Energy Efficient Medium Consistency Equipment for Pulp Mill Applications

Vesala Reijo & Kumar Mukesh*

ABSTRACT

In Pulp & Paper Industry, pumping of the stock is an area which has vast potential of saving the energy. The development of Centrifugal MC Pumping Technology opened up new possibilities of the stock transfer and process development when it was for the first time successfully tested at mill scale in 1977 to 1978, Since then there have been many advancements and MC* Pumping Development has now introduced 3rd generation MC* Pumping System Products with larger capacity ranges, higher pump heads, higher pumping consistencies and lower energy consumption.*

MC Technology is a proven way of saving energy by way of pumping the stock a higher consistency which a normal Centrifugal Pump can not handle. MC* Pumping Technology has also found a wide range of_other pumping applications.*

This paper explains the concept of Medium Consistency Operations and discuses the advancements in MC Technology.*

MC* PUMP-THE KEY IN THE PUMPING AND TRANSFER OF MEDIUM CONSISTENCY (MC*) STOCK

INTRODUCTION

The centrifugal MC* Pumping opened entirely new possibilities for stock transfer and process development when it was for the first time successfully tested in mill scale in 1977 to 1978. The first commercial fluidizing centrifugal MC* Pump with degassing strarted in a chemical pulp bleaching application in 1980. Figure-1 shows a typical MC* Pumping application in a modern bleaching line.

Fig. - 1 MC* Pumping application in a modern bleaching line.

During the past ten years, MC* Pumping development has introduced the second generation pumping system products with larger capacity ranges, Higher pump heads, higher pumping consistencies, lower energy consumption (Fig-2), and in addition to that a wise range of different new or modernized MC* Pumping process applications has been developed.

Ahlstrom Pumps Corporation
-Karhula, Finland
*** Ahlstrom Pumps Pte. Ltd.**
Office 7, M.G. Bhawan
Flat No. 204-206, Local Shopping Centre
Madangir Road
New Delhi-110 062

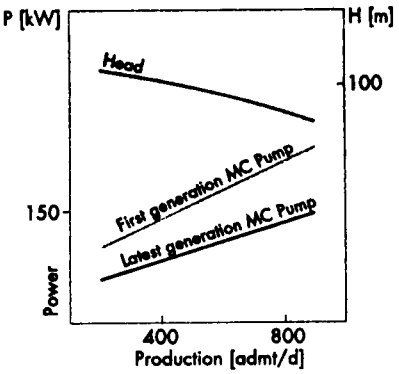

Fig.-2 Power consumption savings

Besides MC* Pumping, there is a number of other process equipment and solutions where the principles of MC* Technology have been applied. Research about flow behaviour of different pulp types has also been remarkable. Even though the majority of the applications of MC* Technology can be found in the chemical pulping processes, there are several interesting solutions of MC* Technology for paper mills and the stock preparation closely integrated to the paper mill (mechanical and recycled pulps).

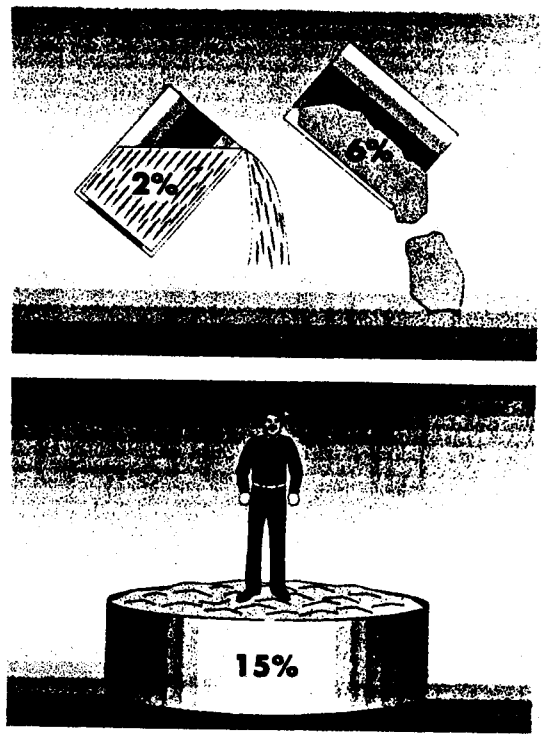

Fig.-3 Effect of stock consistency on flow characteristics

Fluidization, i.e. disintegrating the fiber network in the stock, is the solution in the pumping of medium consistency stock

Even at low consistencies, stock fibers establish a relatively stable fiber network (Fig.-3), which is disintegrated by the rotor of the pump as it rotates. The stock hence becomes fluidized and its flow characteristics resemble those of water. This way, the stock can be pumped reliably at a consistency of over 8% (Fig.-4), and even a consistecny of 18% has been reached with the centrifugal pumping method.

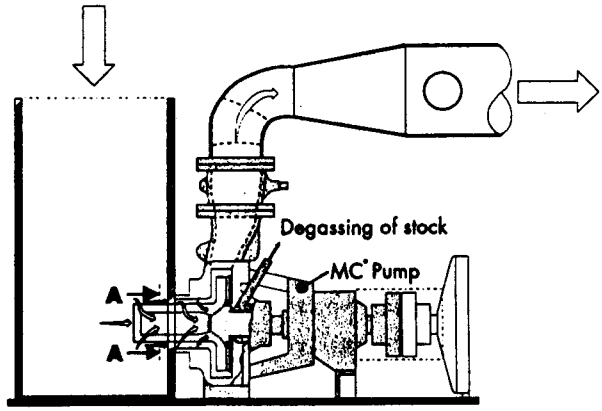

Fig.-4 MC* Pump arrangement for the 8 to 18% consistency range

Stock often contain a large amount of air

The higher the stock consistency, the more it can contain air or gas (Fig.-5) which disturbs not only pumping but also reliable operation of the entire process. In the MC* Pump, this air or gas is separated

