Paper Machine Wire

By R. S. D. Pandey*

WIRE is the most important part of a Paper Machine where actually the formation of paper web takes place. It is a woven metal cloth, which allows drainage of water but retains the fibres. The following table gives a short history of development of Paper Machine wire with the increase in Paper Machine Production.

Year	Wire width in metres.	Machine speed in metres/ minutes.	Production in Metric Tonnes/ 24 hours.
1803	0.80	5	0.12
1840	1.50	15	0.50
1880	2.50	60	3.0
1903	4.0	140	20.0
1924	7.70	365	170.0
1934	8.13	425	225.0

The metal used for the manufacture of wire is either Phospher bronze or brass. Phosphor bronze combines outstanding properties with a high resistance to the corossion, possesses high degree of strength, toughness, resistant to fatigue and withstands acids and alkalies in normal concentrations. At first appearance stainless steel would appear to be a most suitable alloy, although it has the most desirable qualities. It is subject to rapid work hardening and fatigue when used in a wire, though it has been proved successful for covering cylinder moulds and other drums.

Longitudinal or warp wires are always finished from wires of Phosphor bronze. It consists 6—7% tin, 92.6—93.7% copper and 0.4—0.3% Phosphorous. The strength of warp should be 42—45 kg/mm^2 and stretch 45—60%.

Cross or Weft wires are made of alloy with 20—25% tin and 80—75% copper. The strength of weft wire may be less and may be to the order of 34—40 kg/mm^2 and stretch 32—38%.

Diameter of warp and weft wires are different and are in the range of 0.7—0.3 mm depending on the mesh of the wire. Number of weft wires is about $\frac{2}{3}$ or $\frac{3}{5}$ of the number of longitudinal wires. Diameter of warp wires is ordinarily less than that of weft wires and the ratio of diameters is in the range of 0.85—1.0. The subject will be discussed under the following Head lines :

1. Numbering of wires
2. Dimension of wires
3. Weave
4. Selection of weave
5. Wire mark
6. Drainage capacity of a wire
7. Factors affecting wire life and methods to improve it
8. Cleaning of wires.

NUMBERING OF WIRES :

Characteristics of wires are denoted by its mesh number which is number of warp (longitudinal) threads per unit length. The unit of length internationally chosen is centimetre except in the countries where english is spoken. The relation between metric and english mesh are given below :

Metric	English
8	20
12	30
14	35
16	40
18	45
20	50
30	75
40	100

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DIMENSION OF WIRE :

The length of wires used are in the range of 14—40 metres depending on quality of paper and production desired. Wire length for certain grades of paper are given below :

Quality of Paper	Wire length in metres
Light M.G. Paper made on lick-up machine	14—16
Very light tissue paper e.g., Condenser Tissue	14—16
Quality Paper	16—25
M. G. Packing paper	16—25
M. F. Packing and sack paper	28—40
Parchment	25—32
High speed news print	25—30
Kraft liner for corrugated board	40 metres.

In order to find out the wire length it is necessary to find out load of production in Kg/m^2 per hour from tables available with paper machine designers.

F = b.l Sq. metre

where L is the working length (Centre to distance between breast and couch roll),

b is the width of the wire

Hourly production of machine.

$$Q = 0.06\ b\ v\ g\ \text{kg/hr.}$$

Where v=Machine speed in meters per minute

g=Gram weight of the paper in Grams per metre sq,

b=is the width of the wire

Load on the wire table is denoted by relation -

$$K = \frac{Q}{F} = \frac{0.06\ .\ b.v.g.}{b.L.} = 0.6\ \frac{v.g.}{L}$$

or $L = \frac{.06.\ v.\ g.}{K.}$ Where L is working length.

The relation of wire length and working length depends on quality of paper and machine speed which is in the range of 2.16 to 2.25.

Hence total wire length lw — (2.16 to 2.25) L.

