Synthetic Fabrics Evolution and Design

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SUMMARY

In brief historical development of synthetic fabrics have been discussed in the paper. The development of polyester monofilament yarn is the main reason which successfully made possible to give a proper design to synthetic paper machine wires. The paper has also given desirable characteristics required in the fabric, fabric types available.

INTRODUCTION

Synthetic fabrics were originally run on paper machines in East Germany immediately after World War 2. Since there was at that time a shortage of copper, the trials would not appear to have been particularly successful due to the lack of a suitable synthetic material for use in their manufacture. We will now discuss developments from that date up to the present and what design features have contributed to the success of the synthetic wire.

The next trials and development of synthetic fabrics took place in the United States in the middle 1950's. The company which pioneered this work was the Huyck Corporation who were already manfacturers of synthetic dryer felts and the technology from these was applied to the wet end of the paper machines in order to manufacture a successful synthetic wire. At the time that this work was carried out, suitable monofilament yarns were not available and multifilament yarns, i.e. yarns of several plies made up from large numbers of yarns, were utilised. It is not possible to form a seam in multifilament cloth and to allow a wire to be manufactured without a seam, endless weaving, sometimes called circular weaving was employed. The machine to which these early fabrics were fitted were generally old and slow. There were obvious problems in these early fabrics two of the most important being :

1. Modulus of elasticity and
2. Cross directional stability

We shall investigate these factors at greater length shortly but for the meantime it is sufficient to say that because of these problems a 4-shed weave pattern as opposed to a 3-shed twill as used in metal wires was adopted and the multifilament fabrics were resin coated for stability and bowed rolls "Mount Hope Rolls" were used to maintain the fabric flat on the machine.

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In the early 1960's the development of polyester yarns which overcame the previous problems of monofilament yarns meant that seamed monofilament fabrics became technically possible. It is this type of fabric which is discussed in this paper on fabric design.

A great deal of experience has now been accumulated by suppliers on the manufacture of fabrics which has been translated into new fabric designs. The parameters which govern good fabric design are set out below and are followed by a selection of our fabrics and the types of production for which they are suited.

FABRIC DESIGN

The desirable characteristics of a good fabric are considered to be as follows:

1. **Good stability**
   - 1.1 High modulus of Elasticity
   - 1.2 High rigidity
   - 1.3 Regular width
2. **Correct Permeability (Drainage)**
3. **Minimum Wire Marking Characteristics**
4. **Resistance to wear**

1. Stability

1.1. Modulus of Elasticity—Initial Modulus—This represents fabric stretch from the relaxed condition up to running tension and results from straightening out of the crimp in the machine direction yarns. This accounts for the bulk of fabric stretch. It is not normally a worrying feature as long as

a) the fabric is undersized sufficiently to ensure that this initial stretching is finished by the time running tension is achieved and

b) the machine is capable of accepting a fabric slightly shorter than nominal Pb wire length.

We attempt to maintain this initial fabric stretch at as low a value as possible in order that the relaxed length of the fabric may be as close to the running length of the machine as possible.

Modulus of Elasticity—Running Modulus— This is the resistance of a fabric to stretch and contraction at machine running tensions. The modulus must be sufficient to ensure that running tension is achieved before the fabric stretches to the limit of the machine, otherwise the fabric will become too long for the machine. The higher the machine running tension, then the higher must be the running modulus of the fabric. The modulus figure required to overcome the above problem is generally not too difficult to achieve.

The major problem occurs, however, due to the fact that a fabric whilst travelling round the paper machine will experience different levels of tension at different points on the machine and in particular, will pass from a very high tension area, located after the vacuum boxes and before the driving couch roll, and then on to a relatively low tension area between the couch roll and the first return roll. On high speed machines this tension differential can be as much as 20 kgs/cm.

The effect of this differential is that the fabric having extended in length and contracted in width at the high tension area, then contracts in length and expands in width at the low tension area. The lower the running modulus of the fabric then the more violent and pronounced is the dimentional change. The result in low modulus fabrics may be ridging and creasing over the first return roll.

The modulus of elasticity required to overcome this problem depends on the machine in question, but it would appear that on high speed machines using high vacuum loads a modulus in excess of 1000 kg/cm may be required, whereas fabrics on smaller slow speed machines can operate with a modulus less than half this value.

