Solving The Hard-To-Pump Problems In The Pulp & Paper Industry

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ABSTRACT

The pumping system is one of the most critical parts of the pulp and paper manufacturing process. Its importance to the process is much greater than its capital cost: Over the life of a pump, the initial purchase price can become an insignificant part of the total Life Cycle Cost when you consider the cost of downtime if the pump fails, the cost of lower paper freeness, the cost of damage when pumping shear sensitive chemicals, and of course the cost of maintenance and repair in severe service applications. In this article, we will present an innovative technology that solves the hard-to pump problems in the industry and allows paper mills to achieve productivity gains by pumping up to 18%+ density stock without the need for fluidization or, in most cases, air removal devices. Case histories showing the application of this technology in a number of pulp and paper mills worldwide will be given.

INTRODUCTION

Objective of Presentation

The objective of this presentation is to describe an innovative pumping concept that can overcome some of the key pumping problems facing the pulp and paper industry. This pump technology is based around a patented operating mechanism that minimizes contact between the pump and the product being pumped, and actually becomes more efficient at higher viscosities and higher stock densities. In addition, it produces a smooth laminar flow of product through the pump, eliminating the problems associated with pulsation and vibration.

Although the concept is over 100 years old, it has only been applied commercially to the pumping process in the last 15 years. Since then, the benefits of this technology in the pulp and paper industry have been proven in paper mill installations throughout the world: the pump is able to handle paper stock of in excess of 18% consistency, with no dilution required; the non-impingement design is ideal for shear sensitive materials and allows maximum paper freeness to be retained; the pump can handle fluids containing very high levels of entrained air, depending on application, without vapor-locking the system; and wear is minimal even in severely abrasive conditions.

The first half of this presentation focuses on the pump technology, the second half deals with its application in the pulp and paper industry. In particular, we will examine: the pumping of medium-to-high density (7%-18%+) paper stock; applications in the coatings kitchen, in particular handling abrasive and shear sensitive fluids, and other severe service applications in the chemical recovery process, such as green liquor dregs and lime slurries.

THE DISC PUMP CONCEPT

The disc pump is a totally novel design of pumping system, developed in 1982 by an inventor in Southern California, who went on to found the Discflo Corporation. Discflo holds the patent for this technology and is the sole manufacturer worldwide of the disc pump.

Discflo Corporation, 1817 John Towers Ave, El Cajon, California 92020, USA.

The operating principle behind the disc pump is boundary layer-viscous drag. Its application in the world of pumps is new but it has been widely used in the field of fluid engineering for over 100 years. A common example of this principle, well known in our industry, is the phenomenon of pressure drop or friction loss through a piping system.

The resistance to flow as a liquid moves through a pipe is due to viscous shear forces within the liquid and turbulence along the walls due to roughness. It results in a loss of head or pressure, the amount of which depends on the characteristics of the liquid being handled-ie viscosity, pipe size, pipe condition and length of travel.

If your examine the cross-sectional area of a pipe **(Fig-1)** under laminar (non-turbulent) flow conditions, you see numerous streams of liquid traveling at different velocities. The stationary pipe exerts a 'drag' force on the moving liquid, attempting to slow it down. This drag force is transmitted to all the liquid layers along their parallel 'slip' surfaces. The result is higher liquid velocities at the center of the pipe, with gradually lower liquid velocities as the layers approach the inner surfaces of the pipe. In fact, the layer closest to the pipe can be assumed to be at rest- with zero velocity (Shapiro, Ascher H: "Shape and Flow, The Fluid Dynamics of Drag).

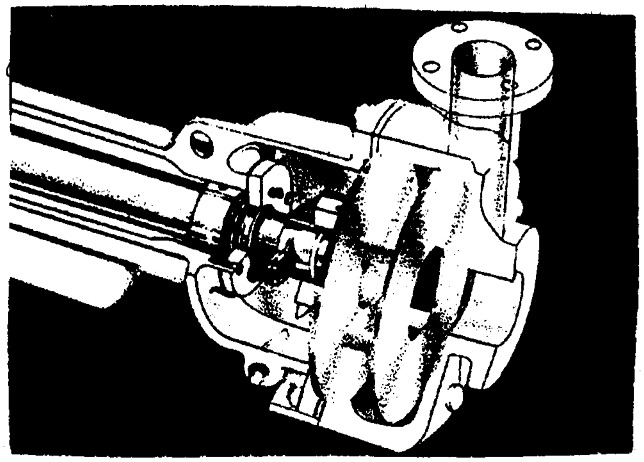


Fig 2. Cutaway diagram of the disc pump, showing the disc assembly. The size, number and spacing of discs varies according to application.

This is the phenomenon of boundary layer-viscous drag and the principle behind the operation of the disc pump. At the heart of this pump **(Fig-2)** are two parallel discs, known as the Discpac. As a fluid initially enters the pump, its molecules adhere to the surface of these discs, providing a boundary layer on the disc surfaces. Layers of fluid molecules are then formed parallel to the discs.

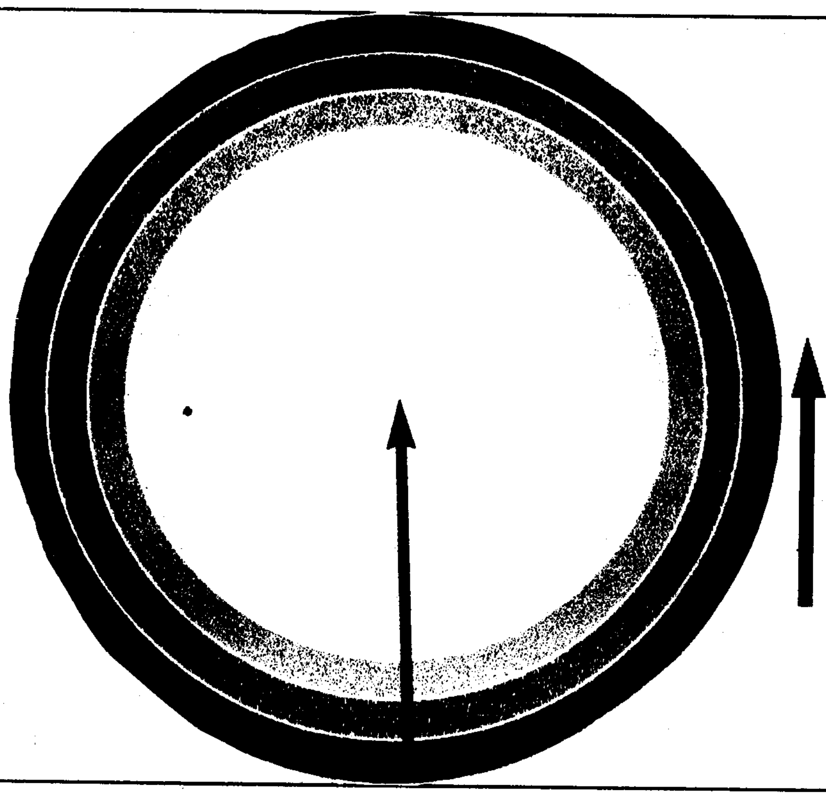


Fig 1. Cross-section of pipe exhibiting laminar flow conditions. Principle of boundary layer-viscous drag creates velocity gradient in pipe, so fluid layer adjacent to pipe wall-ie boundary layer-is stationary relative to the pipe wall, and fluid at the centre of the pipe is traveling at highest velocity.

