Development in construction and design of fourdrinier metal wirecloth

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SUMMARY

The paper traces the history of development of Fourdrinier Machine Wire from 18th century till date. It also deals with limitation of twill wire during last couple of years and the solutions brought forward by wire manufacturer keeping in view the change in inputs and machine condition by and large.

Indeed a sophisticated paper making of 20th century on Fourdrinier Machine was first conceived by Mr. M. Louis Robert a French man and a Clerk in the services of M/s. Didot of the Essone Paper Mill. The invention of the prototype of the present day paper machine is due to gigantic effort by Mr. Robert It was he who in 1798 first thought of using fine wirecloth in continuous form for the production of paper. His efforts were sponsored by Henry and Scaly Fourdrinier, the wealthy English Stationer. After their surname, the word 'Fourdrinier' has been given to the present machines. This invention took place in Great Britain.

The first Fourdrinier Machine was started in England at Frogmore in the year 1803 due to enthusiasm of BRYAN DONKIN an Engineer. The wire on Louis Robert's premative machine was made from Copper Wirecloth approximately 3 meters long and 65 cm./wide. The two ends were joined together by sewing so as to form an endless travelling band somewhat less than 1.6 mtrs in length when running on the machine over two rollers-one at each end.

It was a vital part of the machine which was to grow in improvement as the entire machine underwent its development over the year. It was rather crude use of wire but it was most significant with the view that it established a procedure of operation which still survive and it is likely to continue to be important in the days to come. The same wirecloth is still a most important unit on the gignatic high speed Fourdrinier Machine of today with their enormous output.

Little did Mr. Robert knew in 1798 that his efforts would lead to development of wide machines as much as 6-10 mtrs. running at a speed of 1500 mtrs/min. In our country the widest wire width as on date is 6 mtrs. It may be interesting to note that a wire of these large dimensions contains over one million individual apertures.

In India wire manufaturing was pioneered by SHALIMAR WIRES in the year 1963. Since then SHALIMAR has remained to be pioneer and leader not only for Fourdrinear Wirecloth but for Dandy Roll, Bracket and Accessories, Water Shower and Fabric. All the products so far conceived by SHALIMAR are only and for the Paper Industries and more so for Fourdrinier section making use of immense understanding of Paper Makers' problem and know-how.

WEAVE AND MESH

Unlike other machine clothing, Fourdrinier Wirecloth has only two popular weaves i. e.

(i) Plain Weave and (ii) Twill Weave

Similarly number of meshes which are popularly used by Paper Industries are also limited to 3, (i) 60, (ii) 66 and (iii) 72. In foreign countries while a paper machine reportedly manufactures only a given quality of paper at a constant speed for months together, in India variety of paper are manufactured on a machine during run of one particular wire. With this the functional requirement of four-

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drinier wirecloth are far-more important in our country than aboard. However, with the limited weave and meshes to offer, fourdrinier wire manufacturer could produce a suitable wire by altering the diameter of warp and weft wire increasing or decreasing the number of weft wire, weave and construction.

LIMITATION OF TWILL WIRES:

Till 1976-77 Twill weave wire continued to serve paper Industry with very satisfactory result. However, during last 4-5 years couple of problems have been reported on the use of twill wires. These are-

1. Clogging of wire in patches.
2. Clogging of wire throughout its body.
3. Clogging of wire near the seam.
4. Seam clogging.
5. Seam marking.

SHALIMAR's R & D Department made an earnest effort to lay their hand on all above mentioned problems. Data of problematic cases were compiled and following features in common were found which could be the reason of problem faced on twill wire.

1 Some of the Mills faced the problem with the use of green baggase which are available to them at time of crushing of sugar. This was possibly because green baggase contains higher percentage of pith.

2. With the new units coming in, the demand of bamboo has increased steeply. This resulted into over all crisis of bamboo making it necessary for the Mills to go for hardwood. Thus percentage of hardwood has steadily increased from 10-60%. This had resulted into higher percentage of short fibre.

3. Uue of waste paper and agricultural raw materials.

Machine speed has been increased demanding a change in wire construction/mesh.

5 Due to use of short fibre pulp as stated earlier, the wire now gets clogged The cleaning system has remained unchanged and thus the reconditioning of wire is lagging behind the requirement.

