Medium-consistency MC pumping, chemical mixing, and tower management systems in the newest pulp mills

Jussi Heinonen, Product Manager MC Equipment
Reijo Vesala, Head of Business Segment, Pulp, Paper, and Board
Janne Tamminen, Pump Performance Expert Sulzer Pumps Finland Oy

INTRODUCTION:

Pumping of liquids with a high dry solids content and mixing of bleaching chemicals are matters of great importance for the pulp and paper industry. The proven MCE pumps from Sulzer achieve a previously unattained level of performance when it comes to the capacity range, temperature, and pressure of the pumped medium. They cover a wide range of different pumping system applications for new lines and upgrades of old lines.

Mixing chemicals and stock is one of the most important operations in stock bleaching. Good mixing provides homogenous bleaching conditions, reduces the consumption of chemicals and energy, improves product quality, and reduces the environmental load. The manufacture of pulp and paper entails the pumping and mixing of stock and other suspensions in numerous process stages as well as through many reactors and towers. Sulzer supplies medium-consistency MC pumps, SX chemical mixers, MC discharge scrapers for towers and big reactors, MC dischargers, and SALOMIX tower management systems (TMS) with agitators. They represent the most important stock transfer process equipment in modern oxygen delignification and bleaching processes.

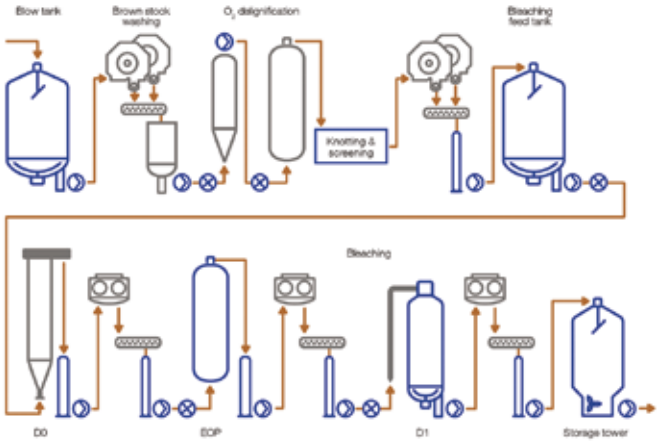

Figure 1: A typical O_2 delignification and bleaching process in a chemical pulp mill. Sulzer produces equipment that fulfills all pumping and mixing requirements and enhances process efficiency by facilitating stable and reliable operation through reactors and towers.

Developments over time

The first commercial fluidizing centrifugal medium-consistency MC pump with degassing started in a chemical pulp bleaching application in 1980. The first-generation MC pumps were brought into the market in the 1980's, followed by the second generation in the early 1990's. The innovative third-generation MCE pumps are now running in several pulp and paper mills around the world, and in most of the high-capacity, single-line bleaching processes.

The highest capacities for the MC pumps can be up to 10'000 air dry metric tons per day (admt/d). Over the years, Sulzer has introduced several improvements to the MC pumping system products, such as larger capacity ranges, higher pump heads, higher pumping consistencies and lower energy consumption.

MC pumping and chemical mixing systems are the most important stock transfer equipment in the modern oxygen delignification and bleaching processes in recycled fiber and mechanical pulp lines. Besides MC pumps, there is a great number of other process equipment and solutions where the principles of MC technology have been applied. These include the SX chemical mixers for mixing both gaseous and liquid bleaching chemicals and steam into the pulp,

the MC discharge scraper for discharging high-consistency towers, and the fluidizing MC discharger for effective flow splitting and up-flow tower feed and discharge. Efficient 'in- line' dilution systems for diluting MC pulp with the static DM dilution mixer into lower consistency enable an improvement of the existing applications.

Innovative Sulzer MCE pump series – a new level of MC performance with MCE pumps

A new level of MC performance over a wide consistency, temperature and pressure range is provided by the unique Fluider™ impeller, comprising effective multifunctional turbulence generation, gas separation, pumping hydraulics, and degassing combined with a wide passage gas removal system of high capacity. These guarantee that the ideal high-performance MC pump is available for the prevailing pumping conditions and applications, offering optimum reliability and interchangeability with the existing earlier- generation MC pumps.