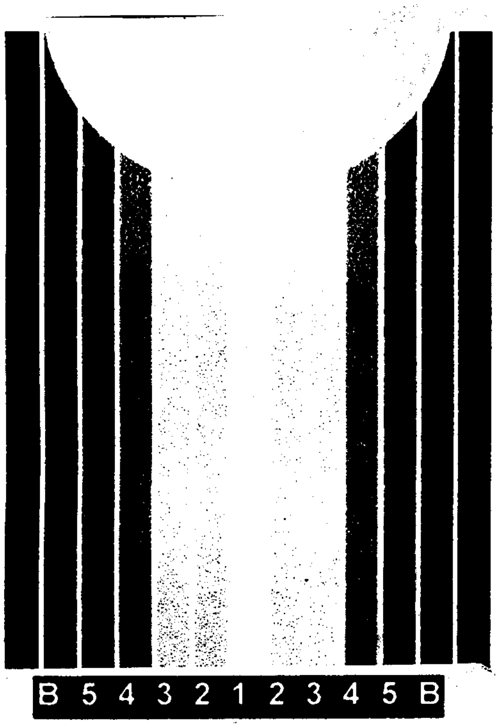


Fig 3. Principle of boundary layer-viscous drag across the width of two discs. Note that relative to the disc wall, layer B is stationary and successive layers are faster towards the center. But relative to an external observer, the fluid in layer B is travelling fastest and that in layer 1 is slowest.

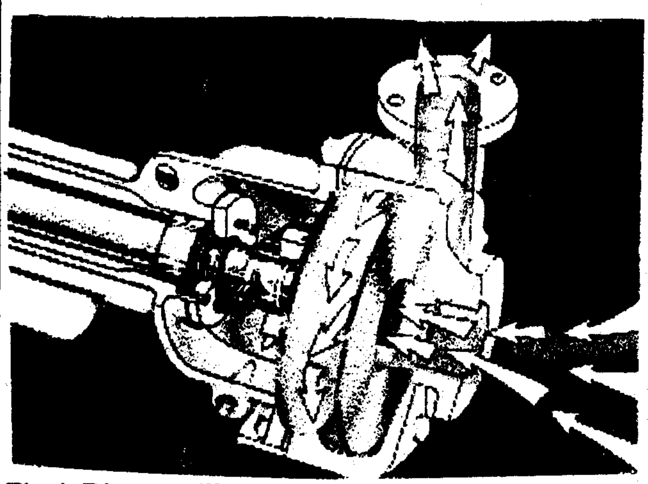


Fig 4. Diagram illustrating the flow of fluid through the disc pump. As the discs rotate the entire fluid mass rotates, creating a powerful frictional force field that "pulls" the fluid through the pump in a smooth, pulsation-free flow.

As the discs rotate, energy is transferred to successive layers of molecules in the fluid between the discs, generating velocity and pressure gradients across the width of the Discpac **(Fig-3).** This combination of boundary layer and viscous drag effectively creates a powerful dynamic force field that 'pulls' the product through the pump in a smooth, pulsation-free flow **(Fig-4).**

It is important to mention here that *relative to the discs,* the fluid molecules in the boundary layer are at rest and the fluid in the space halfway between the discs is traveling fastest. *But to an external observer,* the fluid molecules adjacent to the discs are traveling at the highest velocity, and the molecules between the discs at a lower velocity.

The key point is that the fluid being pumped moves parallel to the discs, with the boundary layer creating a molecular buffer between the disc surfaces and the fluid. There is no 'impingement' by the fluid on the moving parts of the pump. This non-impingement design is where the disc pump differs from other known pumps on the market, all of which use some kind of impingement device-such as a vane, impeller, paddle or screw-to "push" product through the pump. The disc pump uses a pulling or drag principle to move product.

This operating mechanism leads to several key benefits for the disc pump over existing pump systems in the handling of 'difficult' fluids-abrasive slurries, fluids with a high solids content, viscous slurries, fluids with high volumes of entrained air and/or gas, and delicate and shear sensitive fluids-just the kind of fluids found in a pulp or paper mill.

Fluids Handling Capability

Viscous fluids

Due to the non-impingement design and smooth, laminar flow, the disc pump can handle very high viscosity fluids. In fact, the higher the viscosity, the more efficient is the pump's performance, as performance varies with the internal shear or drag forces of the fluid being pumped. **Fig-5** illustrates the effect of drag forces on performance.

Velocity profile #1 represents water with a viscosity of 1cP, while velocity profile #2 represents a fluid with a viscosity of 5000 cPs, similar

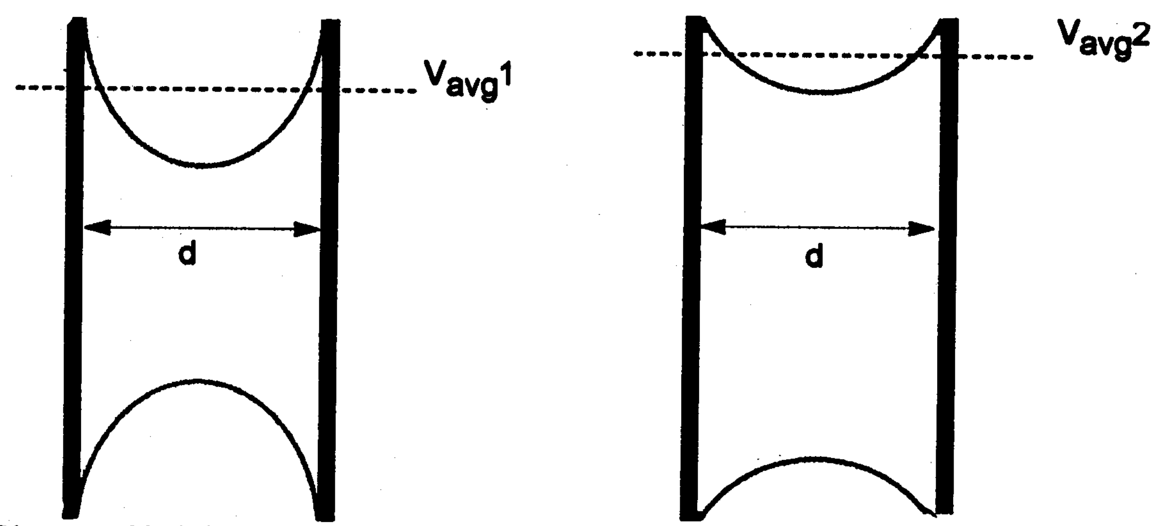


Fig 5. Disc assembly velocity profile for viscosites of 1) 1cP and 2) 5000 cPs. The disc pump can successfully handle viscosities as high as 3,00,000 cPs.

improvements would be shown with 12% density paper stock. If you take the average velocity in each case (V_{av}) and multiply it by the pumping area ($A=2\pi r.d$), you would obtain the flow rate $Q=V_{av}xA$.

The pump would attempt to transfer approximately twice the capacity with 5000cPs fluid, compared with 1cP fluid. Note that this example does not take into account the system piping, etc, which would have a higher drag force on the more viscous fluid.

Non-homogeneous slurries

A non-homogenous slurry is defined as a 'settling' slurry where the particles will easily fall out of solution due to the solids' higher specific gravity over the carrying fluid, for example lime slurries, sand and water, and some clarifier underflows. As a non-homogenous slurry enters the Discpac, the solid particles move to the point of highest velocity relative to the discs, ie the central space between them. The higher the specific gravity of the solids, the more the 'centrifuge' action of the solid. We have found through testing that slurries containing as much as 30-40% solids by volume all get centrifuged to the middle-with no signs of impingement or contact between the particle and the disc surfaces.

