Executive Summary

Paper and board making must be understood as an integrated process from furnish preparation to the roll wrapping process. With the appropriate technology and configuration, production lines operate cost- and energy-efficiently while producing high-quality pulp, paper, board or tissue from a variety of raw materials at the lowest possible total investment and production costs.

This white paper examines the savings that can be gained in four main areas: fabric choice, steam & condensate system configuration, felt conditioning and material efficiency. While energy use is a main emphasis, overall system optimization is also evaluated from the standpoint of efficiency. Producing the same end result with reduced amounts or lower grades of raw materials (material efficiency) is reviewed in terms of state-of-the-art technology upgrades.

Brief case studies are presented in order to support the recommended technology and process changes.
Introduction

Valmet’s global customers in the pulp and paper industry are paying more attention to energy efficiency and energy-conservation solutions. Energy accounts for up to 10-35% of total expenses, depending on the geographic region and type of paper or board being manufactured. When a mill’s energy consumption decreases, its carbon dioxide emissions do too.

According to Jouko Yli-Kauppila, Valmet’s Senior Vice President, Technology, "Other important targets include the efficient use of raw materials, whether fiber, water or chemicals." At paper and pulp mills, improving efficiency in the consumption of energy, water, chemicals and fiber raw materials starts with the main process. The remainder of this white paper examines the papermaking process by looking at four main areas: fabric choice, steam & condensate system configuration, felt conditioning and material efficiency.

Savings by choosing the right fabric

Fabrics are one of the most important wear parts of a paper or board machine. Their properties are essential for the quality of the end product. In every machine section fabrics play their own specific role. Good runnability, durability and cost effectiveness are characteristics that continuously have a major role in fabric development, but also in this area opportunities to improve the energy efficiency of the machine are becoming more and more important. Paper machine clothing is one part of comprehensive energy efficiency improvements and the biggest savings are made possible when fabric choices are connected to wider projects, such as vacuum system optimization and modifications.

This portion of the paper presents some facts and recent development of energy efficiency related to paper machine clothing. An optimal fabric choice for each machine position will always require testing because circumstances vary greatly from machine to machine. The best way to find energy saving opportunities is through co-operation with Valmet specialists.

Forming fabrics

Dewatering and paper structure are properties that guide the development of forming fabrics. When it comes to energy efficiency, they are both essential. However, other properties such as friction and the behavior of the drive load during the fabric lifetime also have an impact on forming section energy efficiency. This chapter gives an overview of the connection between forming fabrics and energy consumption.

Special yarn helps to save energy

One twin-wire liner and fluting machine was suffering from guiding problems at the forming section and a high drive load was also detected. To improve the situation, a PackMaster forming fabric with special yarns was tested on the machine and the effects were very positive: first, the guiding problem was solved and second, thanks to a new fabric and yarn type, the drive power load of the forming section dropped from 75-80% to 60-65%. The energy cost savings were over EUR 100,000 per year.

In a second example, a fine paper machine equipped with a gap former had a slipping problem with the forming fabric. In addition to high drive power load, slipping caused several emergency stops during the first days after starting to use the new fabric. In this case too, GapMaster forming fabrics with special yarn
were tested. The most significant improvement was that the slipping and thereafter the emergency stops became history and the annual machine running time increased by 36 hours. A second consequence was that the drive power load decreased from 78% to 68%, which meant over EUR 70,000 savings in energy costs per year.

In both cases the new forming fabric with special yarn gave clear energy savings. This special yarn has produced good results and savings in many machines, but there are cases, where – because of differences in the machine environment and process – it has not made any significant improvements. This is the reason why yarn development is continuing. Very promising results have been achieved with a new type of yarn, which has slightly lower friction but still enough to prevent slipping. The test results of a fabric with the new type of yarn show that it has the same lifetime, lower friction and better bending stiffness (Figure 1).

To sum up: on one hand, the friction between the roll and the fabric should be big enough to prevent slipping and on the other hand, the friction between the suction element and the fabric should be as small as possible. And which yarn material is the most suitable depends on the machine environment and processes.

What kind of details lie behind the energy savings and how do these new yarns differ from typical yarns?

Traditionally, forming fabrics have been made of polyester and polyamide. Polyester is used to give stiffness to the fabric structure and polyamide gives durability. These two materials have different water absorption properties (Figure 2). Because polyamide absorbs more water than polyester, it swells out of the fabric structure, causing decrease of contact area in polyester-polyamide fabric. This creates roll slipping.