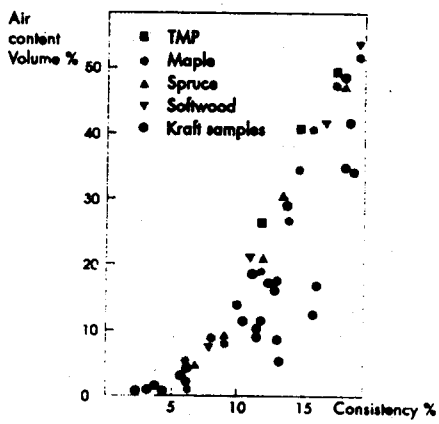

Fig.-5 Air content in the stock

and then removed by creating a certain pressure difference between the inlet side and the degassing chamber of the pump. This is achieved either by a sufficient inlet pressure or by means of a separate or built-in vacuum pump. Pump degassing arrangement is in many cased the most critical factor of pumping and process performance.

MCA and MCV Pumps as alternative designs

Ahlstrom manufactures two parallel MC® Pump series: MCA and MCV. These guarantee that the ideal pump is available for the prevailing pumping conditions, also giving optimum reliability and interchangeability with existing pumps. The MCA Pump (Fig.-6) is provided with a separate, external MDS Degassing System. The MCV Pump (Fig.-7) features a built-in degassing system. Bothtypes incorporate the same benefits of the Ahlstrom second generation centrifugal MC® Pumps. The MCA/MCV

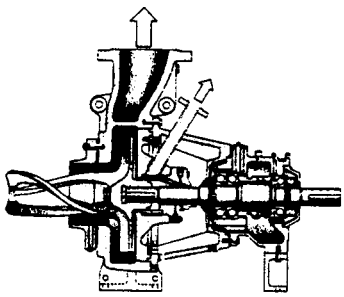

Fig.-6 MCA medium consistency MC® Pump

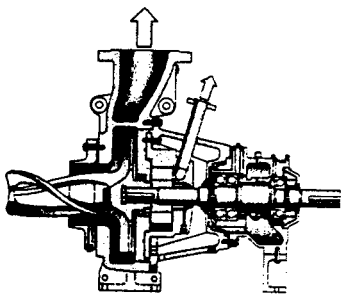

Fig.-7 MCV medium consistency MC® Pump

Pump series covers capacity ranges up to 3000 ADMT/D and pump heads up to 170 meters. Stainless steel material alternatives for these pumps are austenitic cast steels like CG-8M or duplex steels like A-890 Grades 3A and 5A. Titanium and 654MO can also be selected as the material for the wetted parts of the pump.

MC® PUMPING APPLICATIONS

Pumping from a washer or from a blow tank

The most common application of MC® Pumping is to pump stock from washers and thickeners or after a bleaching reactor (Fig.-8). The stock falls into the MDL Dropleg or into the blow tank and is then transferred to the subsequent process stage by the MCA/MCV Pump.

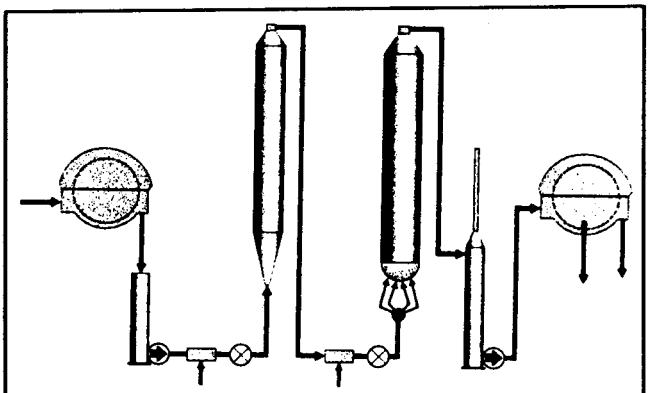

Fig.-8 Pumping systems in a pressurized bleaching stage.

The MC® Pumping system consists of the following key components: MDL Dropleg or a blow tank as a pumping vessel, MCA Pump and MDS Degassing System, or alternatively MDL Dropleg and MCV Pump with built-in degassing system (Fig.-9).

MC® Pumping is controlled so that all the stock falling into the Dropleg can be pumped further at the highest possible consistency (Fig.-10); a pumping consistency of 18% has been reached as a continuous process condition in a mill scale peroxide bleaching stage. The pulp level in the MDL Dropleg is measured by means of a gamma ray, capacitive measurement or pressure transmitter. The flow rate through the pump can be adjusted, depending on the circumstances, by means of a control valve, by changing the speed of the pump, or by applying a combination of these two methods (Fig.-11) the level controller keeps the stock level in the Dropleg constant, not allowing the level to drop nor allowing the level to enter the previous equipment such as the washer; this provides stable operation in the process. The separate or built-in degassing system adapts itself to the respective

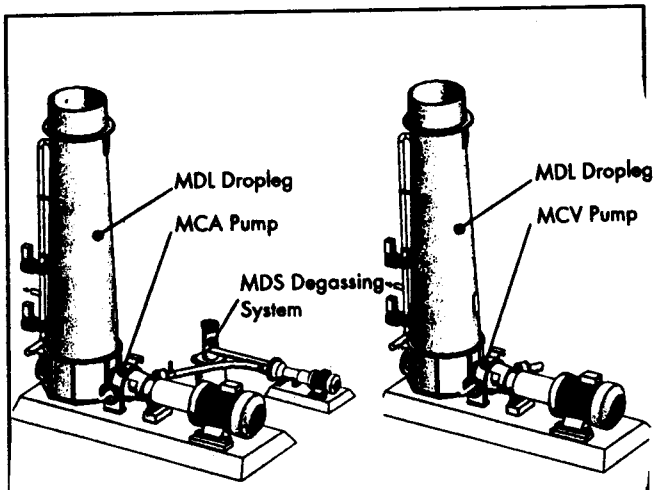

Fig.-9 Pumping system components in Dropleg pumping system.