The MCE pump is provided with a separate external MDS degassing system or with a built-in degassing system. The new technology also makes it possible to arrange several MC pumping applications without installing any degassing pumps and without additional components, extra controls, or drive motors. Sulzer uses the Fluider™ technology and specially designed impellers for pumps developed for intermediate (SEMI-MC) and medium-consistency (MC) applications. The Fluider™ technology uses twisted fluidizer

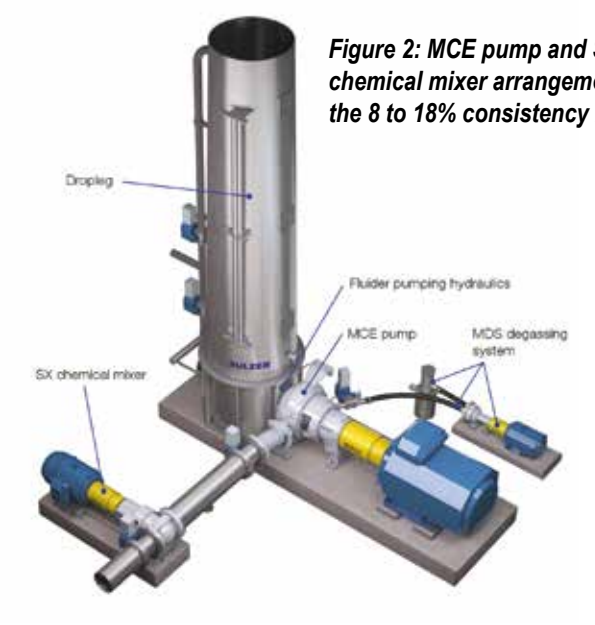

Figure 2: MCE pump and SX chemical mixer arrangement for the 8 to 18% consistency range.

blades with changing pitch that enable excellent pulp fluidizing, degassing, and pumping results in the demanding pulp and paper mill processes.

Pumping systems with Fluider™ technology are mostly used after washers, thickeners, filters, and reaction towers to pump the stock to the next process stage or to a washer. The MC pumping systems can also make sure that bleaching liquid or process chemicals are mixed into the stock efficiently. The main advantages of this technology include high levels of efficiency – thus reducing power consumption – and its ability to maintain an exact turbulence level, which prevents the over-treatment of the fiber. Another distinct feature of the Fluider™ impeller is its ability to work efficiently irrespective of the stock level in the dropleg. The MDL dropleg is a barrel-like tank at the low-pressure side of the pump that ensures proper inflow conditions for the MC pump.

The MCE pump series covers capacity ranges of 10 to 10'000 admt/d and pump heads up to 240 meters. Material alternatives for these pumps are duplex steels like A-890 grades 3A and 5A. 654SMO or titanium can be selected as the best corrosion-resistant material for the wetted parts of the MC pump.

Problem solving with TMS tower management system

Do you have problems related to storage towers? Is the retention time of your storage tower insufficient? Do you suspect that your tower is channeling? Do you suffer from occasional unexplained consistency variations? Do you have problems with air or bacteria in the pulp? Do you want to run a big storage tower with a high production rate, and you need small discharge consistency variations? Do you need a high-consistency storage tower with low- consistency discharge? Do you have problems related to pulp quality? Are you running a storage tower with a low pulp level and want to save energy in pumping?

If your answer is yes to any of the above questions, then Sulzer's TMS tower management system could help your process.

Sulzer TMS tower management system

Sulzer's TMS tower management system controls all pumping and mixing requirements in tower process applications and is based on proven and innovative solutions and products.

The TMS tower management system is designed to improve the performance of any kind of tower, regardless of inlet or storage consistency, shape, or size. The system can be utilized with straight towers, such as high-consistency bleaching and storage towers, reduced bottom medium-consistency storage towers, blow tanks, low-consistency broke towers, and more.

TMS tower management system in chemical pulp mills

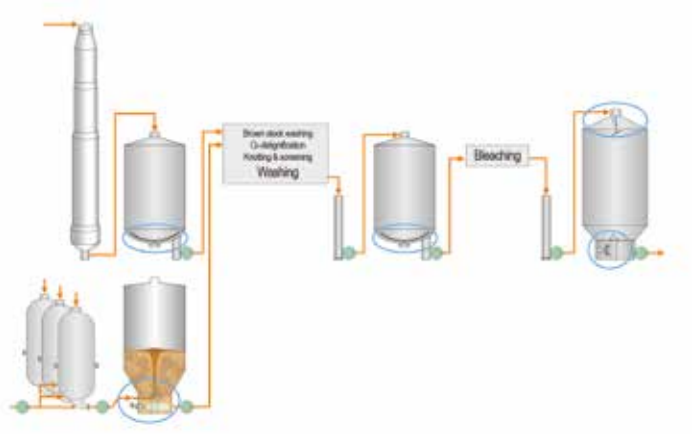

Figure 3: Sulzer MC discharge scrapers, MC pumping systems, TES, GLI, VULCA, and SALOMIX™ agitators in a chemical pulp mill process.

