

A Review On Developments in Paper Machine Clothing For Achieving Higher Energy Savings

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ABSTRACT

Energy saving through optimization of paper machine clothing offers a new approach of non-capital, low cost alternative for energy reduction in paper machine section. The forming section alone accounts for 20% of paper machine's electricity consumption. Half of this is needed for sectional drives and over one - third for the vacuum system. The latest development of paper machine fabrics both in the structural design as well as in fabric material composition, gives paper makers opportunities to reduce friction and thus drag load on forming section. In press section, where major attribution to energy consumption is due to vacuum pumps, significant saving can be achieved by use of hydrophilic yarn based fabric which results in fast dewatering from felts thus reducing load on vacuum pumps. In dryer fabric, fabric permeability has major influence on ventilation of dryer pockets & evaporation rates. The combination of heat transfer, mass transfer and stable transport of sheet affect drying efficiency of dryer section. Recent developments in spiral and woven dryer fabric also provide energy saving opportunities on paper machines.

Keywords: Paper machine, forming fabric, dryer screens, press felts, laminated felts, energy savings.

Introduction

The selection of paper machine fabrics such as wire, felt and dryer fabric is a critical process and clothing strategies are presented to help papermakers increase their machine performance and profitability. 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 paper machine, fabric plays 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 opportunity to improve the energy efficiency of the machine are becoming more and more important. (1,5, 12, 15)

Paper machine clothing optimization offers non-capital, low cost alternatives for reducing energy consumption in most paper mills. Many progressive paper machines have achieved significant improvements in machine speed and operating efficiencies as well as reduction in energy consumption by installing modern clothing designs (1). Paper machine clothing is one part of comprehensive energy efficiency improvements and the biggest saving are made possible when fabric choices are connected to wider projects such as vacuum system optimization and modifications. (5)

Modern forming fabric designs can reduce energy consumption by increasing dryness of paper web entering the press section, reducing drive loads and reducing steam addition to white water by providing better drainage. Press fabric can reduce rewet and increase sheet consistency entering the dryers. Modern dryer fabric designs provide energy benefits by improving sheet-to-dryer contact, improving air movement in dryer pockets and providing resistance to fabric filling. Installation of modern fabric designs has

produced higher overall paper machine efficiency on several machines (1). Present article summarizes some facts and recent development of energy efficiency related to paper machine clothing. It gives an overview of the relationship between paper machine clothing and energy consumption. Since circumstances vary greatly from machine to machine, therefore an optimal clothing choice always requires proper valuation and testing for achieving best results.

Paper Machine Clothing A key to energy saving and minimizing cost

It is interesting to note that the paper machine fabric performance has never been evaluated in form of energy cost. The reason behind this is that fabric cost is relatively low compared to energy savings achieved with modern clothing designs. As a rule of thumb, clothing costs vary approximately 2% of operating cost for different grades. New and well-maintained machines have lower clothing costs than older machines due to less fabric damage and wear. On the other hand, energy costs ranges from 15 to 30% of fiber, fuel and energy cost and other various operating factors. (1)

Installation of modern clothing designs can provide an opportunity for significant energy saving on paper machines. Fig.1. indicates that clothing cost averages 2% of operating costs on typical newsprint machine while energy cost is 32% . If by adopting new paper clothing techniques, clothing cost increases by 25% and energy consumption is reduced by 5% the payback period would be three to four months (1). Payback period can be lower or higher depending on operating parameters on each machine including fabric cleaning, vacuum application, machine limitations and other factors. Care should be exercised while adopting any modern fabric design on paper machine because if precautions for energy cost

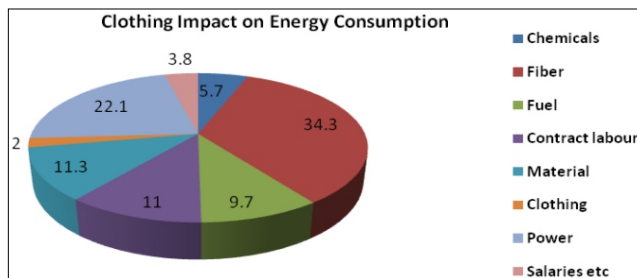


Figure1: Impact of clothing on Energy Consumption of writing/printing grade machine (Source: Fisher Pulp & Paper worldwide 2005 (Fisher International Inc.))

reduction on account of the design improvement are not taken, clothing budget will increase resulting in significant increase in overall operating cost.