In product development, the topography especially of the wear side of the fabric is improved. The new special yarns have shown that they have excellent durability properties, so it is possible to use them 100% on the fabric’s wear side. Thus the contact area on the rolls is bigger than with traditional yarn. This prevents the slipping that causes extra drive load and further unnecessary electricity consumption. The new yarn also possesses very suitable hydrophilic properties: the film of lubrication water between the yarn and the drainage element, such as a suction box, is optimized. These two issues are crucial for energy savings. By using the new special yarn on the wear side, it is possible to fulfill these requirements.
Energy consumption changes during fabric lifetime

In addition to yarn properties, another important issue is the link between fabric lifetime and forming section energy consumption. Typically, the drive load of sectional drives changes during the forming fabric lifetime. It depends on the choice of fabric and on the machine how the power load behaves, but usually the drive load decreases during the lifetime of the fabric. This is a consequence of yarn wear and increased yarn surface area on the fabric wear side. The fundamental reasons for the phenomena are not proven, but one is better contact on the drive roll and another possible reason is that the increased contact surface of the yarn keeps the water film more easily between the fabric and the dewatering element.

The example shows the power load of a modern gap former machine: after the change of inner forming fabric, the power level of the inner fabric drives decreases (Figure 3). The corresponding curve can also be seen on the outer fabric. These drive power curves are different in every machine and also for different fabric types and yarn materials. Nevertheless, it is possible to influence the power curve with the right fabric choice and therefore it is good advice to monitor the drive power consumption. When a downward drive power curve is compared to a flat or even a rising curve, the approximate annual energy saving potential can be tens of thousands of Euros and even as high as EUR 100,000 depending on the cost of electricity.

It has also been observed that when the drive power load decreases, the lifetime of the fabric increases. The background phenomenon is probably that part of the energy consumption of drives goes into fabric wear. An increased fabric lifetime means cost savings, so from this point of view it is also worth paying attention to forming section drive loads.

Fabrics – one element in a bigger picture

To get a full picture of energy efficiency at a forming section, the links between various pieces of process equipment and their effects on energy consumption should be recognized. The forming section uses about 20% of a paper machine’s total electricity consumption. Almost half of the electricity is needed for sectional drives and over one third for the vacuum system (Figure 4). It is therefore worth saving energy in these areas.
There are direct and indirect measures to improve the energy efficiency of the forming section. Direct measures are those that affect the forming section drives or vacuum system. Savings from indirect measures are realized in other machine sections, for example the drying section. Choice of energy efficient fabric is a direct energy efficiency improvement and it is possible to gain the biggest savings if it is combined with optimization of the forming section vacuum system. It should be noted that the effect of too high a vacuum level at the suction boxes causes friction that is more significant than the friction caused by fabric properties. Therefore, the benefits of special yarns can be lost by using non-optimal vacuum levels at the suction boxes.

A well-functioning forming section and optimal fabric can have beneficial effects on other machine sections: high dryness after the forming section typically means less steam consumption in the drying section. It should be remembered that these kinds of indirect energy efficiency improvements are seldom simple. Moreover, they are likely to have complicated causes and effects. For example, a certain forming fabric type can give optimal paper structure that needs less pressing and less drying, but precise prefiguring of which fabric choice would be optimal for which grade, stock, forming concept etc. is difficult without testing and trials.

In order to gain the biggest energy savings, certain rules of thumb should be remembered. The easiest way is to ensure first that vacuum levels are optimal and not too high. Second, monitor the drive power load after forming fabric changes and find a fabric that lowers power consumption without endangering web properties. Third, keep fabrics and forming section in good condition and make use of efficient fabric cleaning.

Press felts
The type of felts that are in use is another significant factor. In the press section, major energy savings are possible with the right felt type, which facilitates the shutting down of Uhle boxes and vacuum pumps. This chapter reveals the facts behind the recent shake-up in the press section – nip dewatering.

Modern felts make nip dewatering possible
Traditionally, water removal from the web in the press section has been carried out with felts, which mainly remove water with the help of suction boxes - known as Uhle box dewatering (Figure 5). To increase water removal this way further would increase the need for vacuum and energy exponentially. In addition, the lifetime of felts shortens as they get worn by friction due to rubbing against Uhle box covers. Also, with traditional, thick felt types the start-up of the press section takes longer time: it might take as much as two weeks to reach saturation point of the felt and normal production speed.

The vacuum system represents as much as 20% of the electricity consumption of paper or board lines. About half of this amount is consumed in the press section: by pick-up and suction rolls and in Uhle boxes. In
many machines there is an oversized vacuum capacity and therefore good opportunities to save energy – usually with easy modifications. However closing a Uhle box alone is not enough but decreasing vacuum pump capacity is also required in order to obtain the biggest energy savings.

In a modern press section, water is removed from the sheet with a nip load through felts onto the roll surfaces, from where it is transferred to save-alls with the help of a foil doctor (Figure 5). Vacuum is then mainly needed for suction rolls and suction press rolls. In addition to a lower vacuum requirement, additional savings can be gained with an extended felt lifetime and lower drive power demand, which are the result of reduced friction. This shift towards nip dewatering is made possible by using new, lighter felt types such as Valmet’s AquaStar, AquaMaster, EcoMaster, or StarMaster.

