies and viscosities will undoubtedly increase the energy required. This effect may be counteracted by a higher throughput or capacity of the screen and hence the energy per unit accept mass flow (specific energy) is required as an indicator. An energy balance around the screen was performed taking into consideration feed, accept, and reject stream enthalpies as well as rotor energy (neglecting temperature changes):

$$W_{rotor} + Q_{feed} P_{feed} = Q_{accept} P_{accept} + Q_{ejectr} P_{reject} + W_{loss} \tag{4}$$

Where W = Power [W]
Q = Flow rate [m^3/s]
P = Pressure [Pa]

In the current setup the rotor power could not be measured separately so that the loss term and the rotor term are combined. The difference between feed and accept or reject pressures can be turned into pressure differentials. By dividing both sides by the accept fibre mass flow rate and remembering that $Q_{feed} = Q_{accept} + Q_{reject}$, an expression for the specific energy can be found:

$$S_{loss} = \frac{W_{spec}}{M_{accept}} = \frac{Q_{accept}\Delta p_{accept} + Q_{reject}\Delta p_{reject}}{M_{accept}} + \frac{W_{rotor}}{M_{accept}} \tag{5}$$

Where S = Specific energy [J/kg or kWh/t]
M = Mass flow rate [kg/s]
Δp = Pressure drop [Pa]

In the experimental setup it was not possible to determine the rotor energy consumption so that the specific energy was determined by the pumping energy loss only. In the case of a shear thinning (drag reducing) liquid like CMC solution the rotor power consumption was not expected to increase greatly with increasing viscosity.

The influence of viscosity on specific energy is demonstrated in **Figure 7**. Firstly it is obvious that specific pumping energy decreases significantly with increasing viscosity. In this example the specific energy is reduced by 30% if the viscosity is raised to 19cP. This trend is expected because of the increased fibre mass flow rate as shown earlier. The second observation is the flattening of the energy-reject rate curve: at higher viscosities the energy does not change significantly with volumetric reject rate. Any increase in specific energy with increasing volumetric reject rate (accept flow rate constant) is principally caused by a larger reject pressure drop because a higher reject rate means a greater reject velocity. In pipe flow it was shown [3] that the pressure drop of a CMC-pulp suspension increases at a lower rate with increasing velocity compared to a water-pulp suspension which would explain the flattening of the energy curves at higher viscosity levels in Figure 7.

The increased mass flow rate is not the only reason for the decreased pumping energy demand as the hydraulic resistance across the screen plate is also reduced in a viscous medium. To demonstrate this a pressure loss coefficient ς was calculated according to equation (6):

$$\varsigma = \frac{\Delta p_{accept}}{\frac{\rho}{2} v_{accept}^2} \qquad (6)$$

Where ρ = Liquid density [kg/m^3]
v = velocity [m/s]