Overview of Paper machine clothing

(1) Forming Fabric

Drainage properties of web and final paper formation are properties that have controlled the developments in forming fabrics. Both above parameters are essential when energy is concerned. Forming fabrics generate energy losses on paper machines. These losses occur as a result of friction between the various mechanical components in the forming area, such as the rolls, foils, vacuum foils and boxes, ball bearings and motors, slippage between the rolls and the fabric and friction between the fabric and the drainage elements. It is to be ascertained that friction between the roll and fabric should be high enough to prevent slipping while on the other hand, the friction between suction elements and the fabric should be as small as possible for which synthetic yarn material is the most suitable choice depending on the machine environment and other processes. Traditionally, forming fabric are made of polyester and polyamide as polyester gives stiffness to fabric structure and polyamide durability. These two materials have different water absorption property and provide desired actions of the forming fabric. Because polyamide absorbs more water than polyester, it swells out of the fabric structure, causing decrease of contact area in polyester- polyamide fabric. This causes rolls slipping. The selection of polymer or their composition also determines the fabric life and also the drive load on forming section. Figure 2 illustrates the relationship between drive load and fabric life based on the material of construction of forming fabric (6). With the development of new special yarn having composition of 75 – 99% polyethylene terephthalate (PET), 20% polymeric siloxane and 0.1 to 5% compatibilizer, the wear side performance of the fabric has significantly improved, showing excellent durability properties, thus making it possible to use it 100% on the fabric's wear side. The enhanced contact area on the rolls, also prevents slipping. This material also exhibits good hydrophilic properties as a result; the film of lubrication water formed between the yarn and drainage element, such as suction box, is optimized. Both these features results in significant saving of energy on the forming section. In practice, it has been observed that these losses are quite high for some fabrics, which results in high drive loads to drive the clothing. Any reduction in power consumption by the fabric at the forming section automatically results in lower energy consumption in wet end of the paper machine.

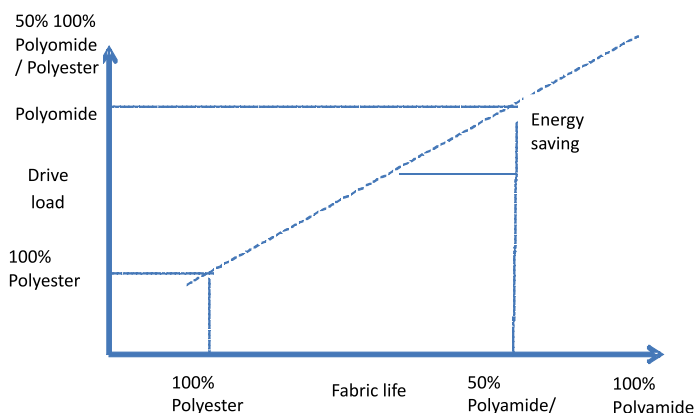


Fig. 2: Effect of fabric construction material on fabric life and paper machine drive load (Source: Huyck .Wangers Europe, www. Xerium .com)

The forming section consumes about 20% of paper machines total power consumption. Almost half of the electricity is needed for sectional drives and over one third for the vacuum system (Fig. 3 & 4) (5). A large power saving potential results in these operations. The first step to reduce energy consumption in forming section is to identify and quantify parameters that have major impact on power consumption. Out of the eight most important parameters identified, i.e. low friction material, fabric wear, float length, type of fibers, ceramic edges, ceramic materials, vacuum, basis weight, two prominent parameters that influence the forming section runnability are the vacuum level and the friction coefficient on the running side of the forming fabric material. Studies conducted by various researchers have shown that higher the vacuum applied on a box, higher is the drive load. The amount of vacuum required, largely depends on the sheet formation process. If sheet has open structure; the drainage would be fast which would result in a lower vacuum and thus saving in amount of power required to drive the fabric. Analysis has shown that the friction coefficient of the running side wires on the drainage elements depends on running side fabric structure and the type of material used for the fabric. The polymeric material available in the market so far that could lower the friction coefficient of the fabric and thus cut energy consumption, unfortunately also shorts the fabric life and is not available in large diameter sizes. This restricts their use with respect to paper and paper machine types.(6)

A recent development on the running side polymer formulation combines significantly lower friction for dewatering with very high abrasion resistance. The composition of their material consists of