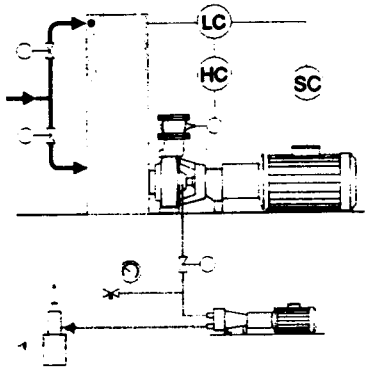

Fig.-10 Control system in MC* Dropleg installation

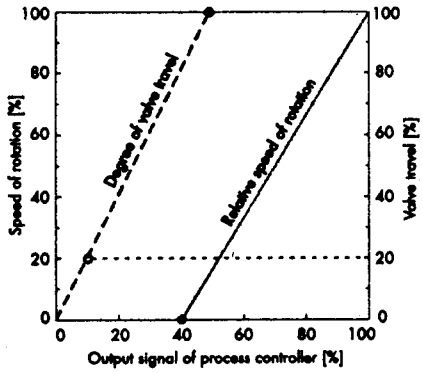

Fig.-11 Combined valve and speed control system

volume of air contained in the stock and to the flow rate used. If great consistency variations occur in the incoming stock, resulting from factors such as consistency disturbance caused by the thickener or washer, the automatic water connections will stabilize pumping.

Flow splitting after discharge from the MC Pump

The Flow Splitter, a "static" flow distributor, is used to divide the stock flow from the MC* Pump to two or three different directions.

The Flow Splitter is fixed directly to the discharge flange of the MC* Pump (Fig.-12).

The Flow Splitter has a welded, specially-shaped sturdy construction, and the standard materials are SS2343 stainless steel, 254SMO or titanium depending on the process requirements. This application is often used in pulp mill processes when creating an option to bypass a bleaching stage and when one Pump is feeding two washers (Fig.-13) or two or three storage towers. This paralled pipeline idea is typically advisable from the point of layout and costs, if the washers or towers are not located far from the pumping system.

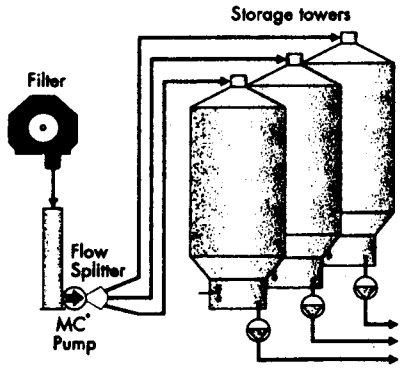

Fig.- 12 MC* Flow Splitter feeding storage towers

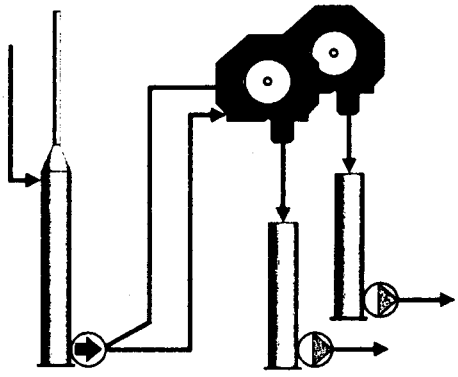

Fig.-13 MC* Flow Splitter feeding two washers.

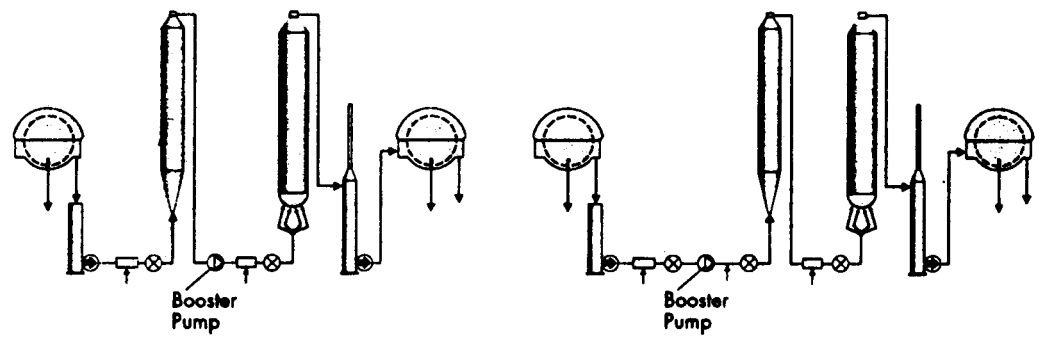

Fig.-14 MC* Booster Pumps for feeding pressurized bleaching reactors.

Booster Pumping to feed pressurized bleaching reactors

In the modern pressurized bleaching stages (oxygen delignification and PO stages), it is necessary to create very high pulp line pressures with the MC* Pump feeding the stage so that the required process pressures can be achieved in the reactors. In these process applications, steam is fed and mixed into the pulp suspension to reach the process temperature, and chemicals such as oxygen are also fed and mixed into the pulp in the pressurized pipeline.