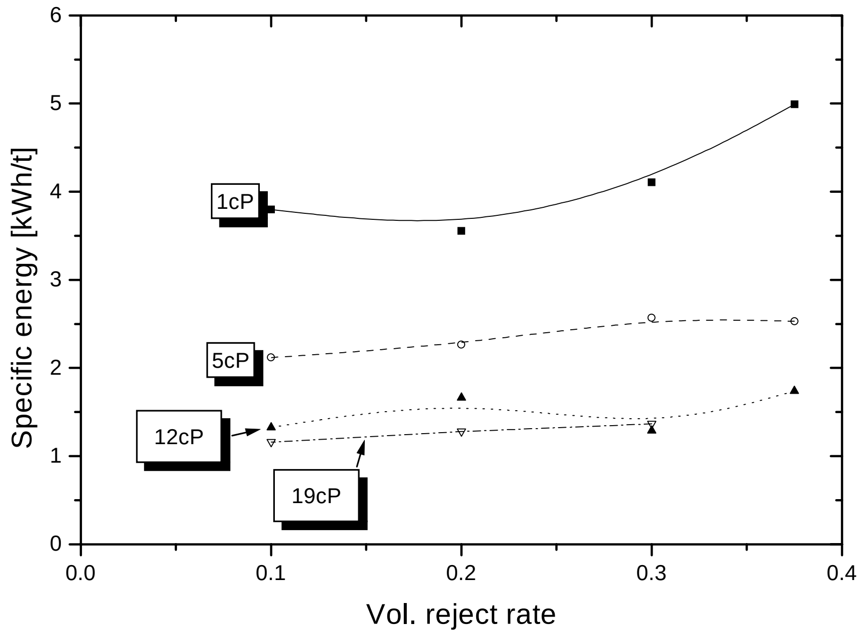

Figure 7. Screening energy demand decreases with increasing viscosity.

In **Figure 8** the pressure loss coefficient of a pulp suspension was plotted as a function of viscosity for the process conditions presented in Figure 7 (R_v=0.2). It can be seen that a reduction in cross-basket pressure loss also contributes to the decrease of screening energy demand.

Discussion

The first part of the discussion deals with the question how fibre flocs or fibre mats and their network strength influence screening behaviour. The second part of the discussion focuses on how the flow field and individual fibre behaviour inside the screen are affected by a viscous liquid.

Fibre network phenomena

In **Figure 9** a comparison of the reject thickening behaviour of water-pulp suspensions at two consistency levels and a CMC-pulp suspension are presented. The relative fibre network strength (extrapolated from results presented in [3]) as obtained from disruptive shear stress measurements [8] are presented with the water-pulp suspension at 0.84% consistency having an arbitrary shear stress value of 100. It can be seen that that the type of suspending liquid has a much greater influence on reject thickening than fibre network strength. This supports evidence presented in various publications (eg. [6]) that reject thickening through the screen is not only a function of feed consistency but also suspension network strength.

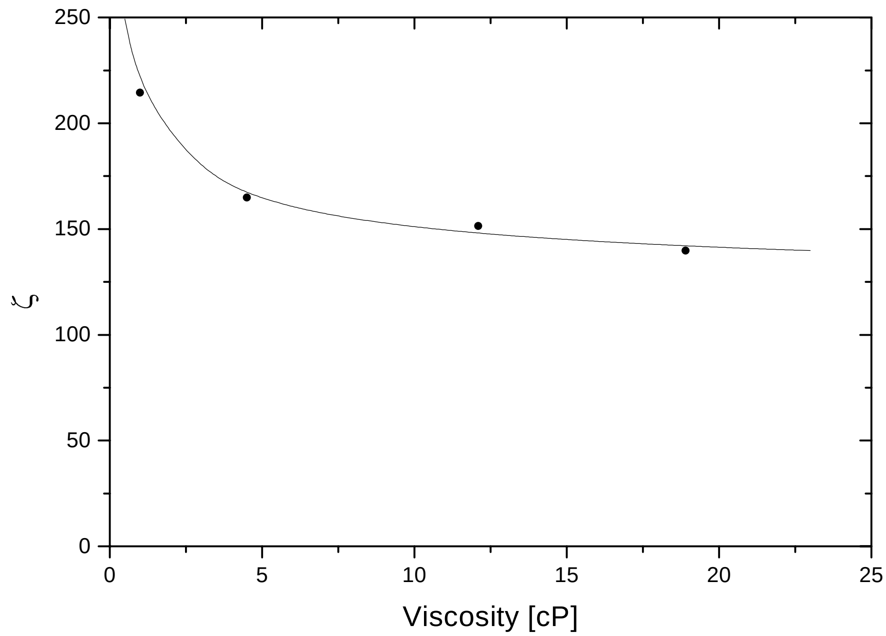

Figure 8. Pressure loss across screen basket decreases with increasing viscosity.