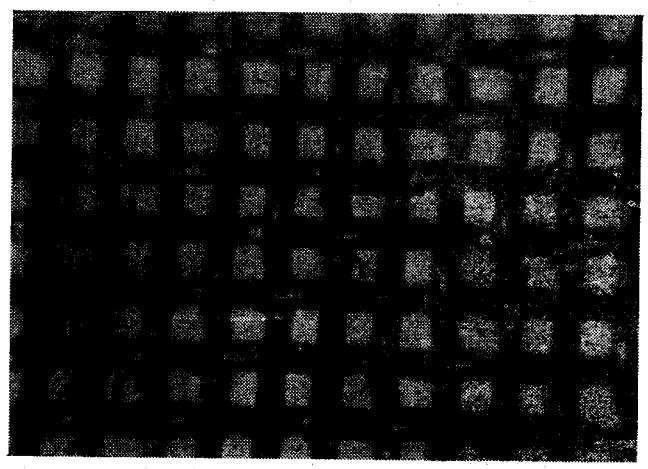
DRAINAGE MECHANISM:

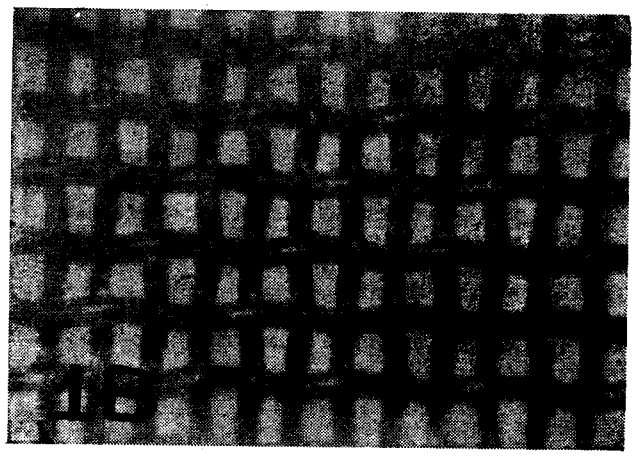
To understand and appreciate the above problems it is necssary that the drainage mechanism of the wire be discussed in detail. Possibly following factors are responsible for the drainage.

1. SIZE OF APARTURE OF THE MESH ;

Normally percnentage open area is referred to indicate drainage characteristic of wire. However, it is obsereved that drainage characteristic of wire in two different meshes differs largely though the percentage open area may be same.

Figure 1 a illustrates dimension of a 60 four shaft wire. In machine direction the length between two were wires is .21 mm. In figure 1 B which shows aparture of a 60 twill wire, this distance is 27 mm. which is 30% higher than four shaft wire. Since direction, a fibre mostly takes place in machine orientation of small distance between the two wires in machine direction provides closer bridge for fibre to settle the wire.

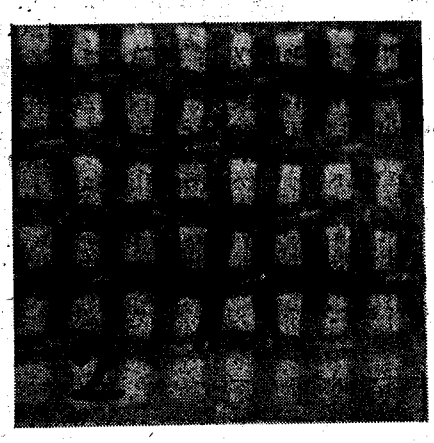


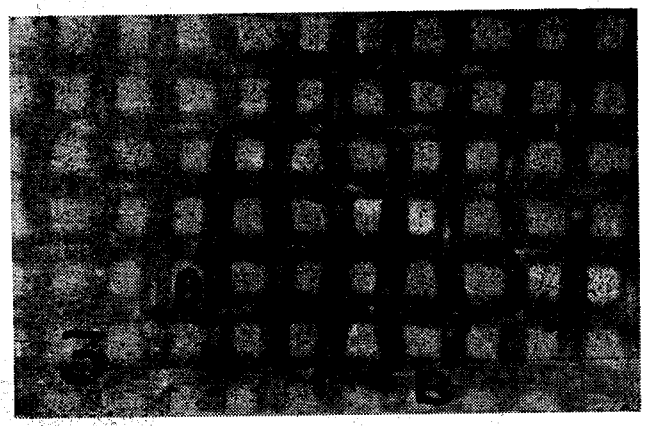


2. ROLE OF FRAME DIMENSION :

Photo 2 and 3 below show difference in frame dimension in two different meshes.

Photo 2 is of twill wire. Portions circled A shows





the smallest aparture and portions circled B shows the biggest aparture. Difference between these two would be to a tune of 1:1.5. This is because of the inherent weaving characterestic of twill wire.

Photo 3 is of four shaft wire. Portions circled and marked A shows the smallest aparture of four shaft wire and portions circled B shows the biggest aparture of the four shaft wire. The difference between smallest and biggest aparture in four shaft wire is 1:1.2. Thus it can be inferred that in four shaft wire the apartures are more uniform than twill wire. Since the drainge and clogging have direct relation with aparture of wire, this plays an important role.

