Development in "Forming Fabric Designs" To meet new Developments in Paper Machines

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INTRODUCTION

Papermaking process and machines have evolved into a modern and sophisticated technology from the old hand-made, mould and small Fourdrin--ier paper machines to high speed, wider width and totally automated machines. The rapid developments in paper machines have taken place due to:

- To overcome inherent quality drawbacks
- Reduce operating costs
- Improve productivity
- Use of recycled & Agro fibers.
- Use of higher quantity of fillers
- Consistent product quality

Likewise to meet the ever changing paper machine requirements and paper end user quality requirements, forming fabric designs have also undergone a sea change from single layer and double layer fabric to triple layer intrinsic MD and CD yarn fabric and three directional support fabric.

PAPER MACHINES

Till 1980s, the paper & board were produced in India, basically on small, old, slow speed Fourdrinier and cylinder mould machines. Developme--nt was stimulated by the limitations of the conventional Fourdrinier and vat machines. It was realized that regarding both speed and width, the limit was reached for economical development of the old basic designs. Secondly, the ever increasing speed of converting machines (printing machines) necessitated paper of better quality, evenness and smoothness.

Fig - 1

Fig - 2

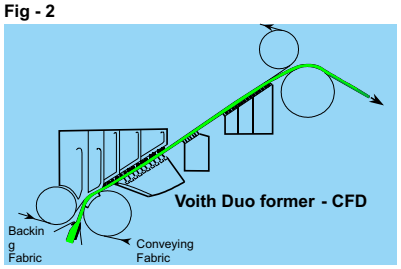

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Fig - 3

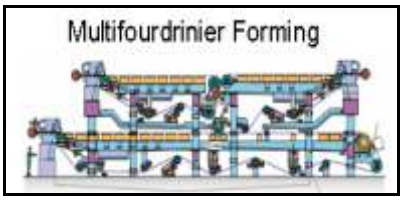


Fig - 4

It became difficult to meet these demand as speed and width were being increased and small irregularities were magnified. On the other hand, lower gsm grades were ruling the market. The demand from the end user pushed the necessity of new forming technologies to the forefront and new and advanced sheet forming technologies evolved to eliminate the limitations of convention--al forming methods. This opened the gates of Indian Paper Industry to machines like:

- Bel-Baie- II, III & IV (Fig-1)
- Duo Former CFD (Fig-2)
- 3 ply multi fourdrinier machines (Fig-3)
- Fourdrinier machines with top dewatering units (Fig-4)
- Papriformer & Duo-former former C (Fig 5)

Development Work:

Earlier the paper companies were the driving force for the development of paper making technology. As paper machines became more complex and the cost of further development rose, R&D was largely taken over by machine suppliers. Several major machine, builders operate pilot paper machines, which serve for the development of new papermaking technologies.

The rapid improvement of paper mach--ines in the last decade is an indication of the benefits papermakers derived from supplier-driven development. It is important to realize however that the interests of paper machine builders are not always identical to those of paperm--akers. So it is important that paper companies too maintain some efforts in papermaking and do not leave it entirely in the hands of suppliers.

The important elements of paper machines are:

- Table configuration
- Forming length
- Type of drainage elements- material and their design
- Cleaning equipments
- Machine speed

Table Configuration:

The earlier machines were usually fitted with number of table rolls. The pressure and suction pulse caused by a plain table had a detrimental influence on the formation of light weight sheet at higher speeds. As the speeds increased the usage of table rolls has become obsolete and gradually diminished.

The present trend of machine table configuration consists of high pulse foil blades Bi-vac and Tri-vac systems.
With high pulse foil blades in the initial forming zone, the fibre activity is maintained with minimum impact on the drainage. The usage of bi-vac and tri-vac systems have reduced the drag

Fig - 5

load / power requirement in the range of 15-30% and hence played a major role in machine speed up.

Fourdrinier Paper Machines:

The flat fourdrinier machines have a speed limitation as they have one sided drainage set-up only.

So, these machines have been rebuilt by installing a top dewatering unit-to enha--nce drainage by removing water from top side of the sheet, 25-30 % of water can be removed by Top wire. Further the fines & filler can be evenly distributed at the center of the sheet for enhancing printability quality.

Twin-wire Machines:

These are the state of the art machines, developed over a period of time to overcome the limitations / shortcoming of the flat Fourdrinier machines & Top Former machines. Majority of the new generation machines are of Twin wire formers due to the advantages mentioned below.