The slower speed layers adjacent to the disc surfaces, which are relatively solids-free liquid, in effect act as a 'molecular buffer' between the disc surfaces and the solids. This action both protects the solid from the full impact of the disc and the disc from the full impact of the solids-thus eliminating excessive product damage and pump wear.

Most other pumping systems have problems handling non-homogenous slurries and slurries with a high solids content. Screw pumps are prone to jamming with very small tramp solids-even a piece of plastic strapping. And large solids potentially jam all types of positive displacement pumps, requiring shutdown for clean out and/or expensive repairs.

Abrasive fluids

The abrasion resistance of a given pump design can be evaluated by studying the flow path of a solid as it passes through the pump. Research has shown that if a particle makes contact with a surface, the surface will wear. The rate of abrasion is a function of the impingement angle-or angle of attack-at which contact is made. The charts in **Fig-6** show how wear rate varies with impingement angle for various substrates.

Centrifugal type pumps usually have high impingement angles of approximately 20^0 to 90^0 which lead to high wear rates. To solve this problem, centrifugal pump manufacturers have attempted to

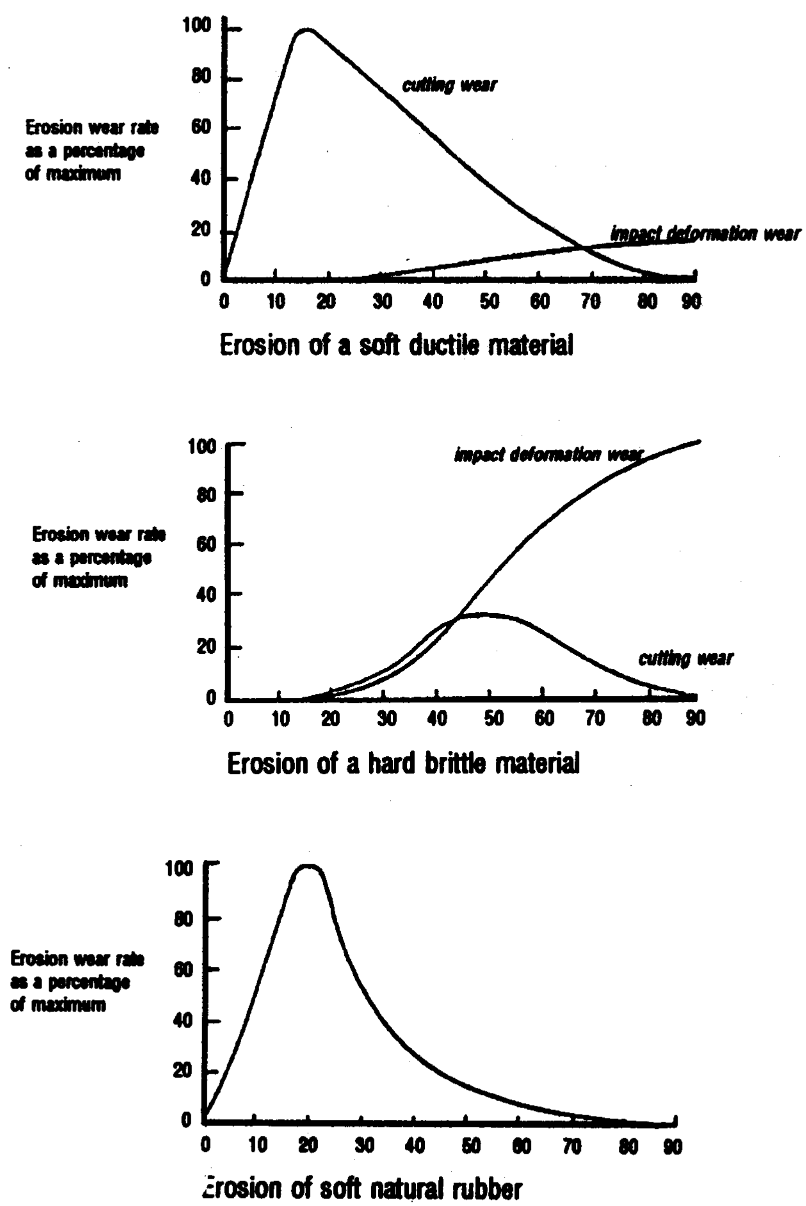


Fig 6. Graphs showing the erosion wear rate as a function of impingment angle for various substrates.

reduce impingement by lowering the vane angles to extend the life of their wearing parts. After years of effort to extend the life of these pumps, these manufacturers still claim that 50-80% of their business comes from spare parts. Also note that although rubber is extremely effective in providing abrasion resistance at high impingement angles, it shows very poor wear rates at low angles because rubber is extremely poor in 'shear'. This explains why progressive cavity pump manufacturers typically claim an 80% spare parts business.

The disc pump offers a good solution to effectively eliminate wear, with impingement angles close to zero. Wear rates, even in extremely abrasive service such as pumping fly ash or titanium dioxide, are low, and spare parts are typically less than 10% of our business.

The rate of abrasion is also a function of the relative velocity between the surface and the adjacent fluid layer. The thickness of this layer is mainly determined by the Reynolds number of the flow.

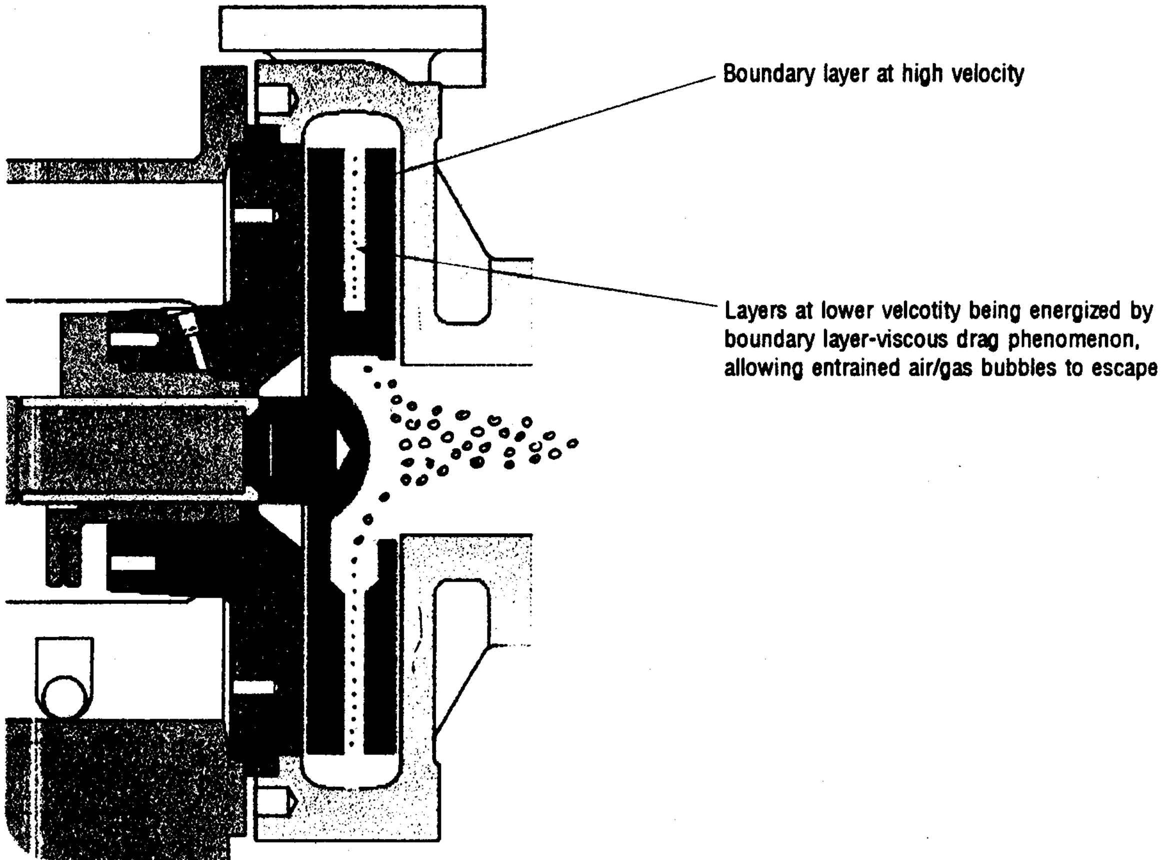


Fig 7. Diagram showing how air/gas bubbles pass through the disc pump without vapor-locking

In the disc pump, the layer adjacent to the discs-ie the boundary layer-is stationary.