The width of wire can be calculated as follows :

$$Bw = b \div 2Z = \frac{(b \div 2Z)}{100 - S} + 2r + 2f + 2L$$

Bw = Wire width in meters.

b = Trimmed width of paper in Cms.

z = Trim of paper on cross-cutter i.e. 2.5 cms.

s = Shrinkage of paper in cross direction in dryers in percent, in relation to wet paper which depends on the quality of paper.

r = Trim on wet part which depends on type of deckle straps
For rubber straps r = 1 — 1.5 Cms.
For other type r = 3 – 4 Cms.

F = Limit of formation
For rubber strap type = 4 — 5 Cms.

Other type = 1.0 Cms

L = Free area on both sides of wire may be assumed. 3.5-5 cms.

Example—Finding the width of wire for a machine making writing paper of trimmed width. b = 4300 mm.

Assuming — Z = 25 mm ; r = 40 mm ; f = 10 mm ; L = 40 mm ; S = 6% then the width of wire

$$Bw = \frac{100\ (4300+2.25) \div 2.40 \div 2.10 \div 2.40}{100-6} = 4.800\text{mm.}$$

WEAVE OF THE WIRES :

1. **Plain Weave**—is made in this way that warp wire passes alternately up and down through weft wires. Paper machine wire in the range of plain weave are from 18—35. Dandy roll wires are finished of heavy wires in the range from 12-35 mesh.

2. **Twill Weave**—"Two up one down" the big weft knuckles are inside and thus almost double the area of weave giving longer life than plain weave.

At the same time large warp knuckles are on the top side almost doubling the area of support to the web. Lower surface of the wire is smooth has more surface and has very high wear and tear resistance. They are manufactured in the range of 18—32. Drainage is slightly less but is more durable and therefore they are more frequently used in the manufacture of paper, than plain weave. 90% of wires used today are twill weave.

3. **Double or Triple. Chain Weave :**

It differs from plain weave in this respect that each simple warp thread is replaced by a group of two or three warp threads of much finer diameter thereby minimising the loss of fine fibres and therefore used for fine papers which require a wire of good tensile strength and a wire which produce a minimum of wire mark.

Numbering of such wire—70/210 (liner inch)

70 is No. of warp group thread/inch and 210 is the total No. of warp thread per inch. The scale of triple warp wires extends from No. 55/165 to 80/240 and enen 85/255. The No. 70/210 is the most common and used for the manufacture of cigarette tissue.

4. **Twisted Wires :**

Where it is desired to use a wide mesh wire, instead of increasing the diameter of warp wires, the single warp is replaced by a cable of fine wires which enable it to obtain flexibility coupled with long life which can not be obtained by using large diameter wires.

Single twisted—Twisted warp and single weft.

Double twisted—warp and weft both twisted.

Seams are today usually made by welding or soldering. Most wire manufacturers now stagger the seams which means that one warp end, starting at the seam goes round the wire in a helical form to finish up at the seam a number of ends away from where it started. This prevents grooving of the boxes as the wire strands do not continue to run in the same place. Snake weave is another method where the wire is woven so that warp ends do not run straight round the wire but in a sinuous form.

SELECTION OF A WEAVE :

Following things are to be taken into consideration when selecting a wire.

1. Wire may leave impression on wire side which gives a different look-through for both sides of the paper. Fine wires are better in this respect than coarse one.

2. Drainage rate depends on mesh and type of weave. Wire for making paper from wet stock

must have more ability for drainage than paper from free stock.

3. Mesh No. of wire should be selected in such a way that loss of fibre through the wire in the back water is not too much. This water with large amount of fibres is put into circulation is not good as it increases two sidedness in the paper. In general, the selection of wire is good when the amount of fibre in the tray water is not more than 400—800 mg/litre in first Section of Table rolls for paper made from chemical pulp or with little amount of mechanical pulp. With mechanical pulp this figure may go upto 3 times.

Quality of paper or type of machine.	Weave	Mesh Number
Cigarette tissue, condenser tissue light printing and decorative packing.	Plain	30—35
	Triple warp	24—30
	Twill weave	
Wood free writing & printing	Twill weave	26—28
Parchment	Plain	26—28
Newsprint	Plain	24—26
Wood free packing & sack paper of average and high gram weight	Plain	18—22
	Twill	18—20
	Twisted	18—20
Thick paper and board from mechanical pulp	Twill weave	24—0
Paper from waste paper	Plain	18—24
	Twisted	16—18
Lick up Machine (Light paper)	Plain	24—32
Board Machine with longwire		
Lower wire	Twisted	9—14
Upper wire	Twisted	8—11
Cylinder machine wire	Plain	18—24
Machine with long wire for removing water from chemical pulp	Twisted	8— 9
Thick Board	Simple	18—24

On the surface of dandy roll we put plain weave wires of mesh No. 12,14,15,16,17,18,24,30 depending on quality of paper.