The modulus of a fabric is affected by the design of the fabric in terms of the weave type, the number of warp yarns per unit width and also the diameters of yarns being used. However, the vital factor in establishing adequate fabric modulus is the amount of stretch which the fabric is subjected to during the heat setting process. The greater the degree of permanent stretch imparted to a fabric during heat setting, then the less is the elasticity remaining in the fabric and so the higher is the modulus.

However, with the high heat setting stretch a problem arises in that because the stretching occurs in the heating zone, then contraction in width also occurs in this localised area, and excessive side contraction can be physically controlled then high modulus fabrics cannot be successfully manufactured.

Fortunately we have developed a process whereby complete physical control of the fabric can be achieved and as a result we are able to obtain modulus figures sufficiently high, we believe to overcome the running problems outlined above.

1.2 *High Rigidity*—This is a feature that effects the runnability of our fabrics in that, should a fabric contain areas of furrows then these slacker areas will tend to fold into creases over the machine return roll. Furrows in fabrics are generally due to width variations. Width variations are a feature of the woven fabric and are caused by uneveness in loom weaving tensions or by variations in weft yarn quality. Unless these width variations can be removed then

a) they will appear as bands of furrows in the finished fabric and

b) they will cause difficulties in matching up the opposite edges of the fabric seams.

During heat setting any uncontrolled side shrinkage will accentuate width variations and so aggravate the problems. Fortunately the heat setting process which we have developed to prevent fabric creasing during high-stretch heat setting, also acts to smooth out the peaks of fabric width variations and so produce a regular width fabric, free from furrows and relatively easy to seam.

2. **Permeability**

Permeability i.e. Drainage, is, after physical stability, probably the most important factor effecting fabric runnability. Permeability determines whether or not the paper machine can efficiently dewater the pulp slurry, but permeability also effects the following features of fabric performance:-

a) Rate of wear: poor drainage will cause suction box vacuum to increase, resulting in higher friction and increased wear.

b) Fabric slippage: poor drainage will result in higher drag load at the boxes which will encourage the fabric to slip on the drive/couch roll and so further increase wear, or result in the fabric stalling.

c) Fines loss/Fabric Blinding: fabrics which have been designed with a permeability which is either too low or too high can give rise to problems of fines loss or fabric blinding.

3. **Wire Mark**

Wire mark is deterimined by the prominance and shape of the yarns dominating the paper making surface of the fabric and the 'cover' or area of surface contact which the fabric presents to the paper matt. Because fabric stretch and side shrinkage occur as a result of the yarn crimps being transferred from warp to weft the wire marking charactristics of fabrics are affected by the degree of stretch imparted during heat setting.

In the case of three-shed twill fabrics, wire mark is caused by the weft knuckle, which is the dominant yarn when the fabric is run in the conventional way. Low modulus fabrics which receive relatively low heat setting stretch have the height of the weft knuckle below, or level with, the warp yarn knuckle. Consequently, low modulus three-shed fabrics produce a wire mark no more severe than a conventional phosphor bronze wire. However, with increased heat setting stretch, weft knuckle height increases above the height of the warp knuckle and so the wire mark from these higher modulus fabrics has tended to deteriorate. Conversely on the underside of the fabric the dominant knuckles of the warp yarns tend with increased heat setting stretch, to drop to the level of the weft knuckle and so yarn 'cover' is improved Consequently, the situation arises that with higher modulus fabrics, the wire marking characteristics of the fabric 'underside' become more acceptable than the wire marking characteristics of the conventional 'topside'.

The same rule applies to four-shed fabrics but in this case on both sides of the fabric the long 'float' of the dominant knuckle produces extremely good 'cover' and surface contact and so the wire marking charactristics are particularly good.

4. **Resistance to Wear**

It is assumed that the yarns used in the construction of the fabric, have a high resistance to:

a) abrasion and
b) chemical attack.

Summary

1. The Modulus of Elasticity of a fabric (resistance to stretch) is the prime consideration when designing fabrics, particularly for high speed machines.
2. With three-shed fabrics the modulus of the fabric effects the wire marking characteristics of the fabric to such an extent that with higher modulus fabrics the conventional underside of the cloth will produce less w]re mark than the topside.
3. The permeability or drainage, of a fabric has an important effect on many of the features of fabric runnability and a correct balance must be struck between adequate fabric drainage and fabric rigidity.
4. Four-shed weave fabrics in their woven state are of a relatively higher modulus than the equivalent three-shed fabrics and so require less heat setting stretch to achieve the same modulus value.
5. The good yarn cover experienced with four-shed fabrics improves their wire marking charactristics over the conventional three-shed cloth.