TMS tower management system in mechanical pulp mills

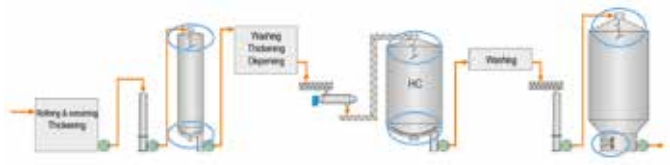

Figure 4: Sulzer MC pumping systems and process pumps, MC discharge scrapers, TES, GLI, and SALOMIX™ agitators in a mechanical pulp line.

TMS tower management system in paper mills

Figure 5: Bleaching.

TMS tower management system in paper mills

Figure 6: Sulzer TES, SALOMIX™ agitators and process pumps in paper mills.

MCE pumping application examples

High production rate single-line pulp transfer

The new MC pumping performance (up to 10'000 admt/d) makes it possible to create high production rate bleaching sequences without parallel pumping and chemical mixing arrangements. Another very interesting possibility is to retrofit the existing MC pumps of earlier generations to improve process economy and increase production rate. Thanks to the high-efficiency MCE retrofit and MCA/MCV hydrofit products, this is possible with minor constructional changes. Often neither piping nor drive unit changes are needed.

High-temperature high-consistency pumping from a low- level pumping vessel

The most common application of MC pumping is to pump stock from washers and thickeners. The stock falls into the MDL dropleg and is then transferred to the subsequent process stage by the MCE pump. MC pumping is controlled so that all the pulp falling into the MDL dropleg can be pumped further at the highest possible consistency and temperature.

High temperatures, e.g. +95-98°C, can now be pumped at a consistency of 12-16% from a low-level pumping vessel with the new MCE pump innovation. This is a significant process cost saving (as chemical and steam costs) and layout advantage for example in the oxygen delignification, EOP (alkali, oxygen, and peroxide) and PO (peroxide and oxygen) stages.

Figure 7: MCE pumps with innovative Fluider™ technology.

The stock level in the MDL dropleg is measured by means of radiometric, capacitive or pressure transmitter measurement. The flow rate through the MC pump can be adjusted – depending on the circumstances – by a control valve, by changing the speed of the pump, or by applying a combination of these two methods. The level controller keeps the stock level in the MDL dropleg constant, neither allowing it to drop nor to enter the previous equipment such as the washer and maintains stable operation in the process. The separate or built-in degassing system adapts itself to the respective volume of air contained in the stock and to the flow rate used. If great consistency variations occur in the incoming stock, caused by a disturbance at the thickener or washer, the control system with automatic dilution will stabilize the MC pumping.

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. Chemicals such as oxygen are also fed and mixed into the stock in the pressurized pipeline.

It is possible that the head requirement of the MC pump results in such a high stock line pressure 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 stock line pressure where steam and chemicals are fed. The solution is to install another MC pump, a booster pump, in the stock line and this way 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.

Figure 8: Typical MC pumping arrangements. The stock level in the MDL dropleg is measured and controlled, thus providing constant operating conditions for the pump.

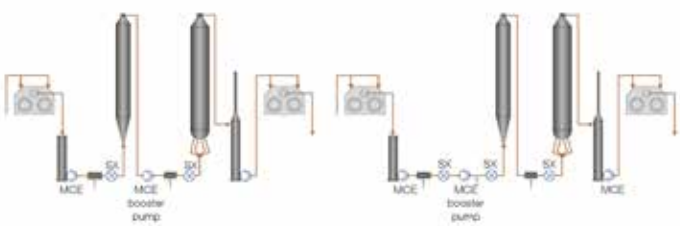

Figure 9: MC booster pumps for feeding pressurized bleaching reactors.

Booster pumping in long-distance pulp transfer applications

In an integrated pulp and paper mill, the distance between the pulp mill and the paper mill is often in the range of 300 to 400 meters. Pulp is generally pumped in a diluted form, but the MC pump enables pumping at a consistency of 10 to 12%. Medium-consistency stock enters the MDL drop leg of the MCE pump from the filter. The MCE pump, which is provided with degassing and rotates at a fixed or

variable speed, pumps the stock to a booster MC pump of the same size, which requires no degassing. The booster MC pump, which is provided with variable speed control, pumps the pulp to a storage tower.

