# The retention and drainage characteristics of Indian forming on Agriresidue Pulps

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The use of non-conventional raw m terials by Indian paper industry requires better understanding of forming fabric designs. The agriresidue and waste paper pulps have few typical features:

(i) Average fiber length of the furnish is small (0.6 to 1.0 mm).

(ii) Pulps are hydrated, thus requiring faster water removal in limited forming zone to achieve proper dry content at couch roll.

(iii) Use of filler is necessary to improve bulk and opacity for writing and printing grades of paper.

Retention is directly related to fiber bleeding. The more is the bleeding at forming zone, lesser is the retention. The bleeding also makes the operation of fabric risky in reference to its life. Analyzing the factors responsible for fiber bleeding, following play a dominant role (1) :

### (i) Papermaking practice

High jet angle impinging on the forming board can cause fiber buildup on foils and wet suction boxes, especially in the early part of the forming zone. Usually long fibers are found to accumulate in this zone. This phenomenon is strongly associated with typical size separation between long fibers (1.0 mm +) and rest of solids.

Using high vacuum in the later part of the forming table, the fiber and fines tend to migrate into the forming fabric structure and cause bleeding conditions.

### (ii) Process disturbances

If the first pass retention of the stock is poor, especially of that of the shorter components, (fines and fillers) the bleeding can occur,

Variations in the efficiency, discharge volume or reject ratio of stock from equ pments preceding the headbox, can cause process disturbances favourable for poor retention and bleeding.

### (iii Forming fabric design

The fiber support characteristics of the forming fabric is very important, and is equally important for long and short fibers.

The role of papermaking practice and the process disturbances is a subject of action and correction by the papermaker handling the machine The limitations of machine design, possible adjustments of jet and forming board, length of forming fabric available to the paper maker and the limitations of vacuum system are the parameters within which a papermaker has to work. This leaves the papermaker with only two aspects for the best results.

(i) Improve the first pass retention of the stock.

(ii) Select the right kind of forming fabric for his requirements.

### The criterion for evaluating forming fabric are

—Relative vertically projected area

—Water Flow Resistance

In general the drainage should take place in uniform manner without either quiescent zones or sudden high volume drainage. The drainage resistance of forming fabric is critical only in the initial forming zone. After the formation of initial web, the fabric works as flow controlling component. Fibers penetrate into the forming fabric thereby reducing drainage efficiency, Thus a forming fabric with dense surface

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may give better drainage if it is able to keep fibers out of fabric structure. The drainage resistance may be adjudged from the void volume and void distribution. The process parameters responsible for drainage are :

—Arrangement of drainage elements

—Fabric Tension

—Stock Characteristics

—Stock Height on Fabric

—Stock Temperature

—Stock Consistency

—Machine Speed

## Drainage and Formation

The sheet experience maximum drainage with initial static elements and low vacuum components before going to high vacuum elements This reduces drag, marking and chances of bleeding. Sheet formation is a complicated process. Generation and decay of turbulence, formation and breakdown of fiber network, transport and retention of fines, compaction/consolidation of web and the shear forces between formed web and free suspension are the phenomenon taking place simultaneously.

The best sheet structure is obtained through velocity formation with jet velocity less than wire speed in a drag mode(3). This gives fibers retained onto fabric rather than inside. Pressure formation drains fibers and fillers through the fabric. Sheet release problem and bleeding can also be more in pressure formation. Excess vacuum at foils in initial stages can seal the web from the bottom. The drainage of water at later part of wet section become difficult. The stock activity on fabric is affected by foil angle. machine speed and foil spacing. If the foils are far apart, shadowing or ghosting can occur. The stock activity on second foil is related to angle of the first foil. Thus for optimizing formation, first foil bank must have lower angle to improve retention and reduce drainage. Foil angles be increased in next foil banks and decreased later. Sometimes it is necessary to improve wet—end chemistry to control flocking, excessive activity or stock jumping (3).