Another advantage of modern felt types is that their start-up is very fast. Saturation point can be reached instantly and it is possible to run all the time at normal production speed. Compared to thicker felt types, the change in production efficiency is remarkable. These felt types also bring other benefits. They have a strong self-cleaning effect in the nip due to high nip dewatering. As in the forming section, long running times and excellent runnability improve the energy efficiency of the press section indirectly.

**Felt structure determines water removal**

One prerequisite for optimal nip dewatering is that the press felts are suitable for the position in question. The structure of the new Valmet felt types promotes efficient nip dewatering, where water flows directly through the felt without any machine-direction movement. AquaStar and AquaMaster felts are made of a non-woven base material. They have a very compressible structure. The paper side yarns are in the cross-machine direction and the stronger yarns on the roll side are in the machine direction. Valmet’s hybrid felts EcoMaster and StarMaster have a strong, non-woven base fabric on one side and a very fine woven base on the other side. EcoMaster is especially designed for positions where the water-removing capacity of non-woven felt is not enough or positions that are marking-sensitive like printing papers. StarMaster in contrast is designed for positions that are not so marking-sensitive, like packaging grades. Common to all these felt types is the fact that they generate higher hydraulic pressures and allow water to flow easily through the felt onto the roll surface. Hybrid felts are suitable for nip dewatering, but they can also carry water to the Uhle boxes, if necessary (Figure 6).

**How to achieve fabrics-related savings?**

The best way to find out about the energy saving possibilities of the press section is to contact Valmet and carry out screening with specialists, combining felt optimization and vacuum system checking. It should be checked if nip dewatering is possible and after that fit the vacuum capacity to the new situation. The felts should be tested position by position, starting from the critical pick-up felt and, when results are promising, moving further. To find the most optimal felt, different felt types should be tested if the first option does not give the best results. The ultimate goal is to reduce vacuum capacity, for example by shutting down liquid ring pumps, because they are the ones that consume energy in the vacuum system.
In one European fine paper machine, non-woven AquaStar was used in the pick-up position while standard woven felts were used in other positions. After a very fast start-up, the felt produced excellent dewatering and during the planned four-week running period there were no edge problems. The Uhle boxes of pick-up felt were closed, which enabled the shutting down of two liquid ring pumps. After that the 1st bottom felt was also changed to AquaStar. Here too, the Uhle boxes were closed and one more pump was stopped. Approximate energy savings were about EUR 250,000/year at an electricity price of EUR 50/MWh.

In another fine paper machine, AquaStar felts were tested in both the pick-up and 1st press position. Similarly, there were no edge problems after a fast start-up and dewatering results were very good. In this case, nip dewatering enabled running without Uhle boxes in the pick-up and 1st press felts. Reducing vacuum pump capacity by three and a half pumps meant annual savings of EUR 300,000.

Nip dewatering is usually suitable for printing paper grades. For example SC machines also require Uhle box dewatering. The 1st nip floods easily and might break the web if the nip dewatering is too powerful. In board machines the possibilities for nip dewatering must be studied case by case. Usually there are still opportunities to reduce Uhle box dewatering and reduce extra vacuum capacity.

For machines where Uhle boxes have to be in use, the Valmet recommendation is a new perforated Uhle box cover. This has lower friction and the felts run longer. Consequently, it provides energy savings. On the other hand, a perforated cover enables more efficient dewatering with the same vacuum level. The extended felt lifetime brings significant cost savings.

**Dryer fabrics**

The dryer section consumes the majority of the heat needed in a paper or board machine. Despite this fact, the wet end of the paper machine usually gets more attention, especially when talking about energy efficiency. The chances of affecting paper quality are smaller in the dryer section, but it should be noted that in the dryer section too, there are good ways to improve energy efficiency. One of these is the choice of dryer fabrics.

**Efficient drying with quality fabrics**

Dryer fabrics support and transport the paper web through the dryer section. The dryer fabric should maintain good paper quality throughout the drying process and the final product quality should not deteriorate. In addition, efficient drying and low costs are important issues in dryer fabric development.

The connection between dryer fabrics and energy efficiency is how the dryer fabric intensifies the drying of the web so that humidity is efficiently removed from the web at minimum cost. This of course occurs while sustaining a high level of paper quality and final product quality. The most important dryer fabric properties are that it maintains its openness, the air permeability is

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**Figure 7. TamStar HP structure pumps fresh air into pockets.**
suitable, the fabric prevents marking, has good runnability and high drying capacity. Recent development of dryer fabrics emphasizes drying effectiveness.

An example of dryer fabric design reducing steam consumption by improving pocket ventilation is seen with Valmet’s TamStar HP. The structure of the fabric actively pumps fresh air into pockets and therefore reduces humidity and improves the paper profile (Figure 7). TamStar HP also has an extremely smooth side for good heat transfer, so it is the optimal fabric type for the double-felted sections of an older dryer section.