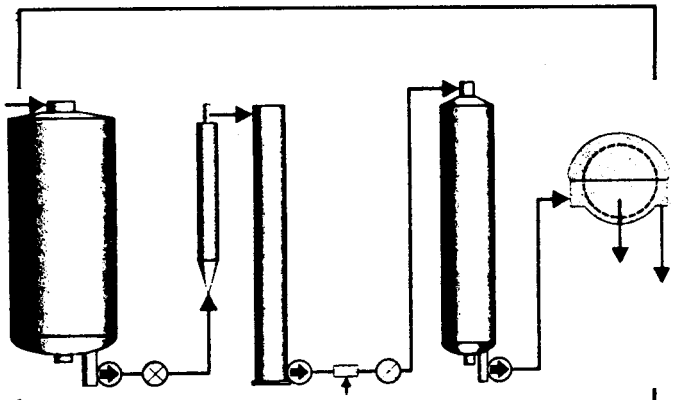

Fig.- 15 Typical tower discharge MC* Pumping systems

It is possible that the head requirement of the MC* Pump results in so high pulp line pressures that the available steam or oxygen pressures are not high enough to enable steam/oxygen feed and control. In these cases it is necessary to find a way to reduce the pulp line pressure in locations where steam and chemicals are fed. The solution is to install another MC* Pump, a booster pump, to the line and thus divide the head generation between two MC* Pumps. The advisable location of the booster MC* Pump depends on the detailed process data and on the mill arrangements (Fig.-14).

Tower discharge pumping

The discharge of large high consistency storage or bleaching towers often involves difficulties, especially when a well-controlled pulp flow to bleaching or to the washer is required (Fig.-15).

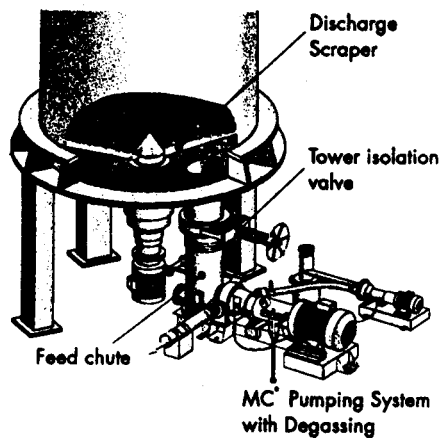

Fig.-16 Pumping system components in a tower discharge pumping system.

The MC* Tower Discharge Pumping System consists of the following key components: Discharge Scraper, MTB feed chute, tower isolation valve, MCA Pump and MDS degassing System (Fig.-16).

The Discharge Scraper manufactured by Ahlstrom operates in connection with a medium consistency tower discharge pump. The Scraper scrapes the stock over the complete bottom area of the tower and lead it into the feeding chute of the MCA Pump, thus enabling an even discharge and simultaneously

preventing channeling of the stock in the tower.

The Discharge Scraper also stabilized the pumping procedure. The Discharge Scraper is available with or without a possibility for dilution. The diluting scraper simultaneously dilutes the stock uniformly and discharges the tower without interference. When using diluting scrapers, the consistency of the stock in the tower can be high (20 to 25%) and the pumping consistency is then within the MC range.

MC® Discharge Scrapers are manufactured in different sizes up to a diameter of 6500 mm. Each scraper size is available with or without the possibility for dilution. The smallest scraper sizes with a planetary gear are suspended from the tower bottom while the bigger sizes are provided with a spur gear which is fixed to the floor under the tower (Fig.-17). These constructions do not require any separate additional bearing units.

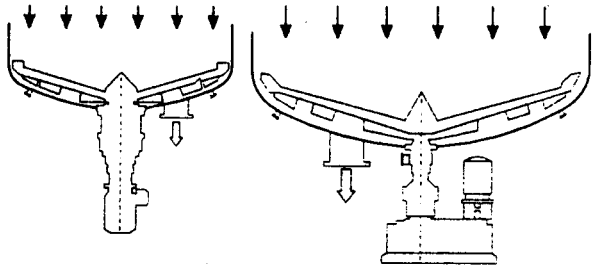

Fig.-17 MC® Discharge Scraper Constructions

The MC® Discharge Scraper material alternatives are SS2343 stainless steel or 254SMO.

The MC® Tower Discharge Pumping System can have different control strategies:

- The flow controlled (FC) controls the flow rate of the MC® Pump by the valve (Fig.-18), variable speed of the pump,or by a combination of these methods.
- The level controller keeps the level in the tower constant by using the above valve and/or pump speed for control or,
- Flow control and level control are used at the same time so that the flow rate is kept constant and the flow rate set point is changed only if the level in the tower tends to change beyond the level set points.

Gas/air is removed by having a degassing system in combination with the MC® Pump (Fig.-18). Pulp can be diluted to the process consistency with the tower bottom water connections, with a diluting Discharge Scraper, and also in the MTB feed chute (Fig.-18).