In alkaline papermaking sheet looks wetter. One should be cautions in reacting to this wet appearance. Actually the lower levels of slurry are heavier in solids, while the bulk of Water is carried above the fiber mat. This top water gives wetter appearance (4). Alkaline system results in relatively more fabric wear. This is mainly due to higher filler content in web with alkaline systems. To reduce fabric wear material of vacuum box coverings and the water available for lubrication need proper consideration. Fabrics must be designed with higher mesh and count to improve retention and reduce wear. retention aids be preferably used to support the function of fabric for improved retention

## Forming Fabrics

The fiber supporting characteristics of the fabric are primarily dependent on (2) :

—Number of support points

—Distribution of support points

—Orientation of support points

—Surface topography

These parameters depend on :

—Mesh or Number of MD strands per unit length

—Count, Number of CD strands per unit length

—Weave pattern

—Running attitude, Long knuckle up or down

## Single layer fabrics

The most commonly used fabric is 4-Shaft. One surface is dominated by long MD knuckle while other by long CD knuckle. For most of applications, sheet is formed on the long MD knuckle surface. The CD long knuckle surface is wear surface. The loss of thickness in CD monofilaments does not influence the load bearing capacity of fabric. Fibers on such fabrics tend to align towards machine direction.

However, the low basis weight papers are preferred on long CD knuckle for better fiber support and improved release (2). It may give prominent wire making. When long MD knuckle is wear surface, the wear resistance of fabric is reduced. The primary variables in 4 shaft fabric are :

—Mesh, or no. of MD strands per unit length.

—Count, or no. of CD strands per unit length.

—MD Strands diameter.

—CD Strand diameter.

—Running attitudes.

These variables are not totally independent. The number of strands per unit length and their size are interdependent becauae, as the number of strands in either direction is increased, strand diameter must be decreased to maintain adequate drainage capacity. Larger CD strand diameter will result in increased wear potential. The fabric becomes slightly coarser making fabric prone to marking and bleeding.

Development of the 5–shaft fabric has the major impact of compromising between opposing characteristics (2). It provides more void volume for the same mesh, count and strands dia. Open bottlenecks drain faster. In fact it is necessary to increase mesh and count to prevent extremely fast drainage during initial forming zone preventing solid loss. Increase in mesh increases its stability and wear potential.

## Double layer Fabrics

The 5 shaft design provides drainage capacity equal to that of the previously discussed 4 shaft design. It is substantially finer fabric which, with improved stability and wear potential. The double layer fabrics have almost 100% MD strand density, i. e. no. of MD strands per unit length x strand dia should be 1. CD strands are stacked almost one over other thus void volume and drainage capacity improved but the thickness of fabric was much higher (2).

The most significant effects of this double layer structure are :

—Controlled initial drainage

—Increased fiber support

—Improved stability

Since the capillaries for the removal of water change their direction several times, the velocity of drainage is reduced and the web is formed slowly and uniformly. This also results in lesser solid loss during initial forming. Increased strand number offer higher fiber support thus less penetration of fibers in fabric.

## Optimization of Forming Zone

Figure 1 shows volume of water removed vs. foil angle and stock activity. It also gives percent solids removed from the sheet vs. activity (3). It is interesting that the foil causes a pulse, which makes the stock suspension move or jump on top of the forming fabric. The degree of this activity is affected by foil angle, machine speed, and foil spacing. It is apparent that the activity curve directly affects the amount of water removed. The solids pulled through the forming fabric are also affected.