Twin wire machines like Papriformer, Bel-Baie, Duo-former, and Sym former, etc have been developed with specific requirements of:

- Higher operating speeds
- Increased dewatering by Hydraulic forces (4 times as compared to fourdrinier)
- Flexibility of paper grades & raw material usage.
- One sided sheet
- Wider width
- Smaller operating area
- Lighter gsm grades
- Greater optimization

The main difference of twin wire machines can be classified as:

- No defined table configuration
- Vertical / inclined head box
- Water removal mainly by roll and blade former and or combination.
- Roll former with or without shoe
- Blade former with or without matching shoes

FORMING FABRIC DESIGNS:

When so much hectic pace of development is taking place in paper machine building with reference to speed, quality of sheet made and dewatering mechanisms, how can the forming fabric designs lag behind. The ever demanding papermakers have put a great pressure on forming fabric manufacturers and they have responded equally. The fabric manufacturing process has itself undergone a sea change in technology upliftment.
The forming fabric is woven by considering the following parameters:

1. Fiber Support Index (FSI)-top surface mesh count & top yarn diamete--rs & weave pattern.

2. Drainability-DA% vary with the position of the fabric.

3. Frame Length-the aperture formed due to weaving of MD & CD yarns in a defined design. This can be varied depending on the fiber length & Concept of porometry.

4. CD / MD Ratio: The better the ratio, the better the fabric stability in both CD & MD. A new concept of Z-direction stability in the fabric.

5. Surface Topography-Top surface uniformity & its non-marking ability.

6. Wear Volume of the bottom-for longer life.

FORMING FABRIC DESIGN DEVELOPMENTS:

History

In the beginning, the fabrics imitated metal wires the early design being 2/1 twill. Because of inherent lower stability, these fabrics had stretching, guiding and creasing complications.

The next design was 4 shaft, which eliminated a lot of warp crimp and promised better stability.

The next designs in single layer were 5 shaft, 6 shaft and 8 shaft-which are still ruling the single layer designs and are being widely used in all segment of paper grades.

The development in fabric designs are an integral process of meeting papermakers and paper machines requirement. Basically a forming fabric is supplied to perform three operations:

- Allow water to drain through its drainage channels
- To support and retain filler and fibers to form a desired sheet
- Give a reasonable trouble free life

There are many designs available for different types of Paper machine configurations & different grades of paper made on it. The fabric design selection depends on:

- Type & configuration of the machine
- Paper quality & GSM
- Raw materials used
- Table length / drainage mode
- Machine speed
- Filler grades

A perfect forming fabric needs are:

- Free from marking
- Good retention (fibers and fillers)
- Good sheet formation and release
- Better wear resistance, dimensional stability.
- Good drainage
- Easy to keep clean

To meet the above multi-functional requirements, many design variations are available. But all the requirements cannot be met in one single design. Fabric manufacturing is a compromise of one requirement over the other.

On one hand, we can have a finer mesh fabric for excellent sheet properties at the cost of stability and life. And on the other hand a coarse fabric which gives longer life and stability but sacrificing fiber support aspect.

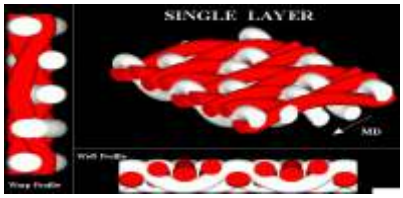
Due to growing use of short fibers, recycled fibers, higher speeds and shorter forming lengths of the machine, fabric design complexity has increased. In early stages of synthetic fabrics, there was no concept of porometry of fabric especially in single layer design due to its straight through drainage characteristics.

Development Work:

Single Layer Designs:

Single layer weaves had many limitations. One set of MD strand and one set of CD strands made a simple weave to form one weave for both sheet side and machine side in an opposed direction. All MD strands of the fabric predominantly present on the sheet side are able to support the sheet with

limitation as the most CD strands are disposed to the machine side for wear resistance of the fabric. More over the fabric is less rigid and dimensionally not stable because of the inherent weave design factors.



To overcome the basic constraints / limitations of single layer fabrics to meet present day paper machine requirements-multi-layer designs were developed.

Multilayer Designs:

Forming Fabric Requirements for Twin Wire Machines:

As these machines are operated at very high speeds (avg speed 1200 + mpm & some machines have gone beyond 2000 + mpm), the stress on fabrics to meet those challenging conditions have increased because of those speeds,

The Hydrodynamic forces are exceptionally high & call for a very dimensionally stable fabric in both CD & CMD (CD/MD ratio should very close).

The fabric requires lower void volume for easy drainability & reduced water carrying in the fabric body. This requires a very high count / fine mesh & low caliper of the fabric.

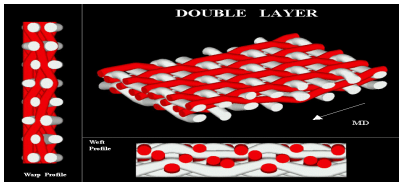
The fabric should give maximum support points to retain the fibers & fillers, even while maintaining drainage in a very short forming length & smooth release of the sheet to minimize fines carry over in the return circuit of the fabric.

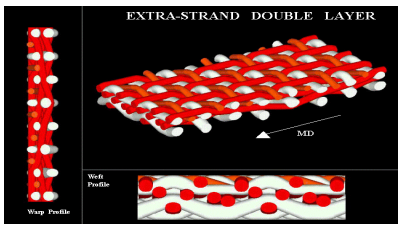
The fabric should be easy to clean inspite of the complex double warp intrinsic design by keeping the adequate Permeability of the fabric.