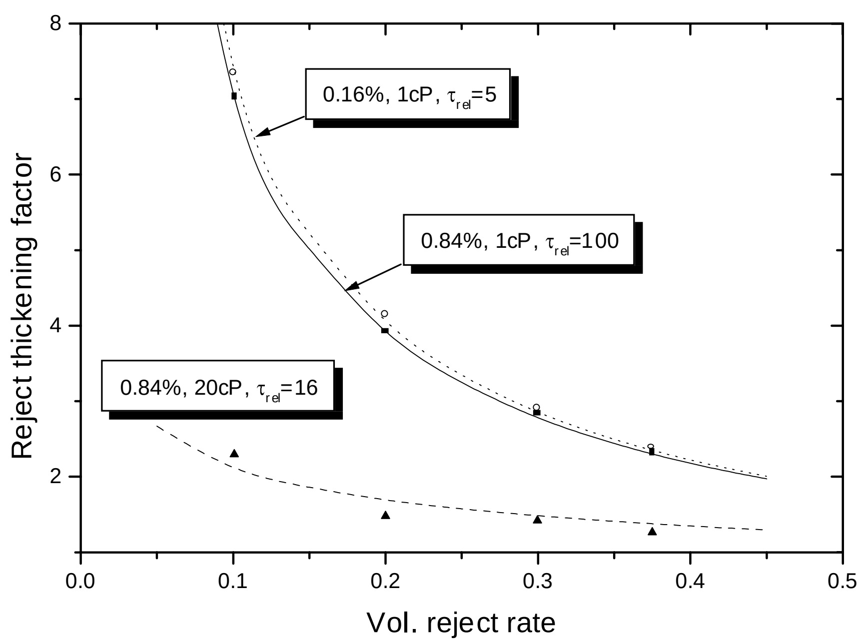

Figure 9. Reject thickening versus volumetric flow rate.

The pressure drop across the screen basket is affected by fibre network strength τ_d and is shown below. It could be assumed that pressure drop is affected by flocs inside the screen apertures as well as any fibre mat covering the basket hole inlets. **Figure 10** shows how pressure drop changes with accept consistency which was varied by increasing the feed consistency. In the case of the water-pulp suspension the pressure drop increases steeply with increasing accept consistency. The accept consistency is a measure of how many fibres are actually (on average) inside the screen apertures at any one time. Despite the four-fold amount of fibres within the aperture compared to water the CMC-pulp suspension only shows a very slight increase in pressure loss across the screen with increasing consistency. It is possible to increase the accept consistency to much higher levels without screen plugging. This is even more remarkable considering the 'quality' of the fibres being accepted is high. It was shown in Figure 6 that the higher the viscosity the longer (and thicker) the fibres in the accept fraction which means that 'flocs' are even more likely to exist. From this finding it was concluded that the fibres inside the screen holes may not affect pressure drop as much as one may surmise, but that fibre interactions (as outlined in the introduction) are a more important factor.