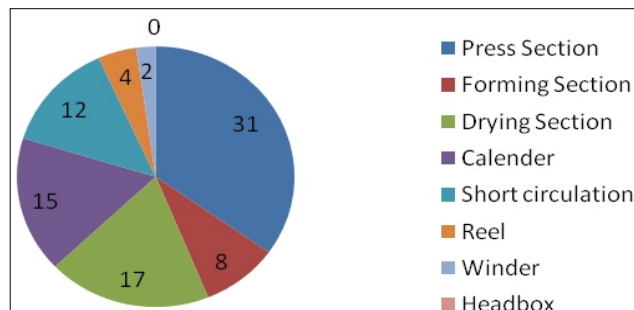


Fig. 2: Paper machine Electricity distribution

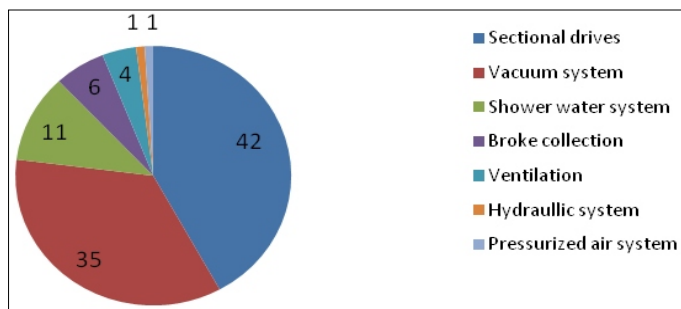


Fig. 3: Forming section electricity consumption distribution

90 99.8% PET and 0.2 to 10% nano- carbon tubes and is said to have elongation 5 20% lower than PET and abrasion resistance 50 500% greater than PET. Another polymer, comprising of 90 99.8% PET and 0.2 10% nano graphene are said to provide high modulus of elasticity and abrasion resistance than PET alone. Use of these new polymeric yarns reduces power consumed in the forming section and has enormous energy savings potential upto 30%. (6, 7). Thus, the drive load can be reduced without any compromise with regard to fabric life or stability.

A well functioning forming section and optimal fabric can also have beneficial effects on other machine sections: high dryness after forming section results in less steam consumption in drying section. It should be remembered that this type of indirect energy efficiency improvements are seldom simple. Moreover, they are likely to have complicated cause and effects. e.g. a certain forming fabric type can give optimal paper structure that needs less pressing and drying, but precise estimation of the effects of fabric choice for a given grade, stock, forming concept etc. is difficult without testing and trials.

In order to gain the desired energy savings, following must be ensured. First ensure that vacuum levels are optimal and not too high. Second, monitor the drive power load after forming fabric changes & find a fabric that lowers power consumption without endangering web properties. Last but not least, always keep fabrics and forming section in good conditions take care of efficient fiber cleaning.(8)

Few success stories of mills after the installation of new technology wire fabrics as reported in the literature are summarized below (1).

Forming Fabric Case Study 1

A newsprint machine with a Symformer top-wire forming unit operating at 1200 mpm was able to reduce forming section drive load by replacing the base fourdrinier double-layer fabric with a triple-layer fabric. Drive load went down by 212 kW and provided USD 71,000 annual savings.

Forming Fabric Case Study 2

A 100% recycled fiber based Machine has reduced forming section drive load after installing a triple-layer base fabric. Forming section drive load went down by 30% and provided a 352 reduction in horsepower and annual savings of USD 7,06,000.

Forming Fabric Case Study 3

A linerboard machine saw good benefits after installing an intrinsic weft, triple-layer design on the base fourdrinier position. The machine makes brown board with white top liner in a speed range of 400 to 600 mpm. Installation of new fabric results in improved sheet CD profiles, improved retention and formation on white top, increased solids off the couch from 22 to 24%, reduced retention aid addition by 20% while maintaining 94% retention, reduction in forming section drive loads by 8% and improved over all paper machine efficiency.

(2) Press Fabric

The press section accounts for about 18% of energy consumed by the paper machine. From this 18% of energy consumed, 71% is attributed to vacuum pumps, 21% to various drives and 8% to other energy consumers such as steam boxes.(6)

There have been significant improvements in press fabric designs in recent years. Some current fabric designs that perform well include laminated, multi-axial, seamed, fabric with special surface treatments and anti-rewet designs. Laminated fabrics are made with a combination of two of these base weaves and are used to improve fabric performance on the most demanding press section. Yarns in multi-axial fabrics are oriented in at least four directions (10). This results in better pressure uniformity, improved sheet moisture profiles and better compaction resistance, which provides good dewatering throughout fabric life.