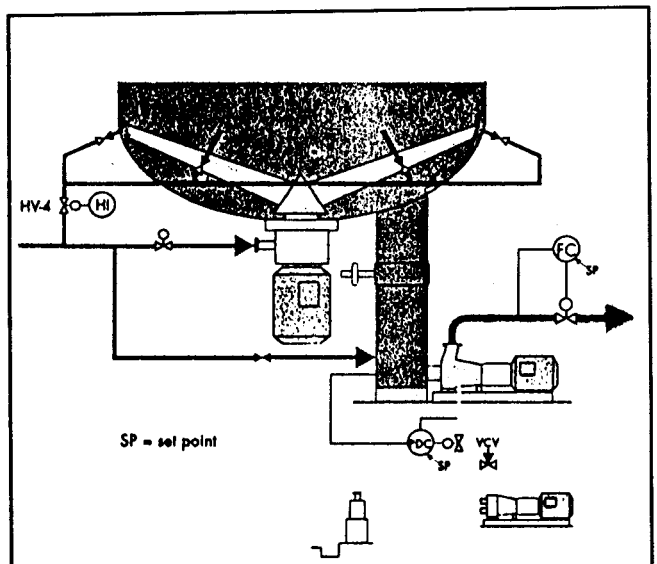

Fig.-18 Control system in MC® Tower Discharge Installation

Booster pumping in long distance stock transfer applications

In an integrated pulp and paper mill, the distance between the pulp mill and the paper mills is often in the range of 300 to 400 meters. Stock is generally pumped in a diluted form, but an MC® Pump enables pumping at a consistency of for example 10 to 12%. Medium consistency stock enters the dropleg of the MC® Pump e.g. from the filter. The MC® Pump, which is provided with degassing and rotates at a fixed or variable speed, pumps the stock to a booster pump of the same size whereno degassing is required.

The booster pump which is provided with variable speed control pumps the stock to storage tower (Fig.-20)

Pumping and controlled flow splitting to storage towers or to intermediate mixing chests with an MC® Pump and a Flow Discharger

It is often necessary to transfer bleached pulp

Fig.-19 MC* Tower Discharge pumping system.

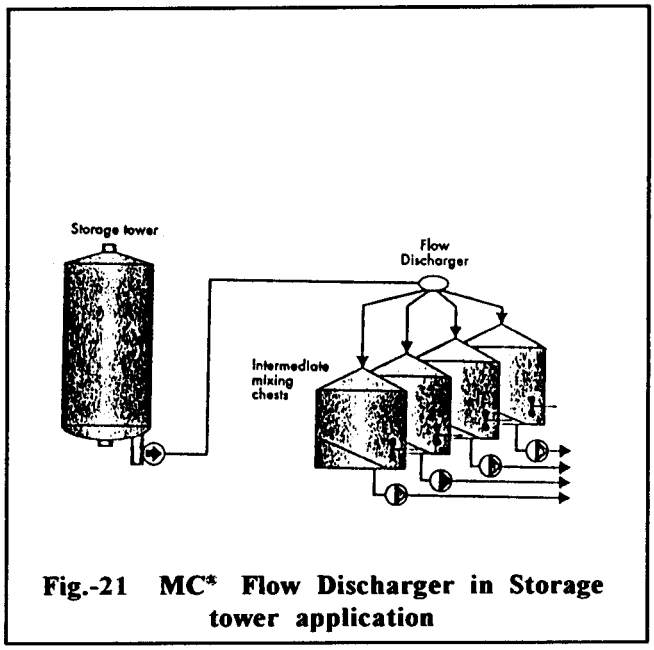

Fig.-21 MC* Flow Discharger in Storage tower application

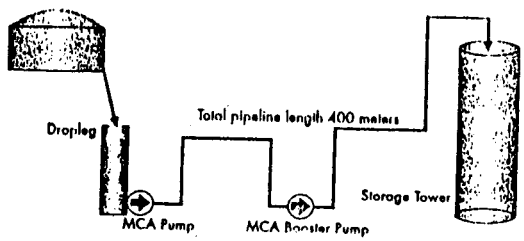

Fig.-20 MC* Booster Pumping process application

from the pulp mill to several storage towers which are all located relatively far (50 to 400 meters) from the bleached pulp washer and thus also far from the corresponding MC* Pump (Fig.21). This application is carried out so that there is only one discharge pipeline from the MC Pump to the area of storage towers, and the flow is then divided at the end of the pipeline to several flows directed to the towers.

The same type of application is useful also closer to the paper machines when the stock has to be distributed into several intermediate mixing chests. The storage tower to feed the tanks is equipped with MC* discharge. The Flow Discharger is used to split the flow in equal proportions to the intermediate mixing chests (Fig.22).

A plug flow is generated in the pipe when pumping medium consistency (8 to 16%) stock and the fiber network holds the plug together. Dividing this kind of flow to precisely controlled partial flows at the end of a pipeline is not possible with a valve only; an MC* Flow Discharger is used in this application to fluidize the pulp and to divide and control the partial flows to the towers. The MC* Flow Discharger operates so that the stock entering the chamber of the Discharger is fluidized by a rotor, and the outlet connections are constructed directly to this same chamber. Depending on the application,