FABRIC TYPES

The main types of fabric design produced are:-

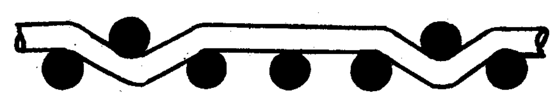
1. Plain weave (2 shed)
2. Twill Weave (3 shed)
3. 4 Harness satin weave (4 shed)
4. 5 Shaft twill (5 shed)
5. Double layer fabric

The first type, plain weave is only used for one type of fabric 18 A.O. grade which replaces twist wires for pulp machines. Plain weave means that the warp filament passes over then under 1 weft filament as in the drawing below. This is the simplest possible weave pattern.

The second type, twill weave (3 shed) is the normal design for metal wires, and also for fabrics for lower speed and tissue machines. In this design the warp filament passes under 1 weft filament then over two weft filaments as in the drawing below. This type of fabric includes 47-D-1, 55-D-O and is identified in our fabric brochure under "warp run" as 1/2 or 2/1.

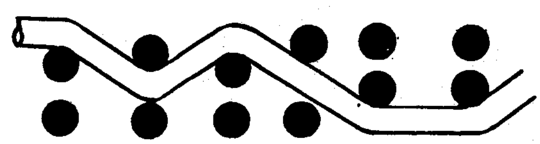
The third type 4 harness satin weave (4 shed) is the normal fabric design for high speed machines running at speeds in excess of 400 m.p.m. manufacturing Newsprint, Kraft, Printing, Gravure paper, etc.

In this design the warp filament passes under 1 weft filament then over three weft filaments. This design is more stretch resistant than 3 shed due to the fact that there are less crimps in the warp filaments. This is one of the most important physical properties required for large fast machines, together with cross machine stability, permeability and paper side smoothness. This type of fabric includes 38-H-1, 46-J-1 and is identified in our fabric brochure under 'warp run' as 1/3 or 3/1.



The fourth type, 5 shaft weave is exactly the same pattern as three shed twill except that the warp passes over 4 wefts instead of two wefts on the underside.

The fifth type, double layer fabrics, have a compound weave which is from 5-shed upwards. There are two sets of warps immediately above one another and the warp follows a more complicated pattern which is shown in the sketch underneath

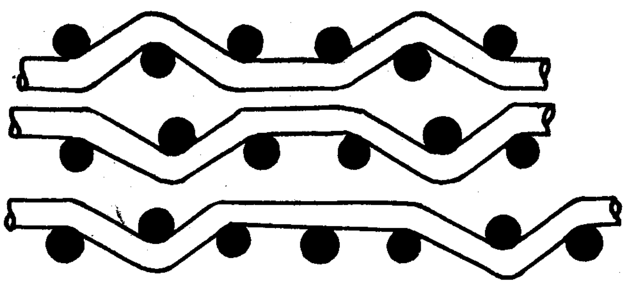


INVERTED FABRICS

Metal wires which were for many years the normal wet end clothing for paper machines were manufactured in twill weave. In this design the smooth or topside of the wire is the side with the long weft (cross direction) float. The under two warp knuckle of the wire is the side of the wire which contacts the paper machine and is therefore the wearing surface.

In fabric wires the heat stablisation treatment which the fabrics undergo means that the smooth side of the fabric is tansferred to the opposite side of the cloth, that is to the side with the long warp float. The long weft knuckle which contacts the machine surfaces is therefore the wearing surface. This means that normally fabrics are run "upside down" compared with conventional phosphor bronze wires. The drawings below show the warp runs for

1. Phosphor bronze wires
2. 3 – Shed fabrics
3. 4 – shed fabrics.

1.
2.
3.


There are two cases where the fabrics would not be run in this configuration. These are :

1. High speed tissue machines with a suction breast roll, and
2. Kraft Paper Machines which produce sach Kraft and have problems with M.C. cross direction strength ratio.

The reasons for supplying fabrics to these machines with a conventional bronze wire configuration, fabric to paper sheet, is the improved drainage and machine runnability which this configuration gives.

In the case of tissue machines the sheet has fewer pinholes, has less tendency to stapling through the fabric and is more easily lifted from the fabric by the suction pickup. Kraft paper machines however, benefit from the improved cross direction to machine direction strength ratio, especially at high speed, and as in the case of tissue by improved suction pick-up performance.