With latest designs of unique hydrophilic yarn-based fabric that has an unmatched saturation capability sight from the start comparable to that of sponge. The "sponge effect" results in immediate nip saturation, i.e. maximum nip dewatering is achieved and enables a very fast start-up. This efficient drainage significantly reduces the vacuum requirement at suction boxes, which results in potential saving of vacuum energy. Another advantage is the minimization of the friction at suction box covers, which contributes in energy saving up to 8% of the total energy consumed by paper machine drives. This energy saving further increases when suction boxes are completely backed off. However, it is only possible if the press felts are specifically designed for this type of specific operating mode (6).

Another innovation in press felt is in the structurally bound weaving technology, where the drainage channels facilitate the flow of water in the press felt fabric, similar to the design used for forming fabrics (13). The precisely positioned MD & CD yarns in this new generation fabric are impressive when compared to multi-axial or laminated felt designs. The extremely fine paper side, controlled drainage, low initial void volume and uniform profiles result in immediate start up, high nip dewatering, perfect runnability and improved printability.

Press fabric variables related to water removal are pressure uniformity, compressibility and flow resistance. Pressure uniformity is affected by fabric base structure and batt application, large scale pressure uniformity is related to batt structure. Fabric compressive properties affect nip width, peak pressure achieved in press nips and fabric void volume. Compressibility of press fabric decreases

as fabric compact and become filled with contaminants. Flow resistance is the rate at which water can enter and exit the fabric. Low flow resistance allows water to move easily into & out of the fabric.(10)

A combination of woven and nonwoven structure gives excellent dewatering properties. They also offer the benefits of smooth surface, insulation against marking, dimensional stability and reduced plugging (9). A few case studies cited in literature illustrating this innovative approach are discussed below (1).

Press Fabric Case study 1

A fine paper machine producing copy paper grades with a tri-nip press plus a fourth press increased overall paper machine economics by upgrading press fabric designs. Laminated triple-layer fabrics with 15 denier batt were replaced by multi-axial fabrics with 9 denier flat fiber batt. Basis weight was run at 70 80 gsm to meet bulk and smoothness specifications with the original fabrics. The sheet was bulkier and smoother out of the press section with the multi-axial fabrics. The sheet required less calendering so the basis weight could be reduced to 9 gsm. The fabric changes also permitted a 5% increase in machine speed, reduction in main dryer section steam consumption, and a 25% reduction in number of breaks per day.

Press Fabric Case study 2

A southern linerboard machine operating at 500 mpm has a double-felted extended nip press operating at 900 kg/cm. The mill installed multi-axial fabrics on the top and bottom positions. Production remained constant due to speed limitations. Smoothness improved from 241 to 187 (lower is better). Steam consumption went down by 175 kg per day. Annual savings were USD 9,27,000.

Press Fabric Case study 3

A light-weight coated (LWC) paper machine operating at 1300 mpm installed multi-axial press fabrics on all four positions on their tri-nip plus fourth press section. The resulting 1.4% increase in press exit sheet solids provided the benefits of reduced steam consumption, which dropped from 0.6 kg steam/kg paper to 0.5 kg/kg at the same production rates (878 tons/day) resulting in annual energy savings of USD 3,32,000.

Press Fabric Case study 4

A tissue machine achieved total annual savings of USD 2,59,000 after installing a modern forming/press fabric design. The machine produces 12- 16 gsm tissue grades at speeds up to 1800 mpm. Overall energy consumption decreased by 4.4% including 400 ft/ton of gas and 15.6 kWh/ton of electricity.

(3) Dryer Fabric

Paper drying in dryer section of machine is influenced by openness and contact pressure of dryer fabric with the paper web. Fabric permeability has a large impact on ventilation of dryer pockets and evaporation rates. Some modern dryer fabrics have been designed

to provide high resistance to contaminant buildup so that fabric permeability can be maintained over time. Contact pressure caused by fabric tension and surface structure influence heat transfer from dryers cylinder to the sheet. The combination of heat transfer, mass transfer & stable transport of the sheet affect drying efficiency the dryer section (1).

Fabric permeability has a large impact on drying rates. Opening up dryer fabric increases the quality of hot, dry air introduced into dryer pockets and the draining force for drying.