In the vaned impeller of the centrifugal pump, the fluid undergoes an abrupt acceleration and change of direction as it enters the rotor. This reduces the boundary layer thickness to where particles pass across the rotor surface at nearly the midstream velocity, increasing the wear rate. This effect is strongest at the impeller inlet.

2.1.4 Fluids with high volumes of entrained air/gas

The disc pump can handle high amounts of entrained air or gas without vapor-locking or causing pump cavitation-an effect commonly found in centrifugal type pumps. It has been shown in certain industrial applications to handle as much as 80% air/gas entrainment. In the pulp and paper industry, this ability of the disc pump results in eliminating the need for vacuum systems or air removal devices in almost every case.

As the discs develop their boundary layer of liquid, it sets in motion numerous parallel streams of liquid travelling at higher velocities towards the center between the discs, in relation to the Discpac. As with solids, air and gas bubbles have mass. Therefore when they enter the pump, they travel to the point of highest velocity and lowest pressure **(Fig-7)** and do not make contact with the discs. They remain entrained and pass out of the pump.

Entrained air in water is difficult for centrifugal pumps. Studies indicate total pump failure at 7% air volume on closed impeller horizontal centrifugal pumps. With centrifugal pumping systems, air and gas bubbles accumulate in the eye of the impeller, the lowest pressure area of the pump. Over a period of time, which depends on the amount of gas entrained, the gas can starve the impeller to the point that it ceases to function, causing the pump to vapor-lock. **Fig-8** shows the collection areas for air and gas in conventional centrifugal pumps.

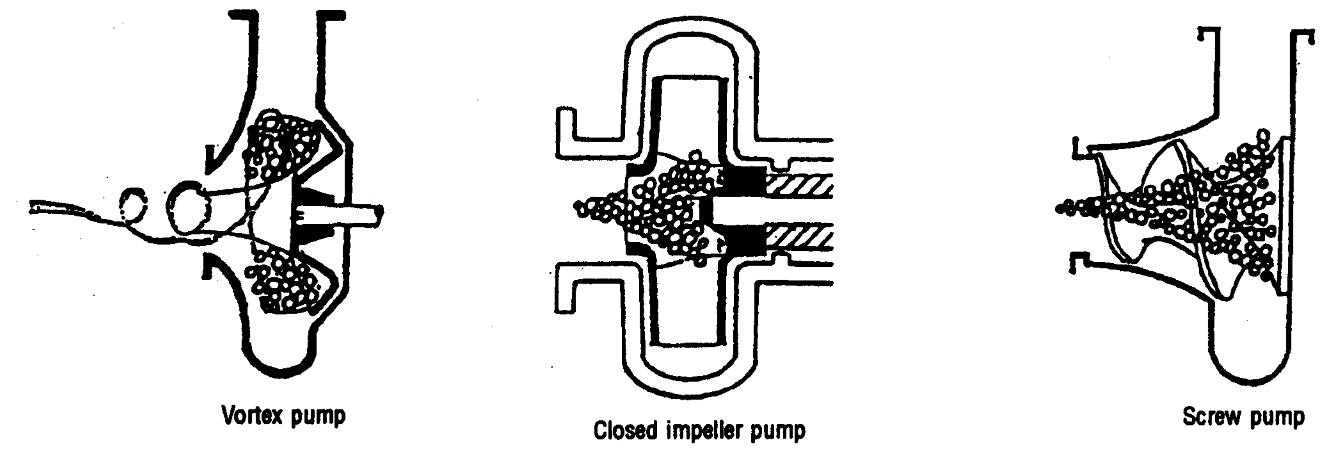


Fig 8. Diagrams showing the collection areas for air/gas in conventional centrifugal pumps

Delicate and shear sensitive fluids

Loss of product due to the pumping system is an expensive problem for many companies, whether they are processing shear sensitive paper coating chemicals or manufacturing paper stock. The non-impingement design of the disc pump has proven to be an effective solution to this problem. Product "moves itself" through the pump and the boundary layer formed on the disc surfaces protects the product from the moving parts of the pump.

Pump Operating Characteristics

Low NPSH requirement

The 'Net Positive Suction Head' available (NPSHa) is the most important element in the design of an effective pumping system. The Net Positive Suction Head available (NPSHa) is defined as the Total Suction Head in feet of liquid (absolute being measured from the pump centerline) less the absolute Vapor Pressure in feet of the liquid being pumped. The value must always be positive and can be calculated from the following equation.

For Positive Suction: $NPSHa = H_{st} + H_a - H_{vpa} - H_{fs}$

For Suction Lift: $NPSHa = -H_{st} + H_a - H_{vpa} - H_{fs}$

Fig-9 shows where measurements are taken for a normal pump installation and with a suction lift.

The other value to consider is the Net Positive Suction Value required (NPSHr), which is determined by the pump manufacturer. For the disc pump, it depends on several factors, including type of inlet to the Discpac, disc design, pump flow, operating speed, nature of liquid being pumped, etc. The NPSHr value can be defined as 'the reduction in total head as the liquid enters the pump'. This reduction in head takes place between the suction flange of the pump and the low pressure point, ie the eye of the discpac. Friction, turbulence and entrance losses prior to the pump all play key roles in determining the NPSH required. We know that for the disc pump, the more laminar the flow, the lower the NPSHr.

The available NPSH must be greater than the required NPSH for the pump (NPSHr) or serious problems can result. There may be a reduction in head and capacity accompanied by excessive noise and vibration. This phenomenon is caused by the vaporization of liquid prior to the low pressure area of the pump due to insufficient NPSHa, and then the implosion (or collapsing) of the vapor bubbles as they pass to regions of higher pressure. If the vapor bubbles collapse near an adjacent surface- such as the impeller vane in a centrifugal pump- it is subject to tremendous shock from the inrush of liquid into the cavity left by the bubble. This shock actually takes off a small bit of metal and the pump parts take on the appearance of having been badly corroded and sponge-like.