**Proper fabric style means steam savings**

In relation to energy efficiency and steam consumption, keeping dryer fabrics clean is very important. Dirt on the fabric deteriorates heat transfer and prevents vapor removal off the web. One of the most common problems even in modern paper machines is an inclined permeability profile. For instance, if there are several dryer fabrics in the dryer section that have a plugged back side, the result is a poor moisture profile. A poor profile is usually corrected by over-drying and profiling. Unfortunately both ways are only a waste of energy and do not take care of the root problem. In addition, clean dryer fabrics decrease web breaks and improve the quality of the end product. Valmet has developed an efficient cleaner for dryer fabrics, called OptiCleaner Pro. It enables continuous or sectional cleaning during production.

Valmet has also developed a dryer fabric called TamStar HS to enhance high pressure cleaning efficiency. Some fabric types may not enable efficient cleaning, but the structure of TamStar improves both the cleaning result and the runnability. TamStar is also a durable fabric with a long lifetime, and is therefore also a good choice regarding energy efficiency (Figure 8).

Another issue to be mentioned is dryer fabric tension. Too low fabric tension causes runnability and fabric wear problems. But most importantly, the heat transfer from the web decreases considerably if the fabric tension is too low. For example, on one European paper machine, increasing the fabric tension from 1.5 kN/m to 3 kN/m decreased steam consumption by 10%. A change in heat transfer depends on machine speed and roll surface temperature (Figure 9). All in all, the heavier the grade, and/or the higher the steam pressure, the bigger the savings. A typical recommendation for dryer fabric tension is 4-5 kN/m, but the TamStar structure and seam allow use of a high fabric tension of up to 7 kN/m, which further improves heat transfer.

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Experience has shown that in many paper and board machines the dryer fabric tension is not monitored regularly. Since fabric tension has a direct effect on steam consumption, tension measurements should be taken regularly and the condition of stretchers should also be checked and measured. Seldom are the tensions too high and fabric is not the limiting factor. Maximum tension possible for a machine should always be used for efficient operation.

**Summary – choosing the right fabric**

Paper machine clothing has an effect on the energy efficiency of a paper machine. The development of paper machine clothing is continuing more and more to take into account the possibilities of decreasing energy consumption. Lower drive loads in the forming section, nip dewatering in the press section and efficient heat transfer in the dryer section are made possible by using Valmet’s high quality fabrics. Keeping clothing in good condition, taking care of the right tensions, regular cleaning and first and foremost, choosing the best fitting clothing for each position are guidelines that will ensure long fabric lifetimes and efficient use of energy.

**Savings by optimizing steam and condensate**

It is a frequently held perception that paper and board machine steam and condensate systems only serve the dryer section. When we deal with the energy efficiency of steam systems, however, we need to consider all steam consumption locations along the whole production line, from steam generation, the heating of process water, hood ventilation and cylinder drying, and the return of condensate back to the power plant or other uses (Figure 10).

Steam typically represents roughly three quarters of the total energy consumption of paper and board machines. An average of three quarters of this steam goes to dryer cylinders, while the rest is split between ventilation, steam profilers and the heating of process water and some other less prominent uses.

The total amount of steam energy needed hinges on the efficiency of heat transfer, the recovery and utilization of low temperature heat energy (flash steam, condensate, air, water) as well as steam leaks, condensate losses and heat leaks.

In addition to the price and consumption of steam, overall costs also depend on the steam pressure required, the quality of steam and condensate, and condensate losses.
Dryer section cylinders typically consume 1.15 to 1.25 tonnes of steam for each metric ton of water evaporated. The most efficient machines consume 1.1 tonnes of steam per tonne of water. Added sheet moisture (+) and other drying (-) also need to be considered when calculating the volume of water to be evaporated.

Under normal production and operating conditions, the total amount of steam consumed by cylinder drying varies significantly with the percentage of ‘blow-through’ steam that can no longer be utilized in dryer cylinders due to its low pressure level. Blow-through steam is needed to ensure the evacuation of condensate and non-condensing gases from the system. It typically accounts for one to three percent of total cylinder steam flow.

Another significant production related factor is the temperature of the condensate returning from the dryer section, the effect of which on total line steam consumption may approach four percent. When looking at the temperature of return condensate, we also need to consider the role of the power plant, i.e. the optimal temperature for returning condensate, bearing in mind total energy consumption, investment costs, and the quality of return condensate and its effect on equipment and pipes.

Other factors affecting steam consumption during production include steam quality, steam leaks, the efficiency of cylinder heat transfer / required steam pressure, pressure and temperature losses, and moisture profiles. The total steam consumption of the dryer section per tonne produced further depends on break times, sheet break and tail threading controls, and heating and stopping functions.

Valmet's modular steam and condensate systems

The broader grade scale of paper and board produced today has added to the variety of dryer section operating approaches and control needs. Energy consumption, environmental impact and investment costs also play an ever-greater role in the selection of machine concepts and process systems.

Responding to these requirements as a full-scope supplier to the industry, Valmet also deals increasingly with other subprocesses and various new opportunities offered by control systems in its steam system development work. Valmet has developed steam process solutions and machinery modules that are optimized especially for cylinder drying, along with related control, condition tracking, and energy monitoring system solutions. These can be combined and modified to provide the most efficient overall solution for the situation at hand.