Mesh No.	Quality of Paper
12—15	Newsprint and mechanical printing
16—17	Mechanical printing with chemical pulp
18—24	Wood free writing & printing
30	Cigarette tissue

WIRE MARK :

To reduce wire mark wire manufacturers always strike to make wires as flat as possible. Plain weave wires are stiffest as there is maximum interlacing for a given mesh per unit area. Plain weave wires are still used for grades where wire mark is of minor importance. The wire mark is undesirable for printing papers and can be reduced by—

1. Reducing the height of the knuckles.
2. Increasing the area of individual knuckles.
3. Increasing the number of knuckles/unit area.

The technique is to spread the wire over the rollers and grind of the tops of the knuckles. This gives a larger wearing surface to the top side of the wire and decreased the knuckle height.

Increasing the number of knuckles/unit area means wires are closer together and there are more points of support for the web, this can be achieved by using twill weave.

DRAINAGE CAPACITY OF A WIRE—

This depends on :—

(a) the size of each mesh opening.

(b) number of openings/unit/area.

The product of these two numbers gives total mesh opening per unit area, that is to say drainage area which is a theoritical figure. The drainage co-efficient which can be determined experimently is on the contrary a practical figure.

Drainage co-efficient can be defined as the quantity of water passing through a certain area of the wire mesh related to the quantity of water passing through the same surface area without inter-position of the wires. It can be expressed as

$$K = \frac{L}{C\,Z\,Y}$$

Where L = A constant

C = Consistency of stock

Z = Specific resistance offered by stock depending on the quality of stock.

Y = Viscousity of water

K = drainage co-efficient

Of the two wires having the same mesh opening per unit area the one which has greatest number of meshes has the lowest co-efficient of drainage. Thus when mesh opening per unit area is equal fine wires drain of slower than coarse wires.

Mesh No.	%Drainage Area.	Drainage Co-efficient
Plain wire No. 24	25	46
Twisted No. 15	25	38

We may remark that twisted wires have a reduced drainage co-efficient by the reason of large stranded threads which constitute it.

WIRE LIFE :

Life of wire does not only depend on the type of weave, but also on working conditions, quality of paper, machine speed, number and construction of suction boxes and suction applied on them.

Further if grit is allowed to penetrate into the system or to the showers the wire life is drastically reduced because the grit becomes fixed in the top covers of flat suction boxed and be more grit lodging in the rubber cover of table rolls.

The other operating causes of undue wear are counter sunk couch holes bearing two sharp lands on couch, excessive flat box vaccum and excessive friction at the table rolls and wire return rolls.

If the lumps of stock are allowed to accumulate on the table rolls or wire rolls the wire is pushed at these points out of its normal place causing pimples and at these points excessive wear occurs resulting finally in holes.

Another important point in the wire life is the exercise of sufficient care when wire is put on the machine. Damage to the wire during this operation such as kinks, jams, ridges will shorten wire life as well as possibly making of paper more difficult. A depression of even 0.01 inch in the wire will have a marked effect.

The proper application of tension to the wire is of utmost importance. Slip between the machine wire and couch can soon remove a few thousands of an inch and this is easily done if high vaccum are used on flat boxes and tension of the wire is insufficient. When putting on a new wire, after a few turns to allow the wire to align itself, the wire should be tightened up up as much as possible to ensure that no slip occurs on any of the rolls. As the wire nears the end of its life the tension of the wire should be carefully adjusted to avoid over stressing the wire in its weak-end state. In this connection it is pointed out that finer wires appear less tight to the touch than coarse wires.