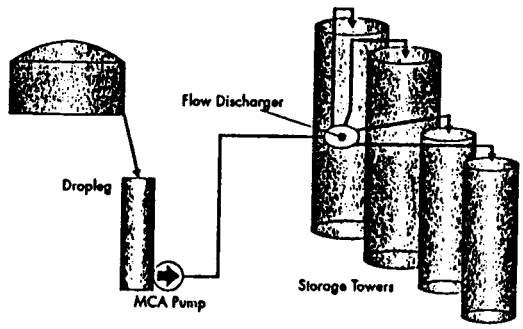

Fig.-22 MC* Flow Discharger feeding a number of intermediate mixing chests

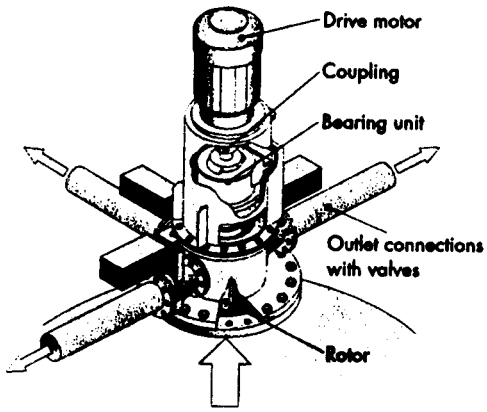

Fig.-23 MC* Flow Discharger vertical installation

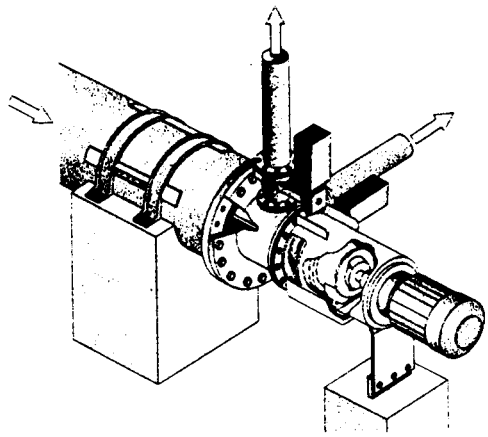

Fig.-24 MC* Flow Discharger horizontal installation

up to four outlet connections are available in one Flow Discharger, all connections with control or on/off valves (Fig. 23). The Flow Discharger itself does not generate pressure, so an MC* Pump is required in the process to pump the stock through the Discharger.

The design of the MC* Flow Discharger is shown in Fig. 23. The Flow Discharger can be installed either vertically (Fig. 23). horizontally (Fig.24) or in any other desired position depending on the application.

The Flow Discharger sizes cover capacity ranges up to 3000 ADMT/D, and SS2343 stainless steel, 254 SMO or titanium can be selected as the material for the wetted parts

Parallel pumping of stock from the conical section of a storage tower

This application enables the simultaneous pumping of stock from two locations in the storage

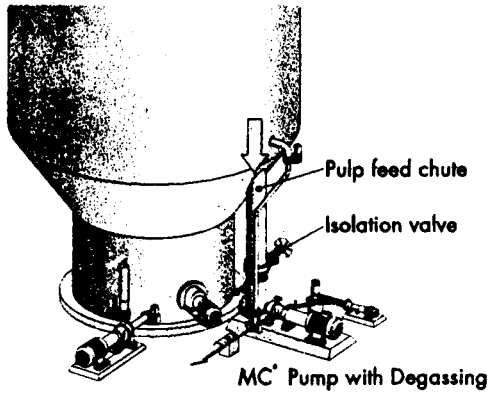

Fig.-25 MC* Parallel Pumping System arrangement

tower. From the conical section of the tower, the stock is transferred into the feeding chute and pumped by the MCA Pump at medium consistency to the following stage in the process. At the same time, stock is being diluted through the lower section of the storage tower and pumped further to the desired location at low consistency. White water from the paper machine can be individually used for diluting and e.g. two paper machines can be fed from one common storage tower. The pumping system arrangement is shown in Fig. 25 and a typical process application in Fig. 26.

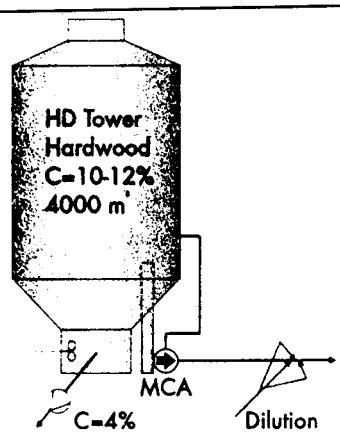

Fig.-26 MC* Parallel Pumping System Process application

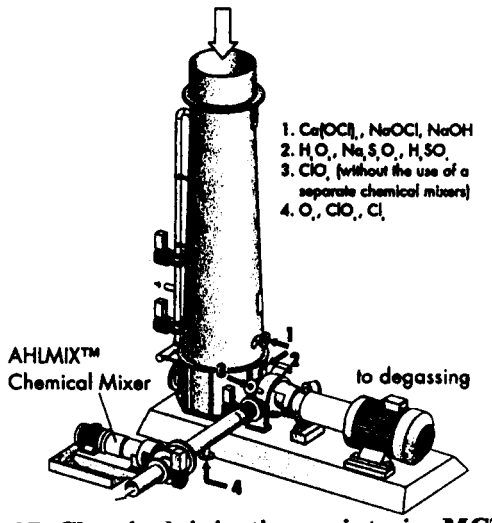

Fig.-27 Chemical injection points in MC® Pumping and Mixing system

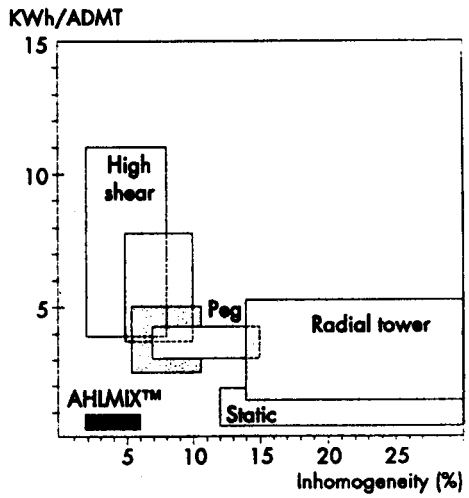

Fig.-29 Mixing efficiency and energy consumption of different types of chemical mixers.