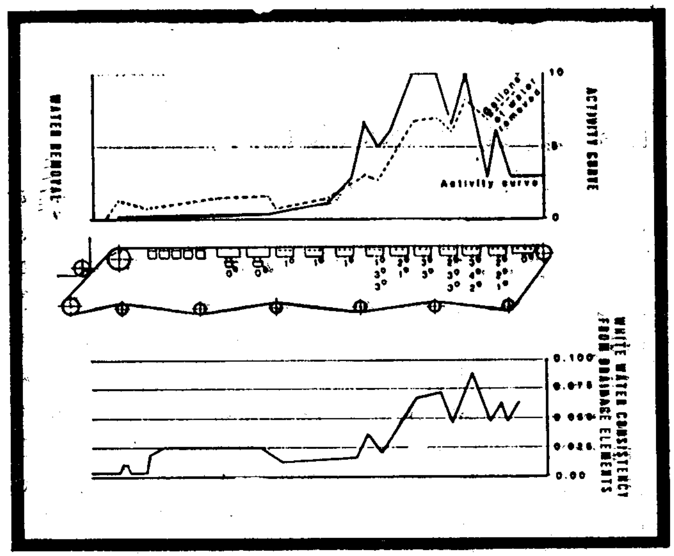


FIGURE 1
(Top) Water removal vs. foil angle and activity.
(Bottom) Solids removal (%) vs. activity.

Figure 2 shows phase shift that are caused by spacing differences with the foil or drainage element distances (3). Phase 1 is the slice discharge coming in contact with the forming fabric at the leading edge of the forming board. Phase 2 usually occurs because of the difference in distance between the leading edge of the forming board blade to the first foil Phase 3 shows a different spacing between a four blade foil and a two-blade foil and a three-blade foil. Foil spacing affects stock pulse frequency, whereas foil angles affect the pulse height.

When stock jump is observed, it appears that the stock is being thrown. In reality, due to the speed of the fabric, the airborne stock is carried down the table from the fabric as a droplet. The point where it lands is generally before the point it left when it became airborne in the forming zone.

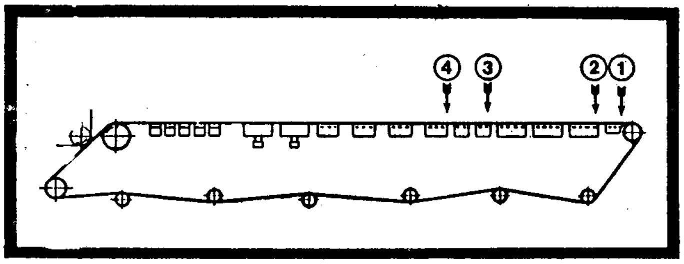


FIGURE 2
Phase shifts caused by different spacing between foils or drainage elements.

## Drainage Characterization

Characterization of table layouts began in conjunction with the use of the first single—layer plastic fabrics. Figere 3, 4 & 5 shows a typical drainage and consistency curve for the standard single layer 5—shed design in conjunction with the table layout. Note the very high initial drainage rate at the forming broad. Drainage rate and consistency measurements from the current double layer standard design are illustrated in figure 4 (5). The forming board has a much lower drainage rate, while the drainage rate throughout the length of the table is more uniform. Overall retention is nearly 68%—compared to 55% with the single layer. Due to controlled drainage rates, High MD warp density, High fiber support level and Smaller overall hole size, the backwash is found to be much lesser (5).

## Experimental Evaluation of Indian Forming Fabrics

The samples from the Indian forming fabrics were evaluated for their Retention and Drainage capacities. To specify the fabrics experimented, some of their characteristic features were also evaluated. Commercial agri-residue pulp from one of the large Indian paper mill was taken for experiments. The results and conclusions are given.

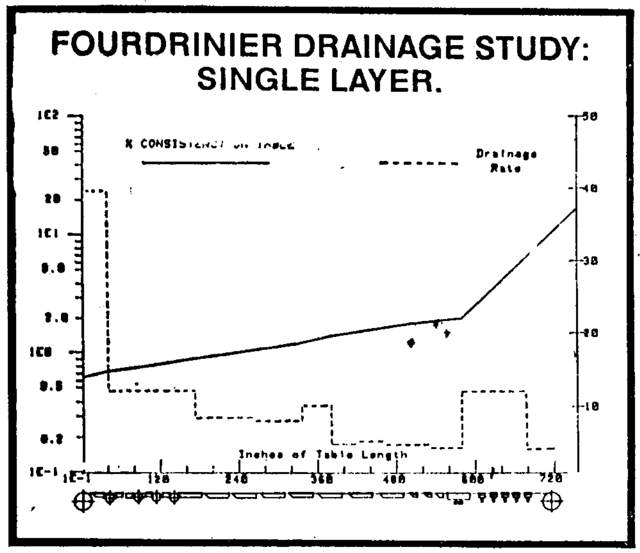


FIGURE 3.