Wear of wire at high speeds is considerable due to pull of the wire at each roll, for this reason flexible wires made of fine wires required on such speeds. As a general rule finer mesh wire have shorter life and lower drainage as they catch up more of fines and build up a denser sheet.

The best working conditions are obtained, by table rolls in greater numbers and of a large diameter, with suction boxes having fairly large carrying surface on which friction will be considerably reduced and suction couch having a high vaccum.

The value of a wire life is judged by production per square metre surface. For some of qualities it is given below :

Quality.	Gm. Wt.	Machine Speed	Mesh No.	Production in Kg/m^2
Newsprint	48-50	150-250	26	7000-8000
Average quality				
Writing and Printing	60-90	100-125	28	5000-6000
Parchment Paper	40	135-140	28	3800-4200
Tissue paper on open and lick up machine	15-20	80-100	30-38	4000-7000
Thick packing paper	—	40-60	17-19	10,000-15,000
Base for building board		—	—	25,000-35,000

SOME METHODS FOR IMPROVING WIRE LIFE.

A. Low Vacuum in flat boxes - "Hessa" suggested a method by which it became possible to increase drainage and reduce total vacuum. A comparison of old method and "Hessa" method has been given below.

	Old method.	New method (Hessa)
No. of suction boxes	3	4
Dryness before vacuum boxes	2	2
Dryness after vacuum boxes	12	12

	Old method.	New method (Hessa)
Vacuum :		
I Box in metres water columm	0.8	0.15
II —do—	1.1	0.20
III —do—	1.4	0.25
IV —do—	—	1.00
Production in Kg/m² wire surface for the whole life of wire	7400 (120 g/m²) packing paper	11,500 (120 g/m²) packing paper

Rotabelt Suction Unit :

Evan's patent Rotabelt suction unit was invented in 1937. Following advantages are gained by using Rotabelt :

(a) Increase in wire life—The rubber sleeve of rotabelt is in contact and driven by the wire and as their speeds are equal, friction is eliminated resulting increase in wire life ; upto 300% can be obtained depending on course of run and on the type of conditions of installations.

(b) Increase in production—A higher vacuum upto 20″ Hg can be used as against flat suction boxes (14″ Hg) resulting a drier sheet and increased production. Avoids "Freezing" of wires as the drag is very small in comparison to flat suction boxes.

(c) Reduction in couch power—30—40% reduction in power are possible depending on type of installation.

Rotabelts can be also used in cylinder machine pick-up felts & suction press felts to eliminate blowing and also for felt conditioning.

Silicon Carbied Tops "KT" :

Greatly improve the life of the wire due to very smooth surface and hard structure.

It has been claimed that the "KT" covers which have been operating for over 3 years at Qubec

North shore Paper Company, Baie Comeau, Qubec are still running maintenance free and there is no indication that they will ever need resurfacing. In addition to operating over 3 years without resurfacing maintenance other proven advantages of "KT" cover installations are :

(a) Wire life increased 2—3 times on high speed machines.

(b) Wire savings of $ 50,000 to $ 100,000 per year.

(c) Power reductions upto 50%.

WIRE CLEANING :

The fourdrinier wire is usually washed with clean fresh water which is considered sufficient but in cases where the nature and amounts of deposits need for more thorough washing dilute acids, caustic solutions gasoline etc. are often used. The latter is particulary effective in removal of pitch which fills the meshes of the wire and prevents good sheet formation. In most of Indian Paper Mills acid washing may serve the purpose. Different acids have different rates of attack on the wire.

Dilute hydrochloric acid does not severely corrode the wire but attacks may be upto 150—200 md. d. (milligrams per square deci. metre per day). Dilute nitric acid vehemently attacks the wire and therefore never be employed for wire washing. Sulphuric acid cold, unaerated and with no traces of oxidising salts does not practically attack the wire. The attacks are only 35 md. d. even with 25% acid. Always cold acid should be used because when temperature exceed 50°C the acid itself may tend to depolarise the cathode areas and promote corrosion. When high acid concentration is needed for washing use of an inhibitor becomes obviously imperative. For example when sulphuric acid is employed for washing it is common practice to use one gallon of formaldehyde for every seven gallons of acid. Modern wires are cleaned by steam, not water or hot stock.

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