Conventional cascade or thermocompressor systems or combinations of these continue to form the foundation for dryer cylinder steam systems. Key innovations include the modular design (Figure 12) of primary system...
components and the packaging of equipment into fully operational preassembled units, along with novel condenser solutions, new control and monitoring system features, fewer components and pipes, optimization of energy consumption reductions in relation to system operation and overall line heat utilization and efficiency, and reduced cooling water needs. Figure 13 presents various dryer section steam and condensate system alternatives.

Benefits and savings compared with traditional systems

Savings in steam consumption

The estimated savings potential for dryer cylinder steam consumption during production ranges from 3-4%. When we add the optimal use of low-temperature heat energy along the full line, the average savings total 6-7%, even topping 10% in some cases.

Savings in sheet break times

Savings associated with grade changes and sheet breaks derive from shorter change and break times as steam pressure changes are controlled by predetermined programs (modules). Decreasing cylinder steam pressures and surface temperatures with a new dual condenser solution at the start of a sheet break is especially effective at cutting break times. These control modules can be re-optimized as operating methods and needs change. The potential resulting efficiency savings may be significant.

Savings in the amount of cooling water needed by the steam and condensate system can be made by optimizing condenser units for their intended use. Condenser units used during production are dimensioned for an efficiency and operating range that suits the applicable production conditions. Break condensers, meanwhile, are dimensioned for the momentary condensing needs of sheet break and tail threading situations. The maximal potential savings on momentary cooling water needs are estimated to total some 40%.

Sealing water consumption is generally proportional to the number of pumps in operation when temperatures are such that pump condensate cannot be circulated as sealing water. New modular machinery solutions facilitate the use of fewer pumps. A reduction in the number of pumps also means a reduction in electricity consumption.

The resulting annual energy cost savings may total thousands of dollars.
**Investment cost savings**

Modular machinery design, preassembly and testing enable better space utilization and easier maintenance, and speed up installation and start-up. These new machinery solutions also reduce steam pipe needs. Estimated savings in the amount of piping required add up to 15%, while savings in the number of components add up to approximately 10%.

**Improved drying power and quality control**

The optimization and controllability of drying power and temperature (e.g. curl control and MD drying temperature and power monitoring) help to optimize the drying process and its effects on sheet quality. These are based on reliable system measurements and related real-time analyses.

The control system stores the best grade-specific running situations, which serve as benchmark or target values when the same grade is run again later. This enables further development and optimization of the drying process and its energy usage, as well as control over the production line’s total heat energy consumption.

Valmet’s comprehensive scope of supply facilitates effective and efficient steam and condensate system solutions. **Figure 14** summarizes the advantages of optimized full-scope deliveries.

**Savings in felt conditioning**

The vacuum system typically accounts for 10 - 20% of a paper machine’s overall electricity consumption. In terms of specific consumption, this means 40 - 100 kWh for each tonne of paper produced. The operating conditions of vacuum systems therefore have a significant effect on energy efficiency. Potential savings can be as high as 30% of the vacuum system’s total energy consumption. More than one-third of all pumping power is needed for press section felt conditioning (**Figure 15**). This article presents recent developments in felt conditioning that offer good opportunities for energy savings. The first step is to choose the most optimal way for dewatering and then modify the vacuum system to get the most out of the resulting changes.

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**Figure 14. Benefits of Valmet’s advanced steam and condensate system**

**Figure 15. Distribution of vacuum system energy consumption**
Felt properties facilitate savings

The operating conditions of press section Uhle boxes vary widely between different paper machines. Many low basis weight machines target nip dewatering and minimize vacuum usage. Machines producing high basis weight paper or board, on the other hand, often still need vacuums in their Uhle boxes to keep felt dryness at the required level. Because of differing operating approaches, felt types also vary a lot from machine to machine.

The dimensioning of felt conditioning at Uhle boxes has traditionally been based on a constant vacuum, i.e. the same air speed in the slots of felt suction boxes at different positions. This method frequently leads to an over-dimensioned vacuum system and huge energy losses under variable operating conditions, and often to low vacuum system efficiency. This basically means that excessively powerful pumps or blowers are combined with traditional vacuum level control principles.

The air permeability of press section felts varies a lot during operation, and the degree of permeability correlation between dry static conditions and wet operating conditions has not been determined. This has also been the main reason for poor efficiency and energy losses in paper machine vacuum systems. Even a vacuum system rebuild may often be required to adapt existing systems to today’s operating conditions. Valmet has developed a model for estimating dynamic felt air permeability (airflow from the felt suction box) under normal running conditions by utilizing actual mill measurements.

If the felt type employed on a paper machine is known well enough, it appears possible to estimate the required maximum capacity of the vacuum system more accurately than before. The air permeability of felts never seems to be in the orange area of Figure 16 under normal running conditions.