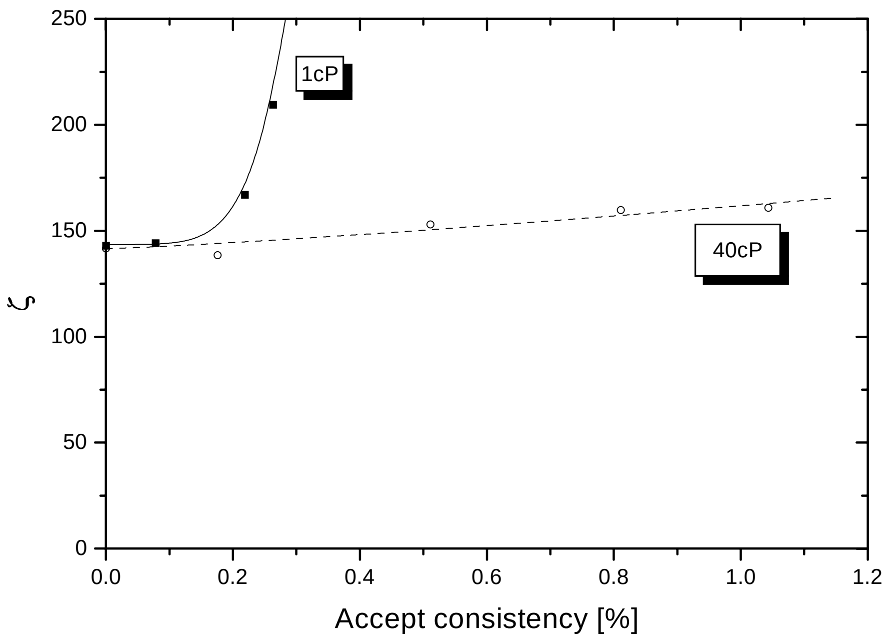

Figure10. Pressure drop ratio ζ versus accept consistency.

In **Figure 11** the pressure drop coefficient ζ is shown as a function of network disruptive shear stress τ_d for varying consistencies at 1cP (water) and varying viscosities at 0.5% consistency. It can be seen that in all cases ζ increases with increasing τ_d to a similar degree. The disruptive shear stress as a function of viscosity and consistency was obtained from a correlation described in [3] which also explains some of the scatter in the figures. It can be seen that ζ is more or less a function of only τ_d irrespective of pulp type or suspending liquid.

There is evidence that floc size is also a function of the disruptive shear stress [3]. The bigger flocs would be able to cover a greater area of the screen holes whereas the smaller flocs have a larger degree of porosity between them. The pressure drop is assumed to increase as the liquid has to force its way through fibre agglomerates. Hence it is concluded that the pressure loss across the basket is related to the state of the fibre network in front of the screen plate. Reject thickening and fibre passage however do not appear to be related to fibre network strength.

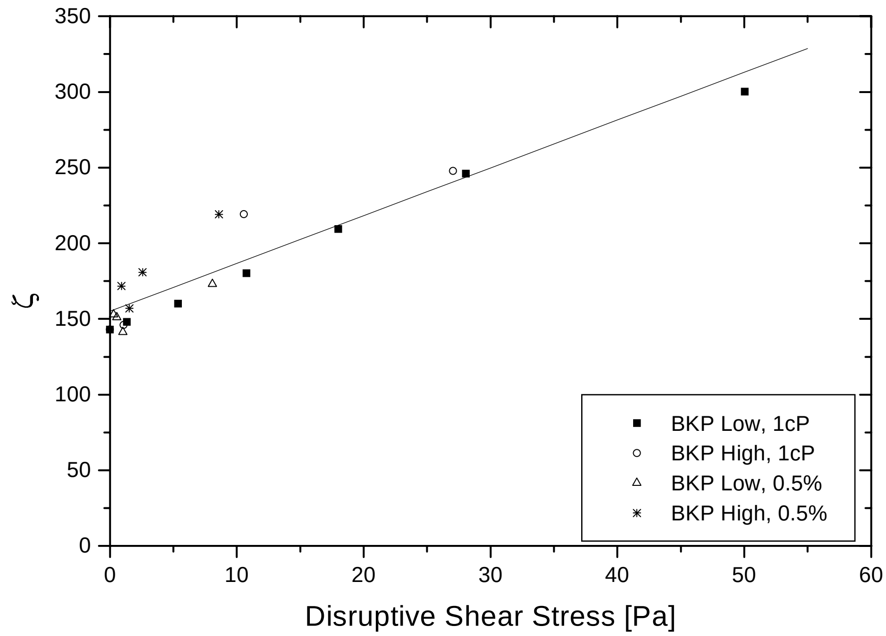

Figure 11. Pressure drop ratio ζ versus disruptive shear stress.

Individual fibre behaviour

The flow field inside a screen is 'chaotic' in nature. It is not only characterised by general turbulent flow phenomena described in pipe flow but also by the overlaying effects of rotor action and suction through the screen basket perforations. The presence of fibres makes matters even more complicated. In the following section the effect of viscosity on the flow field is estimated.