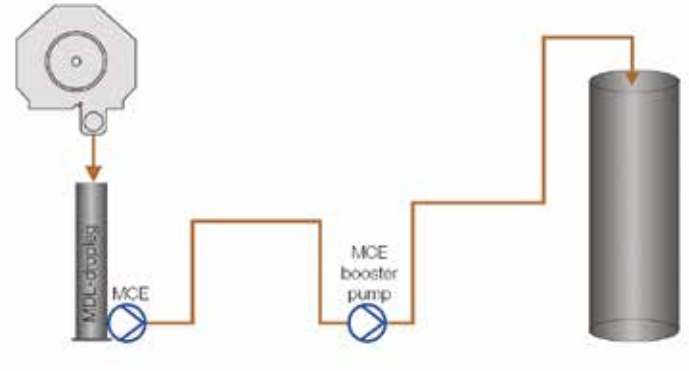

Figure 10: MC pumping system in long transfer line into MC storage tower.

Tower discharge pumping

The discharge of large high-consistency storage or bleaching towers is often difficult, especially when a well- controlled pulp flow to a bleaching stage or to the washer is required. The MC tower discharge pumping system consists of the following key components: MC discharge scraper, MTB feed chute, tower isolation valve, MCE pump and MDS degassing system. The MC discharge scraper manufactured by Sulzer operates in connection with a medium-consistency tower discharge MCE pump. The MC discharge scraper scrapes the pulp over the complete bottom area of the tower and leads it into the MTB feed chute of the MCE pump, thus enabling an even discharge and simultaneously preventing channeling of the stock in the tower.

The MC discharge scraper also stabilizes the pumping procedure. It is available as a diluting or non-diluting model. The diluting MC discharge scraper simultaneously dilutes the pulp uniformly and discharges the tower without interference. When using diluting MC discharge scrapers, the consistency of the pulp in the tower can be high (e.g. 20 to 35%), and the pumping consistency is then within the MC range. Pulp can also be diluted to the process consistency with the tower bottom water connections, with a diluting MC discharge scraper or in the MTB feed chute.

MC discharge scrapers are manufactured in different sizes up to a diameter of 6'500 mm. Each size is available with or without the possibility for dilution. The smallest MC discharge scraper sizes with a planetary gear are suspended from the tower bottom, while the bigger sizes are provided with a spur gear fixed to the floor under the tower. These constructions do not require any separate bearing units. The MC discharge scraper material alternatives are EN 1.4404 stainless steel or 254SMO.

Figure 12: Stock flow splitting with MCE pump and flow divider into three storage towers.

Figure 11: MC tower discharge pumping system.

MC pumping and controlled flow splitting to storage towers or to intermediate mixing chests with an MCE pump and an MC discharger

It is often necessary to transfer bleached pulp from the pulp mill to several storage towers, which are all located relatively far (50 to 400 meters) from the bleached pulp washer and, therefore, also far from the corresponding MCE pump. This application is carried out so that there is only one discharge pipeline from the MCE pump to the area of the storage towers. At the end of the pipeline, the flow is divided into several flows that are directed to the different towers.

The same type of application is also useful near the paper machines, when the stock must be distributed into several intermediate mixing chests. MC pump feeds the chests through the MC discharger. The MC discharger is used to split the flow in equal or in wished proportions to the intermediate mixing chests. A plug flow is generated in the pipe when pumping medium-consistency (8 to 16%) pulp, and the fiber network holds the plug together. Dividing this kind of a flow to precisely controlled partial flows at the end of a pipeline is not possible with a valve only, but an MC discharger is used in this application to fluidize the stock and to divide and control the partial flows to the towers or mixing chests.

The MC discharger operates so that the pulp entering the chamber is fluidized by a rotor, and the outlet flanges are directly connected to the same chamber. Depending on the application, up to four outlet connections are available in one MC discharger, all of them with control or on/off valves. The MC discharger itself does not generate pressure, so an MC pump is required to pump the pulp through it. The MC discharger can be installed either vertically or horizontally or in any other desired position, depending on the application. The MC discharger can also be used in the bleaching reactor feed and discharge applications.

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

This application allows the simultaneous pumping of pulp from the storage tower to two or more locations. From the conical section of the tower, the pulp is transferred into the feed chute and pumped by the MCE pump at medium consistency to the following stage in the process. At the same time, pulp 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 segregated and two or more paper machines can be fed from one common storage tower.

Examples of problems in storage towers

When a storage tower is charged through the roof in the conventional way, channeling can easily occur with stagnant areas developing in the storage zone. The active storage capacity of the tower is, therefore, reduced. Furthermore, severe uncontrollable consistency variations can result from lumps of high-consistency stock working loose from the stagnant zone and falling into the agitation zone. In addition, air is entrained into the stock in the conventional charging method.

In certain towers in pulp and paper mills, only some of the storage capacity is utilized. The broke tower is a typical example, with the broke being dropped down to the bottom. Additionally, a stagnant zone develops in the areas around the fast-flowing zone in the middle. Air is entrained into the stock.

Figure 13: MC parallel pumping system arrangement..