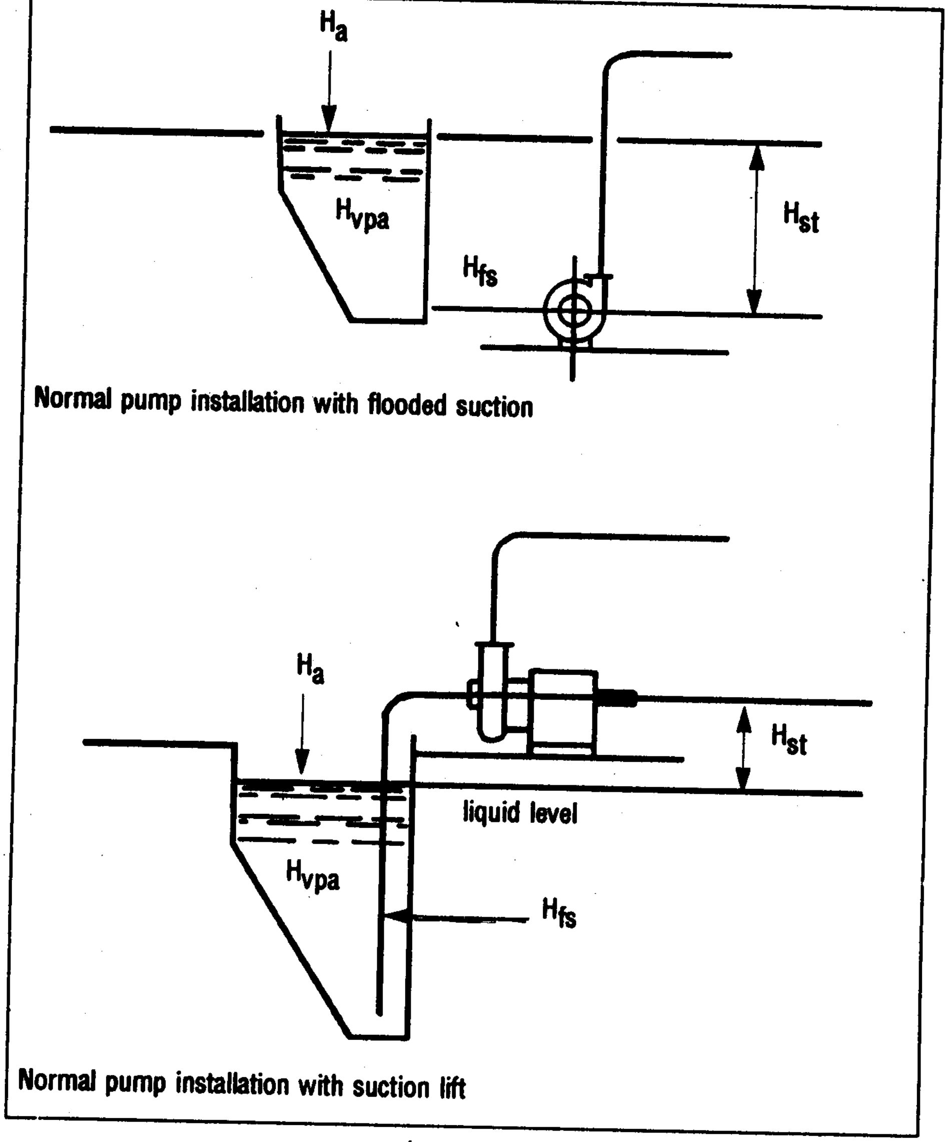


Fig 9. Measurements for NPSH for a normal pump installation with suction lift.

The energy expended in accelerating the liquid to high velocity in filling the void left by the bubble is a loss and causes the drop in capacity associated with cavitation. The loss in capacity is the result of pumping a mixture of vapor and liquid instead of just liquid. All conventional centrifugal pumps are subject to the negative effects of cavitation if there is insufficient NPSHa. Water at 70 deg F for example increases in volume about 54,000 times when vaporized and thus even a small amount of cavitation will reduce capacity.

As discussed earlier, the boundary layer-viscous drag principle produces a very smooth laminar flow pattern within the pump. This gives minimal pressure drop between the pump inlet and the eye of the pump, so that the resulting NPSH required by a disc pump is approximately half to a third that required by a standard NPSHr curve is stable right to shut off.

By observing the operation of transparent disc pumps, we can demonstrate that there is little to no pre-rotation in the suction end of the pump. The result is extremely low NPSH values. In addition, the layers of fluid near the discs in the disc pump act as a buffer or 'shock absorber' to protect the discs against the effects of cavitation and implosions. Even under low NPSH conditions, the disc pump suffers little wear.

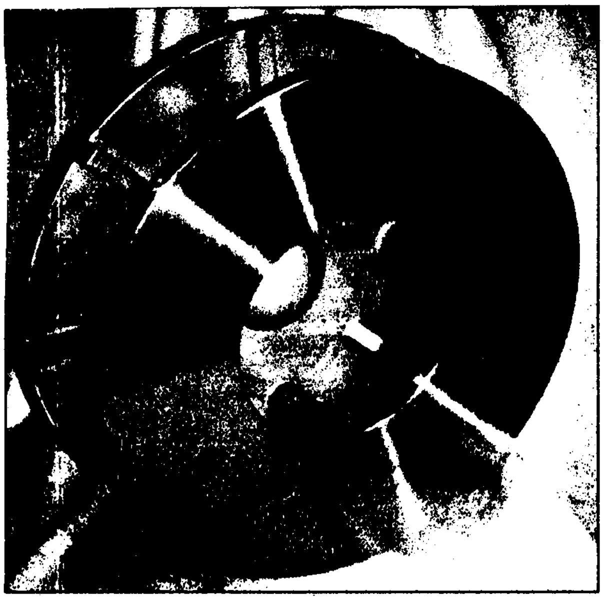


Fig 10. Photograph of the 'high head' disc assembly. The ribs increase friction and hence increase the pump's efficiency, without distrubing the laminar flow. In effect, they increase the thickness of the boundary layer, providing a thicker, more protective buffer between the fluid particles and the discs.

No close tolerances

Most pumps are engineered to close tolerances in order to operate at their optimum efficiency. As the pump suffers wear, however, its efficiency decreases and it required more frequent repairs to maintain an acceptable level of performance. This is particularly problematic when handling fluids containing solids that are (a) prone to settle out and (b) prone to jam in tight clearance areas. The disc pump is a no close tolerance design, which means that component wear has no effect on the pump's performance and operating efficiency. The concentric casing of the pump houses the Discpac with generous clearance in front, back and radially around the discs. Positive displacement and centrifugal style pumps require close tolerances to develop pressure.

Performance curves

There are two types of performance curve that characterize the disc pump. The first is a steep rising H-Q curve which applies to the original 'flat' Discpac design. The second is a flatter H-Q curve, which applies to the second generation, 'high head' design. We will look here only at the performance

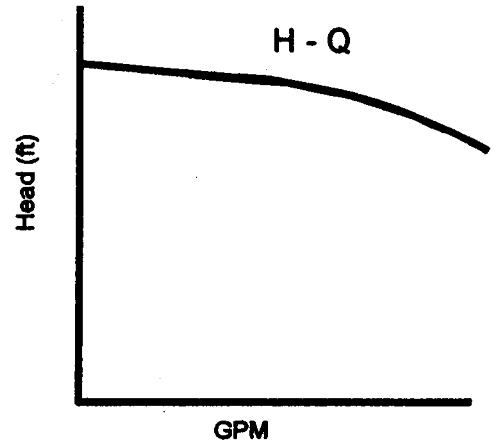


Fig 11. H-Q Curve for the 'high head' disc assembly design. Note that there is little change in head for changes in flow rate, making this design very useful in situations where the pump experiences large or rapid changes in flow conditions.

curve for the 'high head' model' as this is more widely used in pulp and paper industry applications.