MIXING OF CHEMICALS AND STEAM

INTRODUCTION

Mixing chemicals and stock is one of the most important operation is in stock bleaching. Good mixing provides homogenous bleaching conditions, reduces the consumption of chemicals and energy, improves product quality, and reduces the environmental load. Mixing is a key factor in the success of new bleaching sequences. The stock is fluidized in the MC® Pump as the fiber network is disintegrated and also the gas is separated. This allows the efficient mixing of various liquid chemicals already in the pump. Most of these chemical can be feed a low pressure to the suction side of the pump. All gaseous chemicals and steams are mixed with a separate AHLMIX Chemical Mixer. The chemical injection points are shown in Fig. 27.

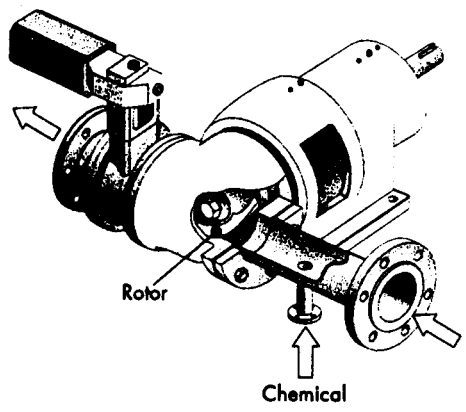

Fig.-28 AHLMIX™ Chemical Mixer

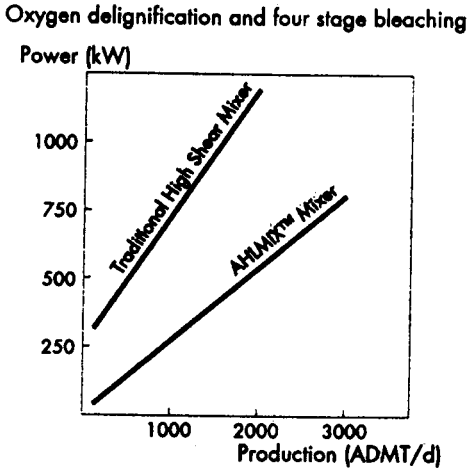

Fig.-30 Installed power in typical pulp mill mixing applications.

Each chemical and steam has its own features and special detailed selection and dimensioning guidelines which need to be followed when injecting the chemical to the pipeline.

MIXING OF CHEMICALS WITH THE AHLMIX™ CHEMICAL MIXER

AHLMIX™ is a medium consistency chemical

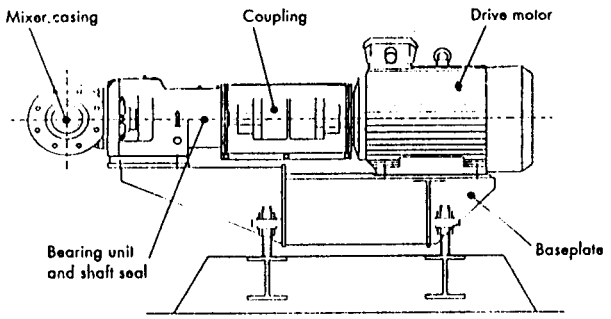

Fig.-31 AHLMIX™ Chemical Mixer design

mixer designed for mixing both gaseous and liquid bleaching chemicals into paper stock. The rotor of the mixer fludizes the stock together with the casing turbulence generators, thus disrupting the fiber network and resulting in the optimum mixing result. Perpendicular positioning of the rotor (Fig. 28) and the unique three dimensional turbulence zone prevent the separation of gas. An inhomogeneity of 5 to 10% is normally considered acceptable; and AHLMIX™ Chemical Mixer reaches and inhomogeneity value of as low as 3 to 6%. The good mixing efficiency and the low power consumption are shown in Fig. 29. Fig 30 shows a comparison example of the installed power of different types of mixers in chemical mixing. The design of AHLMIX™ is shown in Fig. 31.

General AHLMIX™ design features are:

- Perpendicular rotor positioning
- Small pressure drop (0 to 4 meters)
- Small size of the Mixer and valves and thus small space requirement, light weight and easy installation and maintenance.
- Direct drives
- Stopped mixer passes stock flow

The AHLMIX™ Chemical Mixer is used for a consistency range of 3 to 20% and the product sizes cover capacity ranges up to 3000 ADMT/D. AHLMIX™

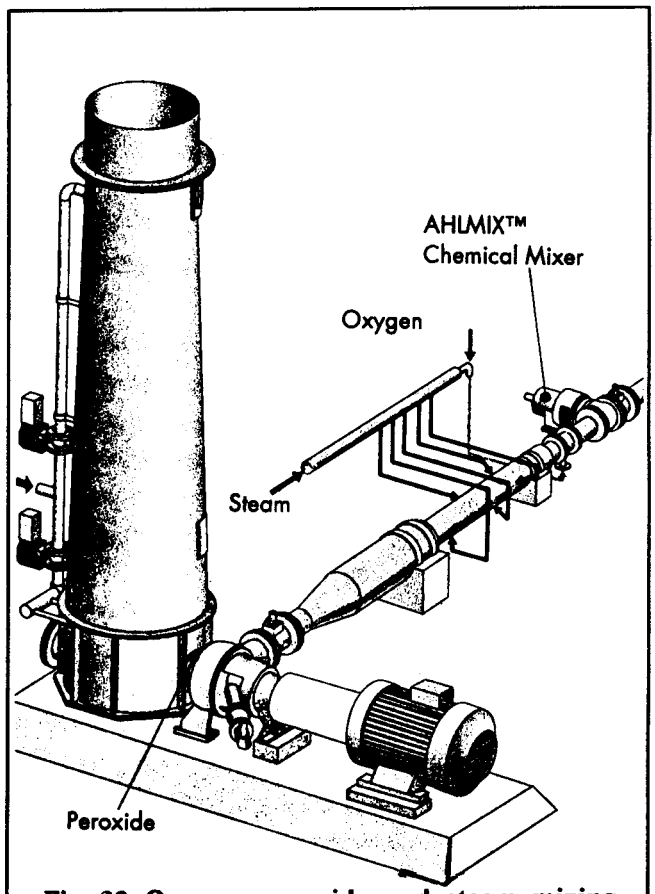

Fig.-32 Oxygen, peroxide and steam mixing.

is manufactured from stainless steel, titanium, Hastelloy or 654SMO depending on the chemical mixed and on the bleaching stage arrangement.