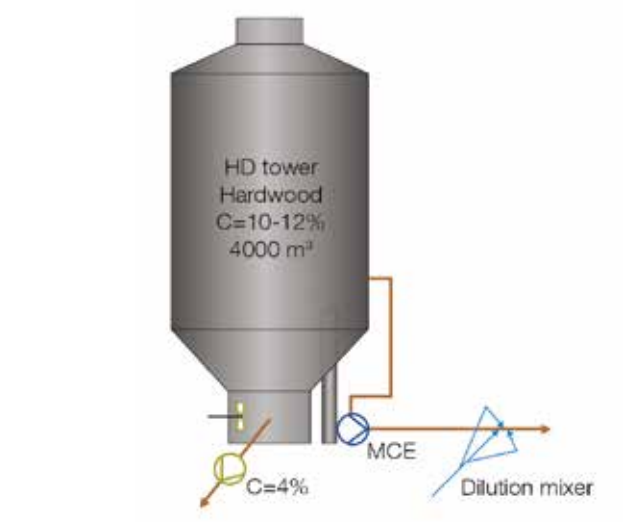

Figure 14: MC parallel pumping process application.

Solutions to your storage tower problems

SALOMIX® TES top entry spreader

TES spreads stock evenly on the top surface to control the flow in the upper medium-consistency or high-consistency part of the tower. The quality of the discharged stock remains good.

TES solves problems with retention time

A mill had problems with a 2'000 m3 storage tower, the upper diameter of which is 12 meters, and the bottom diameter 6.5 meter. The theoretical retention time of the tower is approximately 4 hours with a full stock level. The actual retention time before the installation of TES was less than 2 hours. Test run results show clearly how TES helps the tower to operate with the correct retention time:

Tower level	89%	59%
Measured average retention time	4 h 10 min	2 h 10 min
Theoretical retention time	4 h 24 min	2 h 16 min

TES solves problems with entrained air

A mill had problems with the air content of pulp in its storage tower. Before TES was installed, the air content was fluctuating badly and averaging 6% (blue curve in the figure). After the installation of TES, the air content decreased to 2% and the variation was markedly reduced, as shown by the red curve.

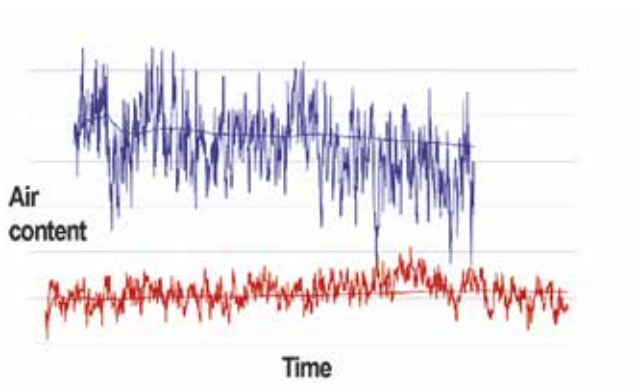

Figure 15: Air content fluctuation by the tower discharge pump before and after the installation of top entry spreader.

SALOMIX® GLI

GLI is a special center fillet located at the bottom of the storage tower. GLI enables the trouble-free operation of medium-consistency and high-consistency storage and bleaching towers with a large bottom zone using several agitators.

GLI benefits

GLI with dilution baffles is used to create a well-controlled mixing/dilution zone at the bottom of the tower.

GLI effectively separates the tower's storage zone from the active mixing and dilution zone, thus providing a powerful tool for ensuring an even discharge consistency and good operation of the tower. More than 100 MC and HC storage towers around the world are operating with the help of GLI.

SALOMIX® VULCA

VULCA is another type of center fillet pillar that is also located at the tower bottom. The filling and pumping of stock are carried out through VULCA.

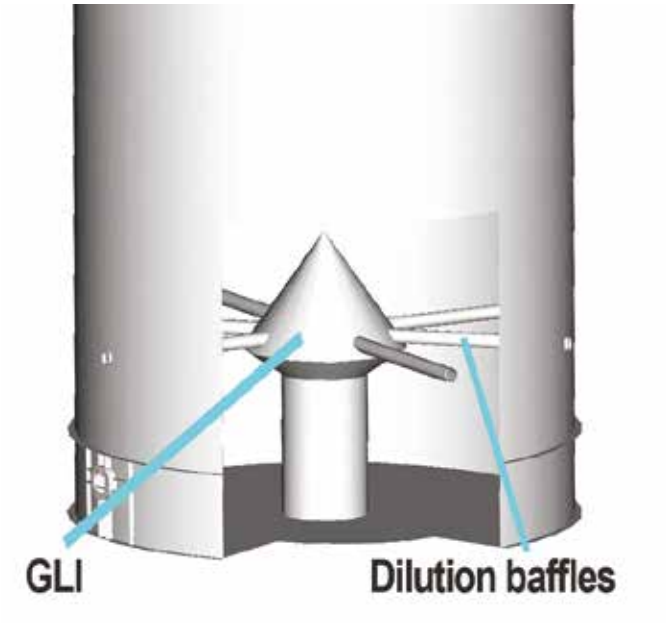

Figure 16: GLI special center fillet.