Double Layer Designs:

Advent of double layer weave design opened up opportunity to dispose one set of independent CD strands to the sheet side while another set of independent CD strands to the machine side for wear resistance. The fabric woven on a single set of MD strands forms independent weave patterns for both sheet and the machine side. These weave improvements had been envisaged mostly to improve on the sheet side weave for better sheet support, sheet release and other sheet related properties. This weave concept offered both the MD and CD strands preponderating on the sheet side by a balanced engineered design to give an enhanced sheet property over the single layer weave. The fiber supporting index figure as per Beran's calculation catapulted FSI by 20 % and improved to a gentle drainage because of an engineered positioning of the sheet side and machine side CD strands.

Double layer forming fabrics have been designed in many ways to serve a wide range of paper making machines & requirements. One significant break through is the "Extra pick " or an extra fine CD strand woven with precision to further improve support and retention the support figure increased by 15% over normal double layer.





Triple layer forming fabric:

Incessant demand for improved paper making is always keeping the fabric designers on their toes. Double layer fabric though very efficient , still have the limitation that the weave designs on sheet and machine sides are to be picked from a group twill and satin weaves because of inherent weave design factors.

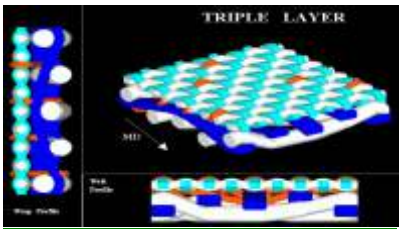
Introduction of two sets of independent MD strands with different diameter opened up plethora of opportunity to design various weaves for sheet and machine side. To cater to a wide range of paper, varied formation, drainage and other paper formation paper making cost matters the triple layer fabric is woven with a small square framed plain weave or short framed twills for sheet side and a strong coarse CD knuckle for wear resistance.

The first generation triple layer had been woven two independent designed fabric out of two sets of MD strands and on weaving- loom joined by added fine CD strands. This type of joining of two layer of fabric did not prove good for application. The fabric had not been good as a mechanical belt because of the weaker bondage, hence delaminati--on took place. Moreover, because the binding stitch added CD strands being unwanted in the basic weave for paper making, created hindrance in application. However the triple layer concept increased the FSI by another 25% over the extra pick double layer fabric.

The second generation triple layer forming fabric design involved some select sheet side CD strands engineered for making the sheet side weave as per requirement while binding with machine side MD strands at select positions. Elimination of the added binder strand and bonding the two layers with the body strands made the fabric an integrated woven fabric making the second generation triple layer fabric more compatible for mechanical forces in application.

The third generation triple layer is woven on two or three sets of MD strands to make a similar fabric as far as sheet properties and other paper making requirements are concerned. More concepts like MD strand binders using warp intrinsic strands from another set of MD strands are also being developed. This has oriented the binding stitches to the machine direction to make the triple layer fabric more tension withstanding at higher speed.

Still there are hoards of new concepts on the anvil to address ever increasing demands of the modern paper machines & the paper makers that are being constantly developed. We hope to introduce more new concepts of paper making forming fabric in near future.



Multilayer designs have been evolved in:

- 7 shed / 14 shed-Double layer, 2.5 layer & Triple Layer
- 8 shed / 16 shed-Double layer, 2.5 layer & Triple Layer
- 20 shed-Special Triple Layer
- 24 shed-Special Triple Layer

And now work is under progress for 32 shaft fabrics

All the above designs in Multi layer fabrics-Double, Extra Support & Triple (Fig-5) have been well established in the industry, especially to cater to the ever developing & improving Twin Wire machines & simultaneous impro--vements being made in top former machines to cater to the specific requirements of the machine as well as the paper sheet made on those machines, as they offer:

- Excellent and exceptional FSI (presently 170+) minimal wire marking, improved printability
- Low caliper - (fine triple layer for gap formers) lower water carrying
- Easy to keep clean (no need for very high pressure oscillating needle jet showers)
- Excellent sheet release
- Enhanced wear volume

Apart from this, they are now being manufactured to suit specific machine requirements with fine tuning of the properties with continuous, constant feedback from the paper makers & paper machine suppliers.

CONCLUSION

It is imperative to state that paper machine developments could not have been successful without the equal and corresponding developments made in the forming fabric designs from time to time.

The forming fabric developments have kept pace with papermakers demand and modern, high speed paper machine--s. In other words, the ability of meeting the stringent requirements of high spee--d machines has further propelled the developments with respect to:

- Speed
- Quality requirements
- Wider width
- Usage of short and recycled fibers
- Higher filler content

As of date-20 shed and 24 shed triple layer fabrics seem to be the ultimate, but they are getting challenged constan--tly with some fabric suppliers already stared work on 32 shed.