Basically there are three superimposed flow fields inside the screen: an axial flow from feed-end to reject-end, a tangential flow caused by the rotor, and a radial flow through the screen apertures. Because of the overlaying axial and tangential flows the fibres move in a helical pattern along the screen plate. The flow direction in the axial-tangential plane changes slightly with the axial position because of the decreasing flow rate from feed to reject end, the tangential velocity component however is by far the dominant one.

A constant (K_{rot}) which expresses the slip between rotor and the suspension near the screen plate was introduced by Gooding [9] and assumed to have a value of 0.15. This value was apparently derived from a two-dimensional velocity field in the wake of a cylinder [10]. The slip factor refers to the tangential velocity between one rotor element and the next one passing by near the screen plate. Wakelin [5] confirmed this value by plotting the reject thickening index or efficiency index versus rotor tip speed. Below a certain critical rotor speed the thickening index decreased suddenly. With the critical speed and the assumption of Kumar [11] that long fibre acceptance increases rapidly above aperture-to-tangential velocity ratios of 0.3, Wakelin was able to confirm the constant to be approximately 0.15. This factor depends greatly on rotor design and distance between rotor and screen surface.

Wakelin's technique applied to the present data and for a 0.5% water-BKP Hi suspension yielded a K_{rot} value of 0.05. The range of the measurements was insufficient to obtain more accurate determinations but it appeared that the critical rotor speed decreased with increasing viscosity. If Kumar's assumption were true even at higher viscosities then K_{rot} would have to increase to obtain a constant velocity ratio of 0.3.

As mentioned earlier, to obtain an exact solution of the equations given in the literature [10] a great number of measurements would have to be made, in particular to determine the drag coefficient of the hydrofoil. The drag coefficient c_D in case of an ideally shaped aerofoil is inversely proportional to the Reynolds number, and to the point of transition from laminar to turbulent flow along the length of the foil, which in turn is proportional to the Reynolds number. It appears however that the Reynolds number itself has a greater influence on c_D than the point of transition which means that the drag coefficient increases with decreasing Reynolds number. From a mathematical analysis it appears that the tangential velocity should increase with increasing viscosity. However it was seen earlier that a water-pulp suspension is more affected by rotor speed than a CMC-pulp suspension at high viscosities. Assuming that flocculation effects are less important for fibre acceptance in a viscous medium it can be concluded from the measurements that the effective tangential velocity either does not change in a viscous medium or that the effect of tangential velocity change is of minor importance.

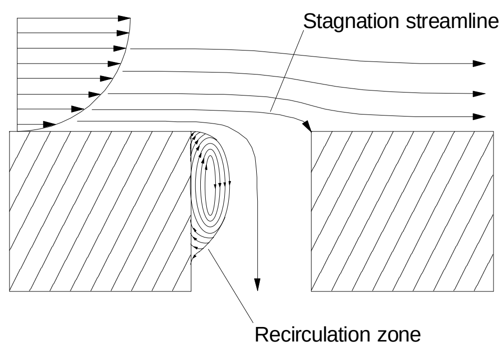

Figure 12. Flow field at a screen aperture.

The flow field at the entrance of the aperture is also important (**Figure 12**). A large recirculation zone at the upstream edge of the hole is formed depending on the transverse velocity of the liquid. Thomas and Cornelius [12] investigated the magnitude of this effect. They found that the width of the recirculation zone is inversely proportional to slot Reynolds number (at constant aperture flow rate) and the wall velocity gradient upstream of the slot. With increasing viscosity both the velocity gradient (at constant upstream velocity) as well as the slot Reynolds number decrease which should lead to a wider recirculation zone (which in turn causes a slightly higher pressure drop for the pure liquid). It can then be concluded that the wider the recirculation zone the higher the maximum velocity in the slot. Thus the higher maximum velocity in the slot and consequently higher fibre drag forces are likely to be responsible for increased fibre acceptance.