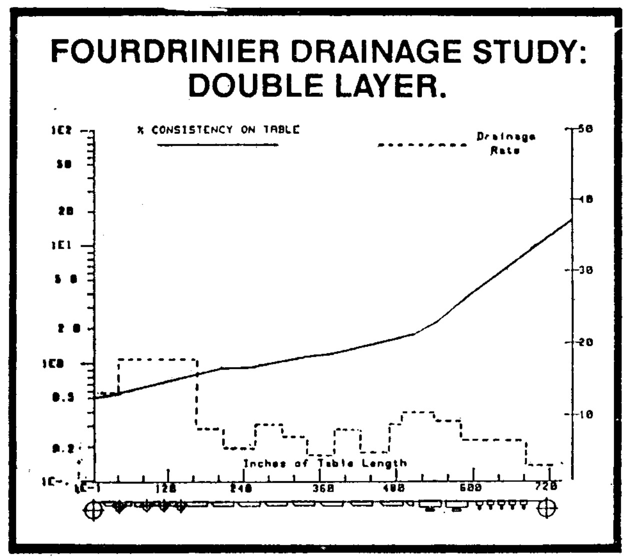


FIGURE 4.

The number of CD and MD strands/cm and diameter were counted with the help of micrscope. Thickness of fabric was noted by micrometer. The percentage of vertically projected area and void volume were calculated as follows.

Vertically Projected area %

$$= 100 - (\text{CD strand dia} \times 10 \times \text{No of CD strands} + \text{MD strand dia} \times 10 \times \text{No of MD strands}) - (\text{MD strand dia} \times \text{CD strand dia} \times \text{No of CD strand} \times \text{No of MD strands})$$

Void volume%

$= 100 \times$ fabric thickness—(n × 1('/4)

× (No of CD strands × (CD strand dia)$^2$

× No of MD strands × (MD strand dia)$^2$

× 1C0/(100 × Fabric thickness)

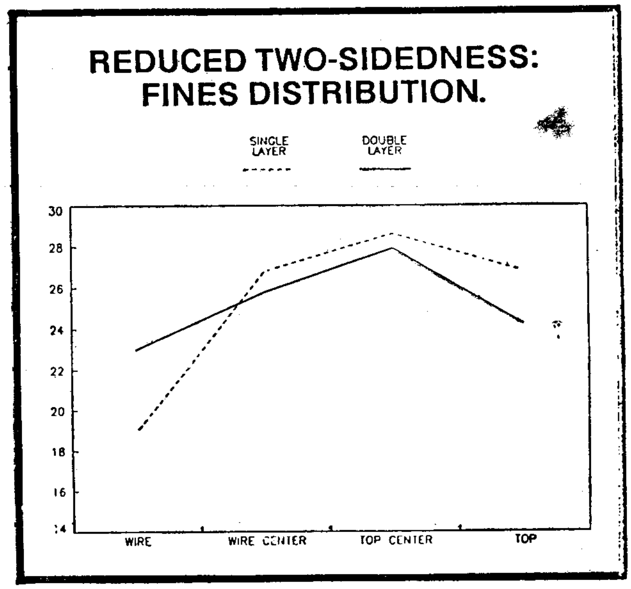


FIGURE 5.