However, it should be remembered that the aging of felts still has a major effect on capacity requirements, that the required operating window can still be as wide as 1:2, and that the vacuum system must be able to operate at a good efficiency level under any operating conditions.

The manner of dewatering really counts

Many papermakers have been optimizing their processes for nip dewatering in recent years, especially at the last couple of felt loops. However, many board machines running heavier basis weights still use felt dewatering, where the majority of water removal occurs at Uhle boxes. A new, more effective felt conditioning method has been developed for these machines. One recent trend in felt conditioning has been the reduction of vacuum levels in order to lower airflows and cut energy consumption.
Maintaining the desired rate of dewatering in this environment requires longer sheet dwell times to give Uhle boxes enough time to remove the necessary volume of water. In Figure 17, maintaining the same relative dewatering rate while at the same time reducing the vacuum level from 45 kPa to 20 kPa means that the dwell time has to be increased from 3.5 ms to 11 ms.

This change is only possible with Valmet’s new perforated Uhle box covers, which reduce friction and give better dewatering results at lower vacuum levels (Figure 18). A perforated Uhle box cover is an effective and straightforward solution for increased dewatering and reduced energy consumption at the press section. The more effective dewatering performance of a perforated Uhle box cover stems from a long sheet dwell time in the suction area. The surface geometry of the perforation pattern also improves water removal at a lower vacuum level, thus saving energy. Energy savings are gained both through reduced drive power needs and lower vacuum system capacity.

Valmet’s SolidCoat technology ensures gentle fabric contact and reduces damaging frictional drag. The cover provides stable support for the felt over the entire suction area; there is no ‘diving’ of the felt into slots as with conventional covers. Felts run longer and good felt condition is maintained throughout the lifetime of felts.

The new perforated cover is easy to install on existing Uhle boxes for fast results. In one recent example, pick-up felt dewatering needed to be increased and splashing reduced on a European fluting machine. An investigation of the situation revealed that the existing Uhle box setup (two Uhle boxes with two slots) was clearly not sufficiently efficient to remove enough water. To solve the problem, one of the Uhle boxes was taken out of operation and a new perforated Uhle box cover was installed on the other.

A 30% increase in dewatering at the pick-up felt was measured after this change, along with a 28% decrease in the vacuum level. Felt conditioning was clearly more effective as the felt remained open longer, and felt moisture profiles stayed good and stable throughout the lifetime of felts. Total annual savings exceeded EUR 300,000 when vacuum system capacity adjustments, lower felt costs, and savings in drive power were all added up.
** Improving vacuum system efficiency **

Once dewatering has been optimized at the press section, extra Uhle box capacity eliminated, and box covers changed, it is time to optimize the rest of the vacuum system. This means that system controls are checked and improved where necessary, and particularly that pump or blower capacity is reduced to match the new operating conditions. The ability to shut down a liquid ring pump (LRP), or several, brings the biggest energy savings.

Existing paper or board machine lines whose operating conditions have changed often suffer from poor vacuum system efficiency. The reason for this is the traditional design of the systems. Vacuum control may entail huge efficiency losses as both LRP and blower systems drift outside their proper operating ranges. Totally new design and control philosophies typically need to be utilized to improve the efficiency of existing systems.

Although a bleed valve is the best way to control LRPs, keeping valves open is not an energy-efficient way to run a vacuum system. The outcome is even worse when restricting valves are used to control LRPs because the pumps will not operate at their design rate and their power needs increase.

With turbo blowers, the situation is a bit different. Blowers work at constant pressure, which means that their control is based on restricting the flow of air (Figure 19). Power needs are directly proportional to airflow. If the hot exhaust air of blowers can be used to heat supply air, for example, their energy efficiency will be even better. Blowers generally consume a bit less energy than liquid ring pumps, but LRPs are still a valid and cost-effective solution for vacuum production, if used sensibly.

It is also worth remembering that liquid ring pumps should be serviced at least once every ten years. Their pumping efficiency falls if seals are in poor condition or there is a lot of dirt inside the pump. Another important issue is the temperature of sealing water, which should be cold enough to ensure efficient heat transfer. Valmet also offers a pump service package that makes it easy to combine pump maintenance with a vacuum system modification project.

** Summary of felt conditioning savings **

Even though many paper machines are today operating totally without felt conditioners, there are also many machines, such as board machines, where felt conditioning Uhle boxes are still needed. Due to the recent development of felts, big potential energy savings await in the vacuum systems of existing paper machines. A vacuum system study conducted on a European LWC machine, for example, revealed significant potential for savings, and the mill decided to rebuild the vacuum system in two stages. Changes in dewatering reduced pump power by 775 kW, and system control improvements brought the total potential savings to 1 MW. As in this case example, vacuum system modifications typically provide a short payback time of less than a year.
No real innovations have been introduced in quite a while for felt conditioning and dewatering. Valmet's new invention, a perforated Uhle box cover, has proven its potential in a variety of situations. Now it is up to mills to decide where the biggest benefit lies for each of them. Is it in increased dewatering, reduced power requirements, improved runnability, or better moisture profiles; or is it in the ability to start using seamed felts?