3 DRAINAGE RESISTANCE OF THE WIRE :

If piece of wire is dipped into a liquid say water aud then taken out, the liquid that will remain in the wire structure is its retention capacity, This capacity increases as the knuckle while weaving the wire be comes sharper and sharper giving more pronounced third dimension i.e. the vertical depth or thickness to the wire. Such thickness of the wire increases, the surface tension and thus increases the resistance to drainage. In case of four shaft wire the knuckles are smooth and thus the thickness is comparatively low giving lesser resistence to drainage.

THE INTERACTION BETWEEN THE WIRE AND THE FIBRE :

The surface tension and drainage characteristsic have direct relation with type of pulp and chemical that have been used for loading the paper.

5. NUMBER OF SHAFTS USED IN A PARTICULAR WIRE STYLE

It has been established that higher the number of shafts in a wire style higher can be the weft count, which has bearing with drainrge Mechanism. Theoretically even a wire with less number of shafts i.e. two shaft (Plain Weave) can be manufactured with higher weft count. practically this is not done.

For designing a wirecloth due care is to be given to take care of stress fatigue. This is achieved by weaving a flexible wire which finally results into elongation problem. When efforts are made to weave a wire, to restrict the elongation, wire loses its flexibility. Thus, an optimum factor is to be chosen.

More number of weft counts result into more number of knuckles which are inversely proportionate to the number of shafts. Further more numbers of knuckles are directly proportionate to the elongation of wire.

DEVELOPMENT OF FOOR SHAFT WIRE :

Keeping above factors in view and in particular point No 5. referred above the idea of manufacturing four shaft wire was conceived in India. Let us first compare the difference between the Twill and four shaft wires.

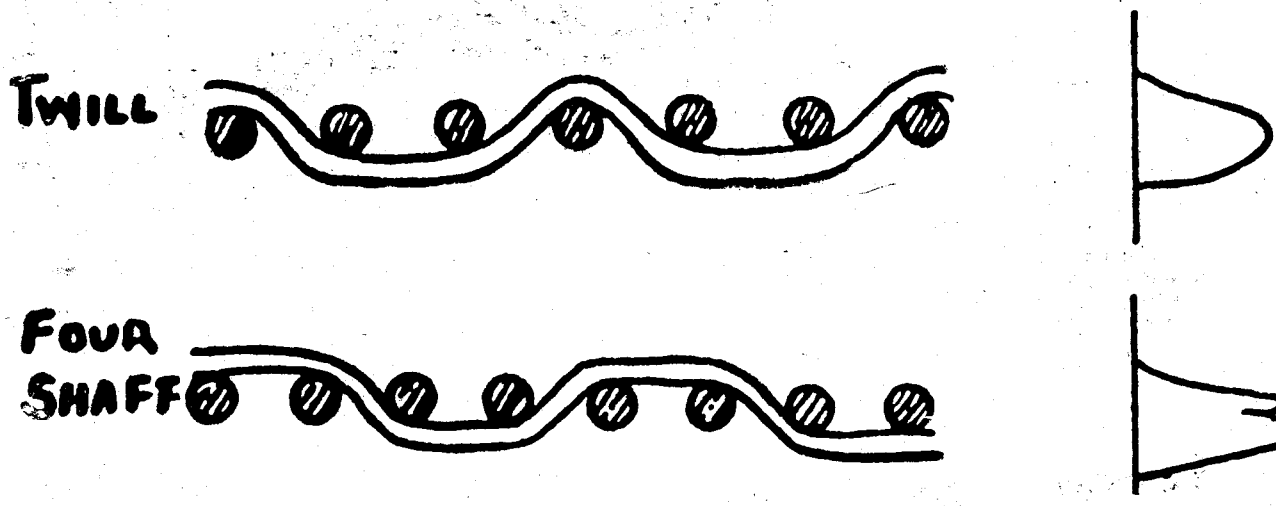
WEAVING PATTERN :

In a twill the weft passes alternately over the two and under one warp wire.

In four shaft wire the weft wire passes alternately over and under two warp wires.