The wall velocity gradient is also related to stagnation streamline which separates the fluid flowing into the slot or hole from the flow further away from the screen plate. The higher the viscosity (at constant upstream velocity) the lower the gradient and the greater the height (distance from wall) of the separation streamline. Olson and Kerekes [13] mathematically analysed the exit layer height defined by Gooding [14]. According to their model, a fibre has to be within that layer to pass through the screen plate. The exit layer height is obtained from setting the near wall velocity gradient equal to the product of the aperture width and velocity.

Their model was applied for the setup used in the present investigation for varying viscosities. It was found that the exit layer height increased with increasing viscosity (non-Newtonian effects neglected). Hence the increased separation streamline and exit layer height (the two may very well be related) at higher viscosity levels both favour fibre acceptance.

Another important factor is the drag on the fibres themselves. Most reported research deals with fluid-particle drag at very low Reynolds numbers for stationary fluids or particles. Thompson and Clark [15] stated that an equation developed by Wadell [16] was most widely used to predict the drag coefficient on a particle of any shape. The equation is in agreement with common knowledge that the drag coefficient becomes independent of particle Reynolds numbers at high *Re*. In case of a typical pulp fibre with an aspect ratio of 90, c_D becomes independent of *Re* at *Re* = 100 which is below the aperture Reynolds number at the highest velocity (*Re* = 461 for water). The relative velocity between liquid and fibre is very small if the fibre can move independently. The more the fibres are restricted by other fibres (flocculation) or by the screen aperture, the higher the relative velocity and the fibre Reynolds number. In both cases however the higher the viscosity the higher the drag force on the fibre. This was expressed by Forgacs and Mason [17] in the following way:

$$F_{drag,fibre} = \frac{\pi \mu L^2 \left(\frac{du}{dy}\right)}{8\left(\ln\left(\frac{2L}{D}\right) - 1.75\right)} \cos(\Phi) \tag{7}$$

where F = Force [N]
Φ = Angle between direction of normal velocity of flow field and fibre axis
μ = Liquid viscosity [Pa s]
L = Fibre length [m]
D = Fibre diameter [m]
du/dy = velocity gradient [m/s]

It can be seen that the drag force is directly proportional to viscosity.

Screen aperture-fibre interaction is also an important factor, as discussed by Tangsaghasaksri [18]. A fibre that is in contact with the edge of the aperture is bent by liquid drag forces which decreases the effective surface available for the liquid to 'attack' the fibre. A change in viscosity will change the flow field (eg. boundary layer) on the basket surface in relation to the flow field inside the screen hole. The degree to which the fibre is bent in either direction may therefore change. Another effect which is quite often neglected to simplify mathematical analysis is slipping between fibre and aperture edge. The viscous layer around the fibre would make the fibre surface more slippery and facilitate fibre acceptance.

Application

The principles described above should apply when the process liquid is changed or when the process temperature is altered. It is sometimes believed that a change of process temperature alters the screening behaviour of a suspension because of a change of the water viscosity. A change of water temperature from, say 55°C to 20°C would increase the viscosity by a factor of 2 and based on the results presented in this paper an increase of fibre acceptance could be expected. However in reality a decrease of fibre acceptance is obtained [19]. The individual fibres are stiffer at lower temperatures and have a much greater effect than the viscosity change of the liquid. This and the fact that each type of liquid has different properties (especially with regard to their ability to develop a lasting viscous layer around the fibres) should be taken into consideration. Black liquor screening is just one possible application of the described principles. It could also be worthwhile to consider different injection points for process additives due to the (positive or negative) effects their addition could have on the screening process.

Conclusions

The following conclusions can be drawn from this investigation:

- The use of a viscous liquid enhances screen throughput / capacity;
- Reject thickening is reduced at higher viscosities;
- The thickening profile along the screen plate is altered;
- Screen pumping energy decreases as a result of lower pressure drop across the screen;
- Increased long fibre passage results in reduced fibre losses for contaminant screening applications;
- Higher fibre acceptance is caused by individual fibre behaviour;
- The suspension inside the screen is much better mixed at higher viscosity levels;
- Injection points for process additives should be selected according to their effect on screening;
- Temperature changes may affect fibre properties more than liquid viscosity.

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