The most important issue in felt conditioning and dewatering optimization is always the selection of the right felts, after which the efficiency of the vacuum system can be optimized. Working with Valmet allows papermakers to combine their felt conditioning and vacuum system modifications in an efficient manner. After dozens of screened vacuum systems, we estimate that the average system improvement project offers 550 kW potential savings, and that roughly 70% of all machines studied can save energy. Is your machine one of these?

**Material efficiency - Use less, get more**

Simply put, material efficiency means producing the same end result with reduced amounts or lower grades of raw materials. This applies particularly to paper and board manufacturing, but also to certain aspects of machinery construction. Material efficiency measures seek to reduce the amount of virgin natural resources required for producing a certain level of output and recycle post-consumption waste material back in the manufacturing process. The reuse of wear parts and components is also part of material efficiency, as is extending the lifetime of machinery, components, and spare parts through reconditioning. Material efficiency includes new product innovations to replace previous products that consume greater amounts of raw materials.

Why is material efficiency so important? Because it is a major cost factor for pulp and paper mills as raw materials represent about 50% of total operating costs (Figure 20). It also provides tools and measures that enable pulp and paper producers to meet global agreements and environmental protection goals by recycling post-consumption waste material, and thus helps to promote sustainability. In the long run, paying attention to the environment is priceless.

Sure, it is easy to keep talking about sustainability and the conservation of natural resources. Few will argue. But the key to material efficiency is a demonstrable mill benefit. The basis for any investment, including an environmental one, is a sound economic justification. The pulp and paper industry is
expecting payback times of less than two years, preferably less than one for process improvements! This is also true for material efficiency investments. The case examples below provide some illustrative savings calculations.

Pulp and paper makers are increasingly adopting a sustainable development profile. Material efficiency is part of sustainable development, and taking it into account is now more important than ever due to the scarcity of natural resources. Developing markets, such as Asia and South America, are growing fast, which also means rising usage and cost of raw materials. Considering all this, Valmet has positioned itself as an environmental solution provider with a comprehensive holistic approach.

Reducing raw materials usage

ValZone metal belt calender

Valmet’s ValZone metal belt calender (Figure 21) saves fiber as the basis weight of fine paper can be reduced by up to 7% (e.g. from 70 down to 65 g/m²). The idea is to maintain the same stiffness level and caliper. When lower basis weight paper is produced with higher bulk, the customers can launch a new high-bulk product, such as a 75 g/m² product with the properties of 80 g/m². This new quality will be priced higher than standard 75 g/m² paper, but so that the printer gets the printing area needed cheaper than with standard 80 g/m². Or in competitive markets the new quality can even be sold at the standard price, which maximizes the printer’s benefit and paper mill gains competitive advantage. ValZone technology also allows the use of up to 5 percentage points higher filler levels while maintaining the same stiffness level.

The very same principle also applies to board making. For example, ValZone gives the same liquid packaging board stiffness and surface quality at 265 g/m² instead of 280 g/m². Think about the environmental effect: over 700 million more quart-sized milk cartons can be produced with the fiber saved by a board machine designed for 300,000 tonnes per year and equipped with ValZone.

Case: Fiber and chemical savings through integrated automation solutions

PABCO Paper in Vernon, California was confronted with a challenge when PABCO Gypsum, its primary customer and sister company, increased production by building a new high-speed wallboard line at its gypsum wallboard plant near the company’s Las Vegas gypsum quarry. PABCO Paper and PABCO Gypsum are part of the Pacific Coast Building Products group of companies, one of the leading suppliers of building products and services to the U.S. construction industry.

The mill took a hard look at how to achieve the increased output and better quality needed to meet the needs of the Las Vegas plant. It then decided to invest in improved process and product quality
measurements, process stabilizing controls, and vastly expanded operator information and decision-making tools supplied by Valmet. The completely new automation infrastructure, which replaced antiquated chart recorders and analog controllers, has paid off handsomely. Product quality variability is much better controlled. In fact, customers now rate the mill’s quality best ever. Production levels are up significantly, and energy and raw material costs have been reduced.

The combined QCS and DCS system started up smoothly. The more stable product quality can be leveraged to gain some impressive savings. Since gypsum linerboard provides surface coverage, furnish consumption can be cut when quality is more uniform. The same leveraging factor applies to chipboards, which are sold by caliper. The mill reports that the improved automation has reduced basis weights by 14%.

Other cost savings also stand out. Steam consumption has been cut by more than 3.5% and chemicals consumption by almost 2.9%. Mark Wasson, Technical Director for the mill reports that "a reduction in the use of chemicals is possible by targeting lower feed rates with the reduced MD variation of basis weight and ply weight, and also having better control over these systems. Steam savings are made possible by lower sheet temperature settings due to the improved CD and MD variation of both basis weight and moisture."