Customer case: VULCA increases pulp production and reduces air

Feedback from a mill indicates that by using VULCA in one line only, significant savings were achieved. For example, the discharge time of the digesters has been reduced from 35-40 minutes to 25 minutes, while digester production has increased by 4%. At the same time, the amount of dilution liquor was reduced from 100 m3 to 50 m3 for each blow, agitation power reduced from 330 kW to 165 kW, and the air content was lowered from 10-15% to 5-8%.

VULCA benefits:

Saves pumping energy.

Boosts bottom zone mixing.

Prevents the mixing of air into the stock at low stock levels.

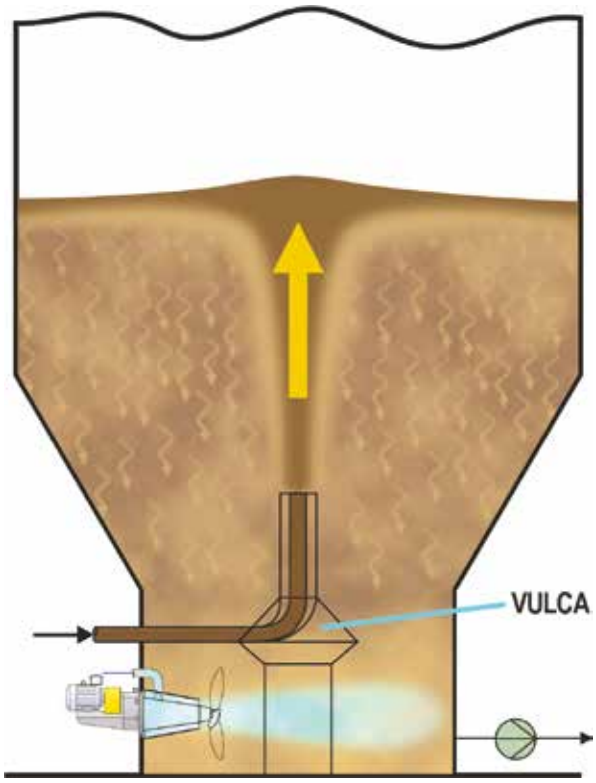

Figure 17: VULCA center fillet pillar.

Process upgrade examples

MCE / MCEV retrofits and MCA / MCV hydrofits for process upgrades

MCE / MCEV retrofit and MCA / MCV hydrofit for the same high 3rd generation MCE performance have also been used for capacity and process upgrades. The installation of an MCE retrofit (new exchange unit with efficient Fluider™ impeller, casing cover, bearing unit adapter, shaft seal and vacuum pump parts for internal degassing in the MCEV models) in existing first-generation MC pumps have made easy process upgrades possible.

The same improvement can be achieved through the installation of an MCA / MCV hydrofit (new MCE pump casing and more efficient Fluider™ impeller and O-rings and gaskets) in existing second-generation MCA / MCV pumps.

These result in improved process economy and increased production rate. The retrofits are possible with only minor mechanical modifications to the bare pump, often requiring no piping or drive changes. References are available in many countries including Brazil, Canada, Finland, France, Indonesia, Japan, Spain, Sweden, South Africa, and the United States.

Figure 18: MCE retrofit application in a bleaching line.

MCE / MCEV retrofit and MCA / MCV hydrofit performance improvements and benefits

MCE / MCEV retrofit and MCA / MCV hydrofit performance improvements offer many benefits to the customer:

- Higher production rates with the same existing basic MC pumping system.
- Cost savings because there is no need to change to a bigger MC pump size.
- Higher pump efficiency and remarkable energy savings are possible.
- Higher pumping heads provide possibilities for process upgrades, e.g. increased bleaching efficiency with higher pumping consistencies and higher reactor pressures.
- Remarkable chemical and steam savings when running the MC equipment with higher consistency.
- Lower operation costs because less dilution water is needed.
- Increased storage tower capacity with higher storage consistency.
- Possibility to eliminate belt or gear drive units that require a lot of maintenance.
- Extended lifetime of equipment and drive units is possible.