The second generation Discpac, developed in 1988, uses a ribbed disc design **(Fig-10)** as an alternative to the smooth disc design. The ribbed or 'high head' discs have a number of straight radial or curved ribs on their inside (opposing) surfaces of a multiple disc configurations, with rib heights approximately 25% of the spacing between the discs. This design has been shown to produce significantly higher flow rates and discharge pressures than comparably sized plain disc designs, for qualifying applications, so the user can select a smaller pump and lower horsepower motor. The ribbed design can be compared to a corrugated pipe. The corrugations or ribs increase friction and hence increase efficiency, without disturbing the laminar flow. Another way to think of it is that the ribs effectively increase the thickness of the boundary layer, so not only does the 'non-impingement principle still apply but it is also reinforced by having a thicker, more protective buffer between the fluid particles and the discs.

The performance curve for the 'high head' disc pump **(Fig-11)** shows that the head varies only slightly with capacity from shut-off to design capacity. Therefore when wide fluctuations of capacity occur with nearly constant pressure requirements, this configuration is the better choice. It is recommended for the following hard-to-pump applications: shear sensitive materials; severely abrasive fluids; fluids with high volumes of entrained air/gas; and situations where the pump experiences large or rapid changes in flow conditions.

APPLICATIONS IN THE PULP AND PAPER INDUSTRY

Pumping Medium-to-High Density Stock

Medium to high density paper stock-ie, in the 7% to 18% range-is a notoriously difficult material to pump. It suffers from friction loss and resistance to flow at these densities; it can contain 20%+ entrained air; and the paper fibers are susceptible to damage (change in freeness). Recently, stock processors have turned to centrifugal-type pumps to handle stock in this density range, but with their need for dilution, fluidization and air removal equipment, these pumps are far from ideal. With the disc pump, as long as paper stock is able to enter the pump, it will operate efficiently. In fact, the higher the density, the higher the friction and the more efficient is the pump, exceeding the efficiency of the traditional centrifugal pumps by 30% or more.

(Stock densities higher than 18% have been handled with the disc system. In an application at the National Research Laboratory in Golden, CO, a disc pump is being used to pump a wood fiber slurry with a 25% cellulose content, without dilution. It has been operating since the Spring of 1995 and no problems have been reported. The pump uses a 3" discharge and a 8" suction connection).

Equally important, the disc pump does not require a fluidizer. In addition to causing fiber damage and therefore reducing paper freeness, fluidizers. put additional radial load onto the pump shaft which adversely affects the life of the seals and the bearings and can cause premature shaft breakage.

Also, the disc pump does not require a vacuum system or other type of air removal device. As discussed in the first part of this presentation, the pump is able to pass very high levels of entrained air. Once the paper stock passes through the discharge, 'plug flow' is attained and friction loss is reduced. With lower friction losses and the elimination of the control valve, the disc pump requires less horsepower than conventional medium density stock pumps.

Pulsation is also a problem with traditional stock pumps. In centrifugal pumps, it is caused by the vanes of the impeller passing the cut water inside the pump. This vibration is transmitted into the pipes in the discharge system, leading to high pipe maintenance costs. The operating principle of the disc pump, on the other hand, gives pulsation-free flow.

The lack of contact between the pump and the paper fibers and the smooth, uninterrupted flow through the pump ensure that maximum paper freeness is maintained. Independent trials conducted at the Pittsfield Research Center on a medium density newsprint/magazine pulp have confirmed that using the disc pump produces no change in freeness.

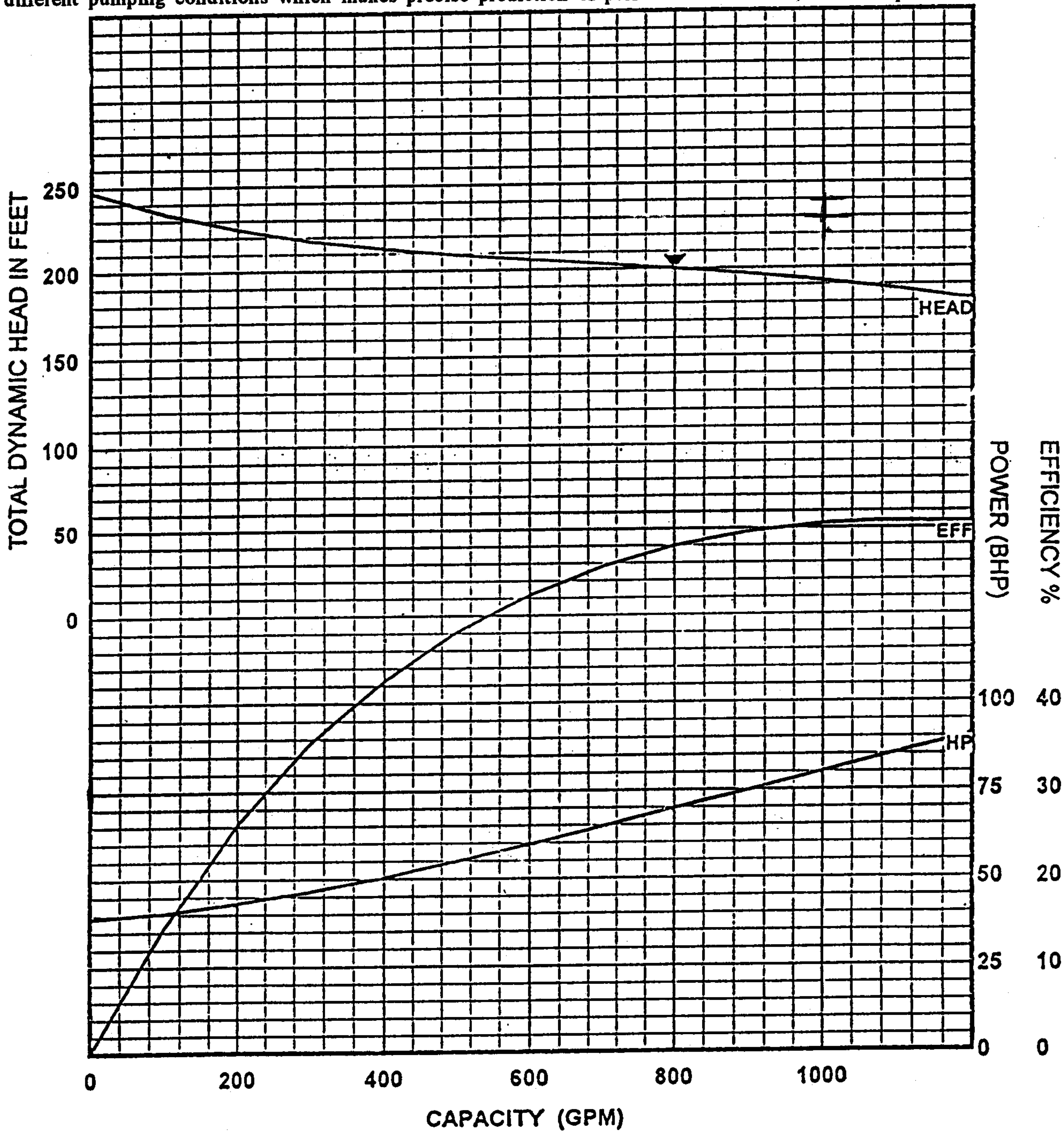
Before moving on to the case histories, it is worth mentioning that other pumps on the market claim to handle 18%+ paper stock. In most cases, however, they are diluting the stock prior to putting it through the pump and are therefore not pumping a true 18% density stock, but more like 8%-10% density. No dilution of stock is required with the disc system, even at 18% density. Injection water is only recommended for initial start up to ensure that the pump is full and in the event of bridging in the standpipe.