Coating color recovery

Typical coating color preparation and washing losses total about 2%. With coating color consumption of 300 t/d d.s., that equals 6 t/d d.s. By utilizing membrane ultra-filtration (Figure 22), it is possible to recover this solid loss and recycle the pigment back for different pre-coating purposes or as filler, in some cases even back to top coating. Calculated at EUR 500 per tonne, the savings on 6 t/d total roughly EUR 1 million per year. Combined with savings in waste water and solid waste treatment costs, the total savings in this example come close to EUR 1.4 million per year, for a payback time of about 1 year.

Replacing raw materials

Using DIP instead of virgin fiber in newsprint production, or utilizing OCC in containerboard products, has been a well-established practice in the industry for several decades now. The trend tends to be that as global recycling rates get better, the properties of these recycled fibers keep getting worse and worse. This is especially true for some local OCC grades. Another trend is the usage of mechanical furnish and DIP in fine paper products, where the traditional furnish mix has consisted of virgin chemical pulps only. This is a cost driven trend, where both producers and process vendors have to adapt to the situation and start utilizing and developing novel solutions. Valmet has lately developed several tangible technologies for cutting materials-related production costs further. Take the OptiLayer, for example. How about turning brown into white without using expensive bleached pulp?

OptiLayer curtain coater

Some 50 - 80 g/m² bleached fiber, like selected office waste, is traditionally used with white top liner board grades to cover a brown filler ply. With Valmet’s OptiLayer curtain coater, a 10 - 16 g/m² opacifying
coating applied with a curtain coater can be used to turn brown board white. This coating costs less than bleached fiber!

The applications are numerous, but let’s take just one example: conventional 180 g/m² uncoated white top testliner, turned white with bleached fiber or curtain coating, as shown in Figure 23. There is a clear customer benefit of USD 25 per tonne in favor of the board maker who chose OptiLayer. In a difficult economic situation, where competition has eroded prices, this can make the difference between survival and demise (Figure 23).

**Bulk saving pressing process**

Imagine a WFU copier paper production line with an OptiPress press section followed by an OptiDry Twin impingement unit. Along with ValZone, this is yet another example of the bulk-yield approach, especially if the press section is being run with limited nip loads. This is possible without sacrificing runnability when the press section is followed by an OptiDry unit, which raises the sheet’s dry content high enough before cylinder drying.

As discussed earlier, one way of utilizing high bulk potential is to actually start producing high-bulk paper but, if the local market conditions will not allow that, another way to benefit from the concept is to add filler, loads of it. From a grade-typical level of 20%, the filler content of paper can be raised close to 30% while still maintaining bulk and caliper values typical for the grade, despite the bulk eating properties of high filler content. Converted to money, the paper maker saves about EUR 40 per tonne. That may just be the difference between the winning concept and the second best (Figure 24).

**Extended lifetime and reuse of components**

Production equipment savings can be achieved by maximizing the lifetime of consumables through optimized design. Valmet’s AttackBar refiner segment is a prime example of this. At Buchmann BM 2 and BM 3 (folding boxboard, Germany), the average filling lifetime increased from 12 to 17 months without changing the refiner’s rotating direction. NimCat screen baskets, FlexSeal suction roll seals, and ceramic coater blades are all products designed for longer lifetimes.

Valmet also provides services that facilitate the use of reconditioned equipment. Fully reconditioned refiners, for example, can be used for a good 20 years (Figure 25). Reconditioned and second-hand
machinery is eco-efficient, as it saves raw materials. As one of our customers stated, "to minimize investment without sacrificing performance is an everyday need". Finally, recycling certain consumables, like doctor blades and rod beds, employing our special recycling concept for these products also saves costs.

Material efficiency as part of future environmental solutions

Valmet’s specific strengths in the material efficiency field include its broad product range and extensive experience. The uniqueness of Valmet is evident in our ability to deliver and manage large supply projects for the forest products and energy industries. Not many companies in the world have this type of know-how in house.

In a nutshell, minimizing the use of raw materials and utilizing cheaper materials will provide cost benefits. New products will create new markets. Recycling facilitates the efficient utilization of raw materials, thereby also minimizing possible waste disposal costs. Customers have long been interested in recycling and reuse opportunities. They are concerned with minimizing costs and complying with ever-stricter laws and regulations. There is no doubt that all customers are aware of these matters. Recycling and reuse are megatrends that are changing the world, and no one can remain unaffected. Pulp and paper makers can now derive a tangible economic benefit from Valmet’s new solutions, of which only a fraction have been discussed here.

Summary

In modern pulp and paper mills significant savings can be gained in four main areas: fabric choice, steam & condensate system configuration, felt conditioning and material efficiency. System optimization may involve changes in process, configuration and technology. State-of-the-art technology upgrades can maximize material efficiency, allowing less or lower quality raw materials to be used.

This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet’s pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers’ performance forward.