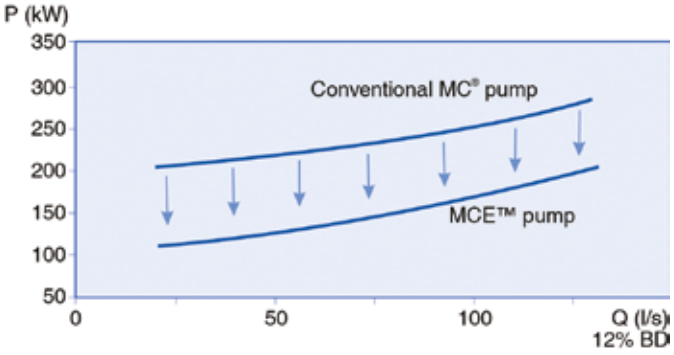

Figure 19: Remarkable power consumption savings with the same pumping head.

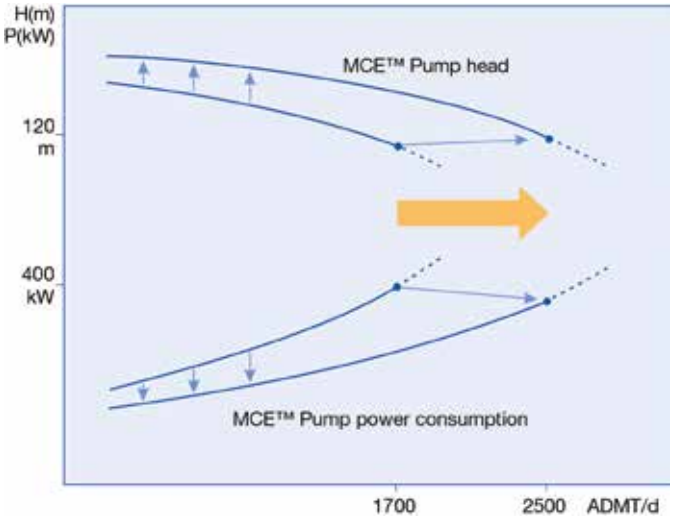

Figure 20: Production rate increase from 1'700 to 2'500 admt/d without increasing the power consumption.

Efficient mixing of chemicals

Mixing of chemicals and steam

Mixing chemicals and stock is one of the most important operations in pulp bleaching. Good mixing provides homogenous bleaching conditions, reduces the consumption of chemicals and energy, improves product quality, and reduces the environmental load. Proper chemical mixing is a key factor in the success of new bleaching sequences.

The stock is fluidized in the MCE pump as the fiber network is disintegrated, and the gas is also separated. This allows efficient mixing of various liquid chemicals in the MDL dropleg and in the MCE pump. Most of these chemicals can be fed at a low pressure to the suction side of the

MC pump. The new MCE pump provides a chemical mixing arrangement also for concentrated sulfuric acid applications.

All gaseous chemicals and steam are mixed with a separate SX chemical mixer. The chemical injection points are in different locations for different chemicals. Each chemical and steam has its own features and special, detailed selection and dimensioning guidelines that need to be followed when injecting the chemicals into the MC system.

Figure 21: Chemical injection points in MC pumping and mixing system.

Mixing of chemicals with the SX chemical mixer

The SX chemical mixer is designed for mixing both gaseous and liquid bleaching chemicals into paper pulp. The SX chemical mixer is used for a consistency range of 3 to 20%, and the product sizes cover capacity ranges up to 5'500 admt/d. The small size of the SX chemical mixer and valves and thus the small space requirement and light weight make the installation and maintenance easy. The SX chemical mixers are manufactured of stainless steel, titanium, Hastelloy or 654SMO depending on the chemical to be mixed and on the bleaching stage arrangement.

The rotor of the mixer fluidizes the stock together with the casing turbulence generators. This disrupts the fiber network and results in optimum mixing, with no gas separation. Perpendicular positioning of the rotor and the unique three-dimensional turbulence zone prevent the separation of gas. An inhomogeneity of 5 to 10% is normally considered acceptable in bleaching. The SX chemical mixer reaches an inhomogeneity value as low as 3 to 6%. This confirms the excellent mixing results – with low power consumption.