STOCK CHARACTERISTICS

| Stock | °SR | Fine Fraction (—)70 fraction | Consistency% |
|---|---|---|---|
| Unbeaten | 25 | 38.78 | 0.499 |
| Beaten | 43 | 49.54 | 0.502 |

FABRIC CHARACTERISTICS

| Fabric Number | Layer/ Shaft | MD Strands Number/cm | MD Strands Dia | CD Strands Number/cm | CD Strands Dia |
|---|---|---|---|---|---|
| 1 | Single/4 | 32 | 0.17 | 26 | 0.14 |
| 2 | Single/4 | 31 | 0.22 | 22 | 0.14 |
| 3 | Single/4 | 26 | 0.24/0.25 | 19 | 0.18 |
| 4 | Double | 71 | 0.09 | 58 | 0.09 |
| 5 | Double | 69 | 0.14/12 | 54 | 0.09 |

| Fabric Number | Vertically Projected Area % | Void Volume % |
|---|---|---|
| 1 | 29 | 75 5 |
| 2 | 22 | 69 39 |
| 3 | 24 | 71 5 |
| 4 | — | 87 96 |
| 5 | — | 81.55 |

## TEST RESULTS

Unbeaten, with 500 rpm in drainage jar

| Fabric Number | First Pass Retention % | Water Removal Efficiency % | 30—Second Drainage Vol. ml. |
|---|---|---|---|
| 1 | 81.86 | 9.95 | 120 |
| 2 | 81.92 | 10.17 | 114 |
| 3 | 87.11 | 9.08 | 111 |
| 4 | 90.61 | 10.50 | 92 |
| 5 | 85.08 | 8.75 | 110 |

Unbeaten, with 750 rpm in drainage jar

| Fabric Number | First Pass Retention % | Water Removal Efficiency % | 30—Second Drainage Vol. ml. |
|---|---|---|---|
| 1 | 79.55 | 9 61 | 123 |
| 2 | 79.94 | 9.97 | 121 |
| 3 | 89 47 | 9.32 | 112 |
| 4 | 86.44 | 10.14 | 96 |
| 5 | 80.71 | 9.52 | 115 |

Beaten, with 500 rpm in drainage jar

| Fabric Number | First Pass Retention % | Water Removal Efficiency % | 30—Second Drainage Vol. ml. |
|---|---|---|---|
| 1 | 79.39 | 11.47 | 116 |
| 2 | 76 00 | 14.54 | 98 |
| 3 | 80.45 | 9.89 | 108 |
| 4 | 81.20 | 14.30 | 109 |
| 5 | 80 50 | 15.15 | 109 |

Beaten, with 750 rpm in drainage jar

| Fabric Number | First Pass Retention % | Water Removal Efficiency % | 30—Second Drainage Vol. ml. |
|---|---|---|---|
| 1 | 70.88 | 12.16 | 129 |
| 2 | 72.97 | 12.04 | 106 |
| 3 | 81.53 | 11.50 | 101 |
| 4 | 74 53 | 10.56 | 108 |
| 5 | 73 06 | 13.09 | 105 |

### Conclusions

First pass retention reduces and 30 second drainage volume increases with increase in turbulence. Thus increased turbulence increases the drainage rate for all types of fabrics evaluated.

Beaten Stock tends to choke the pores of fabric thus drainage volume is less. This is evident from the comparison between 20 and 43° SR pulps.

Fabric number 1, 2 and 3 are having Fiber support index in reducing order. The vertically projected open area for single layer fabric 1 is highest and least for number 2.

Comparing the single layer fabrics, the fabric number 1 has the best Fiber Support Index, Large vertically open area, Large void volume fraction thus gives the best drainage rate and first pass retention. In double layer samples. Fabric number 4 has the best Fiber Support Index, good drainage with good First Pass Retention Void volume is more for double layer fabrics than for single layer fabrics.

Concluding from experiments, Single layer fabric with about 29% projected area and 75% void volume is best suited for agriresidues. In double layer catagory, Higher MD strands with lowest strand dia will perform better for agriresidues.

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