The advantages of being able to pump higher densities of stock are twofold-reduced water bills and lower storage costs. For example, a 10% density stock requires 33% more space to store than a 15% density stock. When you include the costs of acquiring space, building and maintaining additional storage vessels, as well as the extra water costs, the savings resulting from handling a higher density stock for a mill producing say 500-1000 tons/day are considerable.

A performance curve for the disc pump pumping a 15% density OD Bleached Kraft stock at 800 GPM is shown in **Fig 12.** A typical dropleg

Fig 12. Performance curve for the disc pump. The pump is handling a 15 % oven dried Bleached Kraft stock at 800 GPM, 200 ft head, with 10% air entrainment.

This performance curve is based on actual test data which has been adjusted to reflect a reasonable prediction of pump performance. Correction factors are based on field experience and actual test results pumping various materials of different viscosities and specific gravities. Please note that many materials are non-Newtonian in character, and that their properties vary in different pumping conditions which makes precise prediction of performance difficult, if not impossible.



DISCFLO MODEL MH 12064203 RPM 16.9" DISCPAC TRIM	
Pumpage: 15% OD BLEACHED KRAFT	
Solid:	
Solid Size: 0.00 in @ 15.0 % Concentration	Efficiency: 57.95%
Capacity: 800.0 GPM Head: 200.0 ft Temp: 120F	Design HP: 69.7 Max HP: 90.5
S.G.: 1.00 Visc.: 1.0 Cps Entrainment: 10.0% PH: 9.0	
Voltage: 460 Phase: 3 Hertz: 60	

configuration for medium-to-high density stock applications is illustrated in **Fig 13.**

Installation at Pope & Talbot (USA)

This major paper manufacturer has been using the disc pump system for the past 10 years to pump stock with a consistency from 8%-18% from the thickener to the storage area. The pump is operating at the rate of 300-350 ADST/day-with no dilution or vacuum system required. During this time, the pump has not needed repair and no spare parts have been purchased. The only maintenance required has been routine greasing of the bearings. The largest savings, though, have come from eliminating the need for stock dilution. The company has saved tens of thousands of dollars in storage and water costs as a result of moving over to the disc pump system.

Installation at a paper mill in Connecticut

A disc pump was installed at this paper mill in Connecticut in the Fall of 1995. It is being used to pump a 8% stock at a flow rate of 450 GPM. Prior to the disc pump, the mill used a vortex type pump. It could only handle 4.5% density stock and suffered breakdown about once or twice a week. Also, the previous pump could not cope with the entrained air in the pulp, which at times can be as much as 12%. Installing the disc pump has overcome the entrained air problem and allowed the mill to increase the percent stock to 8%, with savings resulting from the reduction in storage and water cots. The pump has run trouble-free over the last 22 months.

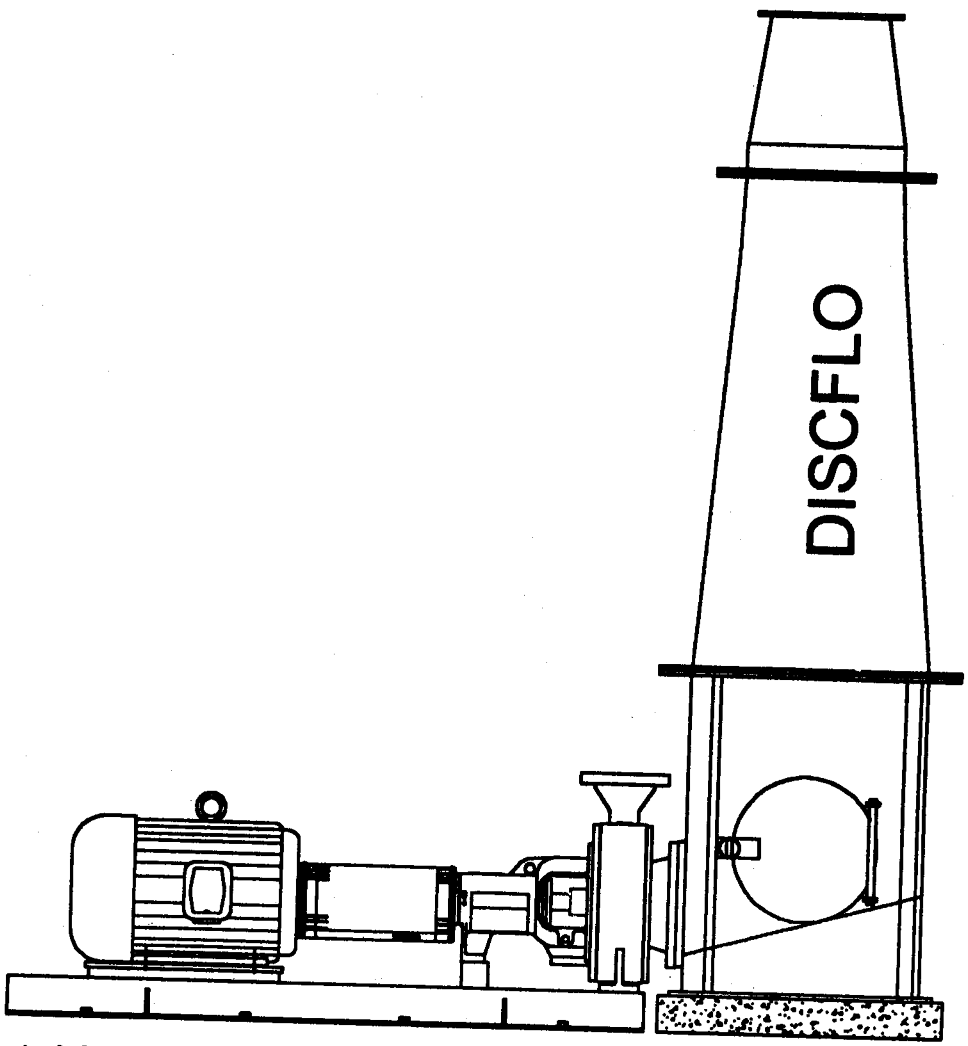


Fig 13. Typical dropleg configuration for the disc pump in medium-to high density stock applications.

Handling Paper Coatings

The coatings kitchen is a key application area for the disc pump technology. The pump's ability to handle both abrasive and shear sensitive fluids has led to significant cost savings compared to the systems previously installed. Applications to date include pumping: titanium dioxide (high solids content and abrasive); clay slurries (abrasive and shear sensitive); latex emulsions (shear sensitive); and cooked starch (viscous and entrained air).

Installation at Union Camp (USA)

At this paper mill in Virginia, disc pumps are being used in one area of the plant to pump cooked starch with a consistency of 4%-8% and in another area, to handle titanium dioxide. The abrasive and viscous nature of these products made pumping difficult. The company tried a number of different pumping systems-including centrifugal, progressive cavity, lobe and air diaphragm pumps-but could not solve the problem of breakdown. Comments the lead operator at the plant: 'We had to tear down pumps two or three times a week." In addition, a full-time shop employee was kept in the area to repair the pipe system, which suffers regular damage as a result of the vibration from the lobe pumps. The company then decided to try the disc pump, and installed five units in their coatings kitchen. After 18 months' continuous service, the pumps have had no downtime. Earlier this year, the company ordered an additional 22 disc pumps.

Installation at a major processor of kaolin clay slurries (USA)

A major processor of 50%-54% calcined kaolin clay slurries installed a disc pump for their product railcar loading station. The pump is delivering flow rates of approximately 525 GPM and consuming 50HP. The previous pumping system could only handle 350 GPM using 100HP, and experienced failure about every 9 to 12 months; the failure was due either to pump wear from abrasion or shaft breakage from the severely dilatant slurry locking down the pump impeller. The company installed 10 disc pumps in total and in four years, have had only one instance of downtime-which was due to premature bearing failure.