Paper mills should select those dryer fabric designs that slow down build-up of contaminants and are easy to clean. Fabrics that run clean throughout life, result in higher drying rates without drop-off near the end of life. Clothing suppliers have developed an effective array of contaminant release products with impregnated fluoro polymers and unique physical construction, including flat-cross-direction & gowned filaments. Many types of dryer clothing are today available in "anti- pitch" Teflon design. These are used at extreme contamination levels or immediately after coating station.(11)

Increase in paper machine speeds and operating pressure and temperatures results in the demand of special dryer screens. With conventional raw materials like polyester, polyamides and acrylic used in dryer screens, designs have been developed which use glass impregnated with synthetic resins, aromatic polyamides (such as Nomex and Kevlar), poly- propylenes (such as Peck and Ryton) and PTFE (14). Recent developments in spiral and woven dryer fabric designs have provided energy savings on paper machine. Spiral dryer fabrics are an endless construction formed by joining helical formed loops of monofilament yarns. They provide higher permeability ranges than woven designs as well as potential for higher drying rates. Spiral fabrics have high contact area surfaces & have no weak link since they do not have traditional seams like woven fabrics. Recent processing and material improvement have resulted in spiral fabrics having no application limits. They can run on fastest writing/printing grade machines. The monofilament structure of the spiral screen and on- going dynamics/interaction of spirals and filling non- filaments during operation, make such clothing systems less vulnerable to contamination and deposits. This has become extremely important when working with waste paper furnishes. Given below are few case studies of improved dryer fabric installation on paper machines. The same has been reported by Reese (1).

Dryer Fabric Case Study 1

A linerboard machine was converted from running all woven dryer fabrics to spiral fabrics. No other changes were made on the machine. Benefits includes; Machine speed on same gsm increased from 570 to 590 mpm, average steam pressure dropped from 370 kg/cm² to 300 kg/cm². Production increased by 8.05 tons/day resulting in an annual profit increase of USD 5,64,000, alternately, steam consumption could be reduced by 3.2%.

Dryer Fabric Case Study 2

Another linerboard machine was converted from running all woven multifilament to all spiral designs. No other changes were made to

the machine. Benefits included: Sheet temperatures decreased indicating that additional evaporation was occurring, Pocket humidity levels stayed low showing that higher fabric void volumes increased air flows and increased drying. Production increased from 889 to 939 tons/day. Average dryer steam pressures dropped from 345 kg/cm² to 250 kg/cm² with annual steam saving of USD 122,000.

Dryer Fabric Case Studies 3 and 4

A dryer-limited uncoated free sheet machine installed a woven "pulsating" fabric design to increase drying rates by reducing dryer pocket humidities. This change provided a 40 to 65% reduction in pocket humidities. Fabric permeabilities of the original and pulsating design fabrics were the same. Machine speed was increased by 20 m/min and steam consumption went down by 2%. Total productivity and energy cost savings were over USD 850,000 per year.

A European machine producing carbonless grades used the same air pulsating technology to reduce pocket humidities by 16%. Steam consumption went down by 6% and machine speed was increased by 17 m/min. Total annual savings were USD 5,20,000.

Conclusion

Application of proper modern clothing fabric designs can produce significant energy saving on paper machines. Energy loss due to friction in wire part of paper machine can be reduced by installation of new generation polymer compositions like PET composition with compatibilizer, carbon nano tubes and nano- graphene. These new polymers not only save energy but they also have high abrasion resistance. In press part, the development of laminated, multi- axial seamed fabrics with special surface treatment and anti- rewet design, significantly reduce drive energy load. The use of hydrophobic yarns in dryer fabric provides excellent water saturation capacity. The latest development in dryer fabric of use of contaminant release products with impregnated fluoro polymers and their unique physical constructions including flat- cross-directional and gowned filaments proved to be a good saving opportunity in dryer section. Use of anti- pitch Teflon designs also provide an excellent means of improving dryer fabric permeability and thus reducing contamination built up. With these technological innovations in next generation wires, felts and fabrics, fundamental characteristics of paper machine clothing like higher wear resistance, reduced clogging, reduced marking, smooth surface, ability to operate at high temperatures and high nip loads and strong seams etc. are addressed. Also, the ever increasing quest for reduction in energy consumption also has taken care of. Mills are coming forth with success stories of installation of high technology fibers on several machines producing different grades. It is evident that paper makers who are not using modern fabric design are missing excellent opportunities to reduce energy consumption & total operating cost.

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