OXYGEN AND STEAM MIXING WITH THE AHLMIX™ CHEMICAL MIXER

In the oxygen delignification stages, oxygen and steam are introduced simultaneously into the steam injection pipe following the MC® Pump. No additional flow control or instrumentation is needed in the stock line. Oxygen can also be injected into the stock through a separate oxygen feeder.

In the AHLMIX™ Chemical Mixer, oxygen and steam are mixed efficiently into the stock (Fig. 32).

A temperature increase of even more than 25°C has been reached by the AHLMIX™ Chemical Mixer. Steam consumption is lower due to the closed and pressurized high consistency system. Disturbances and vibrations are eliminated by the correct dimensioning and piping arrangement and by even and smooth

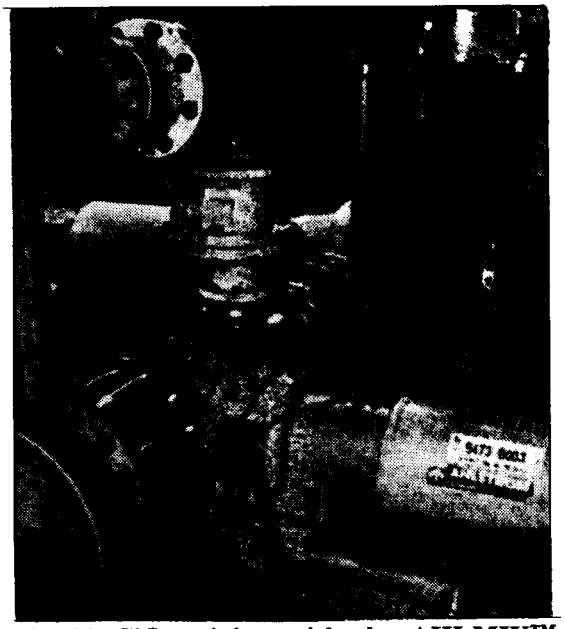

Fig.-33 ClO_2 mixing with the AHLMIX™ Chemical Mixer.

steam injection. The optimum flow control and mixing result are achieved with the AHLMIX™ FS Mixer, with no pressure drop over the Mixer.

Thus the power consumption of the mixing assembly is low, because no extra pump head needs to be generated to pass the stock through the mixer.

PEROXIDE AND PERACETIC ACID MIXING

These chemicals are injected a a low feed pressure to the inlet side of the MC Pump, to a location where air has already been removed from the stock. This way, the chemical reacts efficiently with stock and a good mixing result is achieved. In the PO and EOP stages, steam and oxygen are mixed with the AHLMIX™ Chemical Mixer.

CHLORINE DIOXIDE AND CHLORINE MIXING

When mixing ClO_2 into the stock, a separate AHLMIX™ Chemical Mixer is recommended (Fig.27). In this case the MC® Pump in the stage in question is manufactured from stainless steel. If it is necessary

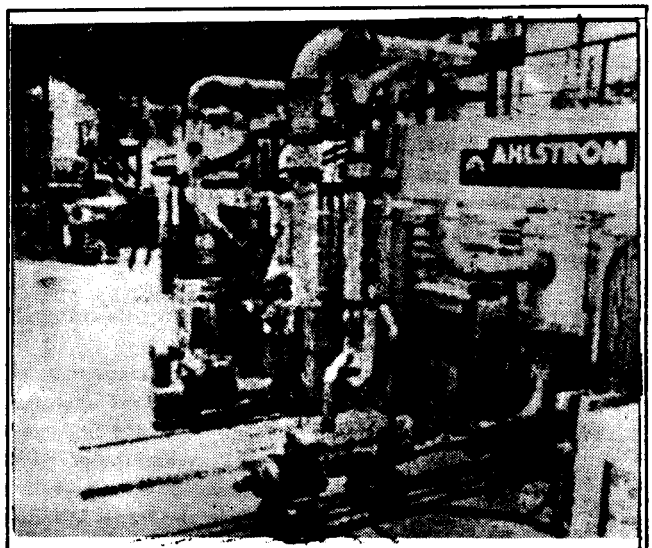

Fig.-34 MC® equipment testing in the R&D Center.

to mix ClO_2 into the stock already in the MC® Pump, the pump needs to be made from titanium. This being the case, ClO_2 is introduced directly into the pump casing, to the high pressure zone.

At the chlorination stage, when mixing both gas (Cl_2) and liquid (ClO_2), one or two AHLMIX™ Chemical Mixers are used,. The compact AHLMIX™ Chemical Mixers can be installed in series, at intervals which create appropriate retention times.

RESEARCH AND DEVELOPMENT

Research and development receive top priority at Ahlstrom Pumps Corporation. As a result, Ahlstrom has today more than 30 patented inventions and a growing number of pending applications relating to MC® Pumping, tansfer and mixing. At the full scale R&D Center, the equipment is tested under process conditions.

Our own foundry and deep metallurgical know-how are also remarkable strengths in developing equipment for these aplications where special corrosion and wear resistance is often required.

Ahlstrom's experience and commitment to the pulp and paper industry have made it a leader in stock pumping, transfer and mixing technology.