Installation at Stora, Skoghall division (Sweden)

The company is using the disc pump for paper coating applications at its existing facility and its new facility-a 320,000 ton/yr carton production plant considered to be Sweden's largest industrial investment of the 1990s. They replace progressive cavity pumps, which required constant maintenance in this abrasive and viscous service, and caused problems further down the line due to their pulsated flow. Stora reports it was spending twice as much on maintenance every year as the PC pumps originally cost. In the six months since installation, the disc pump has run with no downtime and no maintenance, and has solved the problem of pulsation.

Pumping chemical recovery slurries and waste sludge

These are some of the toughest pumping applications in the pulp and paper industry. The slurries from the chemical recovery process-eg green liquor dregs, black liquor, lime slurries- are highly abrasive, viscous, sometimes caustic and have a high solids content. These are the conditions where the disc pump's unique design is ideal and can produce substantial savings in both capital and running costs. The lack of close tolerances in the disc pump and the non- impingement operating principle reduce the incidence of breakdown and the need for frequent maintenance and repair. It has been estimated that in these severe service conditions, users can spend ten times or more the initial purchase cost on spare parts using a conventional pump. In numerous industry installations with the disc pump, it has been shown that the spare parts costs over the pump's lifetime amount to 10% or less of the purchase cost.

Installation at a paper mill in Arkansas

The clarifier sludge being pumped at this paper mill in Arkansas is 70% sand mixed with water and salt brine. The company previously used two self-priming centrifugal pumps in this application to move the 450 GPM of sludge from the cooling tower. These pumps broke down on average once every six weeks and suffered badly from wear due to the highly abrasive nature of the sludge and the high solids content. The plant manager estimated that he was spending around $21,000 PER year PER pump on spare parts. The company then installed a disc pump in April 1995 to replace the two centrifugal pumps. They have been running with zero downtime since start-up.

Installation at Metsa-Kaska (Finland)

In the 22 months since installation, a disc pump has been operating continuously pumping green liquor dregs at a plant in Finland with no downtime and no maintenance or spare parts required, other than routine preventative maintenance. The centrifugal pump it replaced lasted on average 2-3 months in this application. The company estimates a return on its investment for the disc pump of about 120 days.

Installation at Modo Iggesund (Sweden)

The company is using the disc pump system throughout its mill in Iggesund, northern Sweden. In the chemical recovery plant, one pump is being used for lime slurry (SG 1.45, temperature 85°C, pH 14), one pump for black liquor soap (200 cPs viscosity, 85°C) and one pump for lignin/white liquor (95°C and sometimes working under vacuum). A disc pump has also been installed at the waste treatment plant for handling coating waste with 5% dry content (fiber, clay, latex, chalk) and solid sizes up to 20mm. In all these applications, the company was previously having very high maintenance costs and high pump wear rates, as well as problems with unplanned downtime and pulsation. Since the disc pumps were installed in October 1994, Modo has not purchased any spare parts for these pumps, and has reported no maintenance and no downtime. They estimate that the savings amount to $10,000-$20,000 PER pump PER year, with return on investment between six and ten months. The company plans to purchase more disc pumps in the future for applications in lime milk, lime slurry and black liquor.

SUMMARY

'In the future, productivity will be substantially higher than today and less costly processes will be developed, improving capital efficiency and leading to enhanced financial performance"

The American Forest and Paper Association on Agenda 2020, Feb. 1997

Today's paper mill is under increasing pressure to increase process efficiency, productivity, reliability and cost effectiveness. You can achieve this, on the one hand, by preserving fiber strength and maximizing yield, and on the other, by reducing your operating and maintenance costs in all areas of the process.

The disc pump is a genuine breakthrough in pumping technology, and can help achieve both of these goals. The pulp and paper mills who have tried the pump in the notoriously difficult pumping applications have found this to be true. They are reaping the benefits in higher quality product and lower costs.

5.0 APPLICATION AREAS

Pulping operations

White liquor, extremely caustic

Stock and black liquor mixture

Washed and cleaned stock-up to 18%+ density

Chemical recovery

Heavy black liquor-1,00,000s cP

Weak black liquor-high solids

Weak liquor-abrasive, alkaline

Green liquor with dregs-very abrasive and high temperature

Green liquor-abrasive

White liquor and mud-caustic, alkaline and abrasive

White liquor-hot, caustic and abrasive

Lime slurry-abrasive and high solids

Power house operation

Ash slurries

Scrubber solutions

Lime slurries

Bleaching process

Paper stock-up to 18%+ density

Sodium hydroxide

Chlorine dioxide

Paper manufacturing

Slush pulp

Beater room pulp

Coating and filler clay slurries-very abrasive

White water, 0.5% consistency or less-can contain abrasive pigments and clays

Paper treating chemicals

- alum
- latex
- rosin
- wet strength resins
- starch

Paper converting

Clay slurries, clay slips

Emulsions

- PVDC & PVA
- latex
- silicone

Starch, raw and cooked

Casein or soy protein, raw and cooked

Wax, paraffin and microcrystalline

Inks, solvent and water-based

Effluent treatment

Sodium hydroxide solutions

lime slurries

Polymers, coagulant aids

Waste sludge

Knotter rejects

SUMMARY OF BENEFITS OF DISC PUMP IN HARD-TO-PUMP APPLICATIONS

- Pumping severely fluids with minimal pump wear.
- Handling fluids containing high volumes of entrained air or gas.
- Pumping very high viscosity slurries with no breakdown.
- Pumping product containing up to 70% solids with no breakdown.
- Handling stringy and fibrous materials without clogging.
- Pumping extremely shear sensitive products with no damage.
- Smooth, pulsation-free flow.
- Cutting high maintenance and spare parts costs.
- No close tolerance design, leading to high efficiency
- Longer pump life in severe service applications.

SUMMARY OF BENEFITS OF DISC PUMP IN PUMPING MEDIUM-TO-HIGH DENSITY STOCK

- Able to pump up to 18%+ density stock
- No dilution required
- No vacuum system required in most cases
- No control valve required
- No external fluidizer required
- No vibration or pulsation
- No fiber damage
- No change in paper freeness

FIGURE REFERENCES

Fig 1. Cross-section of a pipe exhibiting laminar flow conditions.

Fig 2. Cutaway diagram of the disc pump, showing the Discpac.

Fig 3. Principle of boundary layer-viscous drag creates velocity and pressure gradients across the width of the Discpac.

Fig 4. Diagram illustrating the flow of fluid through the disc pump.

Fig 5. Discpac velocity profile for fluid viscosities of 1 cP and 5000 cPs.

Fig 6. Graphs showing the erosion wear rate as a function of impingement angle for various substrates.

Fig 7. Disc pump design allows 80% entrained air to pass without vapor-locking.

Fig 8. Diagrams showing the collection areas for air/gas in conventional centrifugal pumps.

Fig 9. Measurements for NPSH for a normal pump installation with suction lift.

Fig 10. Diagram of the 'high head' Discpac design.

Fig 11. H-Q curve for the 'high head' Discpac design.

Fig 12. Performance curve for the disc pump pumping a 15% over dried Bleached Kraft stock at 800 GPM, 200 ft head, 10% air entrainment.

Fig 13. Typical dropleg configuration for the disc pump in medium-to-high density stock use.