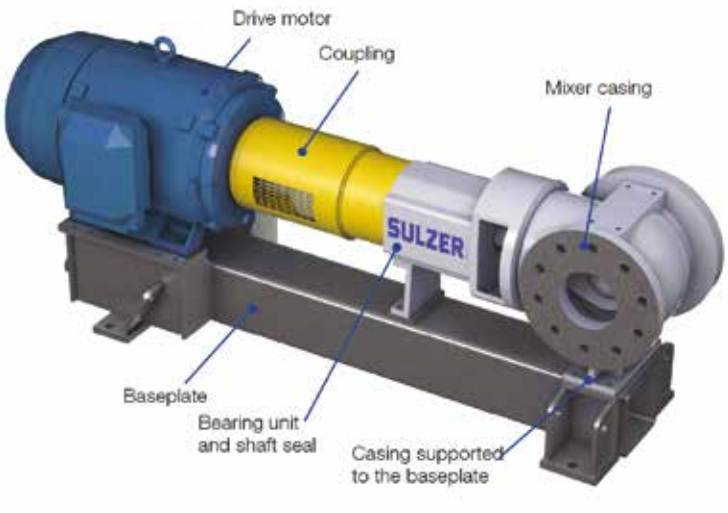

Figure 22: SX chemical mixer design

Chlorine dioxide and chlorine mixing

When mixing ClO2 into the stock, a separate SX chemical mixer is recommended. In this case the MCE pump in the stage in question is manufactured of stainless steel. If it is necessary to mix ClO2 into the stock as early as in the MC pump, the pump needs to be made of titanium. This being the case, ClO2 is introduced directly into the pump casing, to the high-pressure zone.

At the chlorination stage, when mixing both gas (Cl2) and liquid (ClO2), one or two SX chemical mixers are used. The compact SX chemical mixers can be installed in series and at intervals that create appropriate retention times.

Figure 23: ClO2 mixing with chemical mixer.

Oxygen and steam mixing with the SX chemical mixers

In the oxygen delignification stages, oxygen and steam are introduced simultaneously into the steam injection pipe following the MCE 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 SX chemical mixer, oxygen and steam are mixed efficiently into the stock. A temperature increase of up to 25°C has been reached by the SX chemical mixer. Steam consumption is lower due to the closed and pressurized high-consistency system. Disturbances and vibrations are eliminated by correct dimensioning and piping arrangement and by an even and smooth steam injection.

Figure 25: (Right) MC pumping and SALOMIX™ agitator testing at Sulzer R&D center.

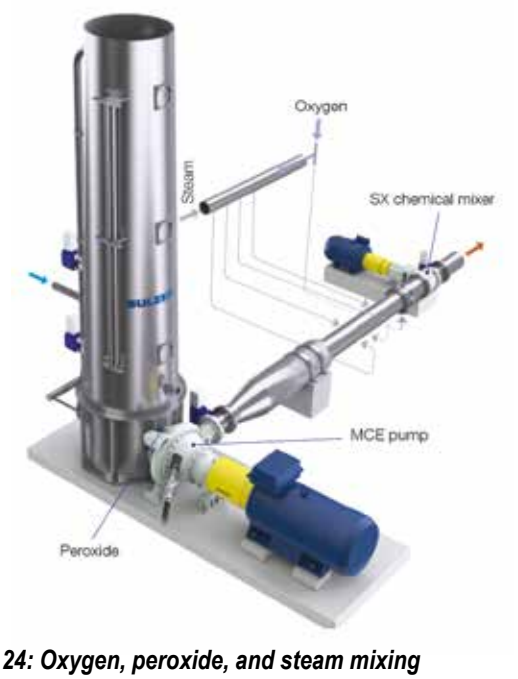

Figure 24: Oxygen, peroxide, and steam mixing

Research and development at full-scale R&D center

Research and development have top priority at Sulzer. At the full-scale R&D center, the equipment is tested under process conditions. Deep metallurgical know-how is also a remarkable strength when developing equipment for these applications, where special corrosion and wear resistance are often required. Sulzer's experience in and commitment to the pulp and paper industry have made the company a leader in stock pumping, transfer, and mixing technology.

CONCLUSION:

The new series of Sulzer MCE pumps reach production rates of up to 10'000 admt/d. In MC pumping applications, the consistency and temperature ranges have been expanded to achieve the most effective conditions in a pulp and paper mill. New innovative ways to use MC equipment are being introduced. These will reduce the investment costs when, for example, parallel tower discharge pumping or modified flat bottom MC towers with a recirculation system and subsequent static DM dilution mixer system are used instead of conventional solutions. The Sulzer SX mixer is introduced for the mixing of liquid and gaseous chemicals and steam to ensure high mixing efficiency and reliable mill operation. Process upgrades are available for updating earlier MC pump generations to the third-generation MCE with a high 75+% efficiency level.

Sulzer TMS tower management systems with a TES top entry spreader, GLI and VULCA center fillet, and SALOMIX™ agitators will help the pulp and paper mill operators to solve tower feeding and channeling problems. Sulzer's TMS tower management system equipment improves the stock quality and reduces the amount of entrained air in the stock, thus reducing the risk for disturbance in the process.