DIFFERENCE IN WARP AND WEFT DIA :

	No. of warp wire	Dia. of warp wire	No. of weft wire	Dia. of weft wire	Percentage of open area
66 Twill	66	.22	48/50	.24	23.4%
60.4-Shaft	60	.24	54	.26	19.09%
60 Twill	60	.24	48	.26	21.71%



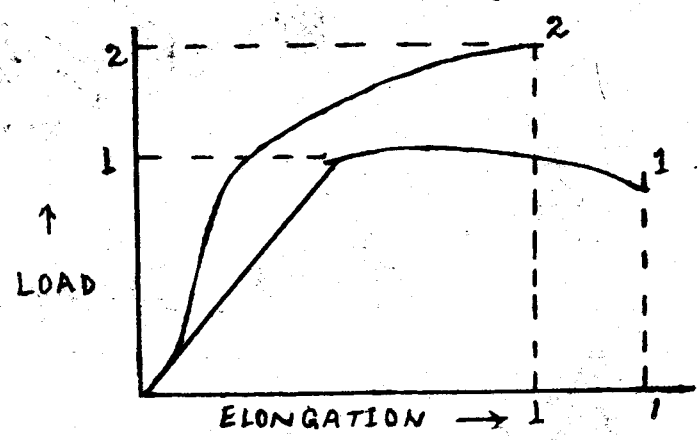
From the above it is observed that a 60 four shaft wire has lesser open area than both 60 twill and 66 twill wirecloth. The main contribution appears to be due to increased number of wefts and slightly higher dia. of warp and weft.

METALLURGY OF WIRECLOTH :

The Fourdrinier (Metal) Wire is essentially made of fine metal wires drawn from Copper Alloys. The warp is made of Phosphor Bronze (7.5-8.5% Tin), in most cases and the weft is constituted by 80/20 Brass. These alloys have been selected and found to meet engineering requirements of paper machine wires after considerable work and are in regular use for quite a long time.

The peculiar condition under which the fourdrinier wire has to perform in a paper machine requires a special combination of tensile, fatigue, wear resistance and corrosion resistance properties. Ph. Bronze alloy under proper condition of processing and treatment provides this unique combination of properties. The high copper content of the alloy imparts it excellent corrosion resistance under most operating conditions in the paper mill. Addition of Tin & Phosphorous leads to increase in tensile and fatigue strength with further improvement in corrosion resistance of the alloyr The hardness is also increased with increase of the tensile strength, but the alloy addition are limited to the extent these do not cause brittleness. The finishing treatment is so controlled to produce wires with high strength and ductility which contributes to high toughness and this alongwith its good bearing properties accounts for the high wear resistance of the alloy.

This criterion may be better understood wlth the help of the stress/strain or load/elongation diagram.



In the diagram two curves have been shown for two different lots. Lot-1 has slightly lower tensile strength but higher elongation which is required where fatigue failure is a problem whereas Lot-2 has lower elongation but higher strength which is important where wear resistance is required.

As we have our own melting unit and a system of in process sampling and quality control we can adjust and ensure the alloy characterestics as per individual mill requirement.

RANGE OF MANUFACTURE OF FOUR SHAFT WIRE

Four shaft wires have been manufactured so far in following meshes :
(i) 60 mesh (ii) 66 mesh (iii) 70 mesh.

APPLICATION :

(i) **60 MESH FOUR SHAFT** :—This wire has been used successfully on machine manufacturing writing and printing paper in weight around 60 GSM at a machine speed upto 350 mtr/min.

(ii) **66 FOUR SHAFT** :—This wire has been used successfully on machine manufacturing writing paper at machine speed 350 mtr. to 600 mtr/min.

(iii) **70 MESH FOUR SHAFT** :—This has been used on the machine manufacturing paper around 40-50 GSM at a speed between 200 mtrs.

ADVANTAGES OF FOUR SHAFT WIRE :

The *major edge* of four shaft wire over twill wire is its *flexibility*. Four shaft wire is so flexible that it is called "*self aligning wire*". We would take the liberty to state here that in our country many machines require modification on fourdrinier section. Twill wire being lesser flexible than four shaft wire gives way faster while four shaft wire sustains for a longer period. The field results have shown following advantages.

1. Clogging of wire on seam has either been totally eliminated or reduced to a great extent on machine where this was a chronic problem with the use of twill wire This appears due to the drainage charac terestic of wire as discussed earlier. We have observed this phenomenon in many Mills in South.

2. **ELIMINATION OF SEAM MARK** :—We have pleasure in reporting that with the use of four shaft wire, seam marking has been eliminated almost completely. The rate of success is over 90%. This has been observed in Mills in Andhra Pradesh and Tamilnadu.

3. **BETTER RETENTION OF FIBRE AND FINES** Since number of weft wire in four shaft wire are more in comparison to twill wire, the retention of fibre and fine had been more. Because of this, finish of paper is better.

4. **HIGHER LIFE** : Higher life has been reported in 100% cases where four shaft wire was introduced in comparison to twill wire. The increase in life is from 15% to 90%. The highest increase has been recorded in Mills at West Bengal running at about 300 mtr /min. This has also been recorded in Mills at Orissa and Andhra Pradesh.

Following two factors appear to be responsible for higher wire life.

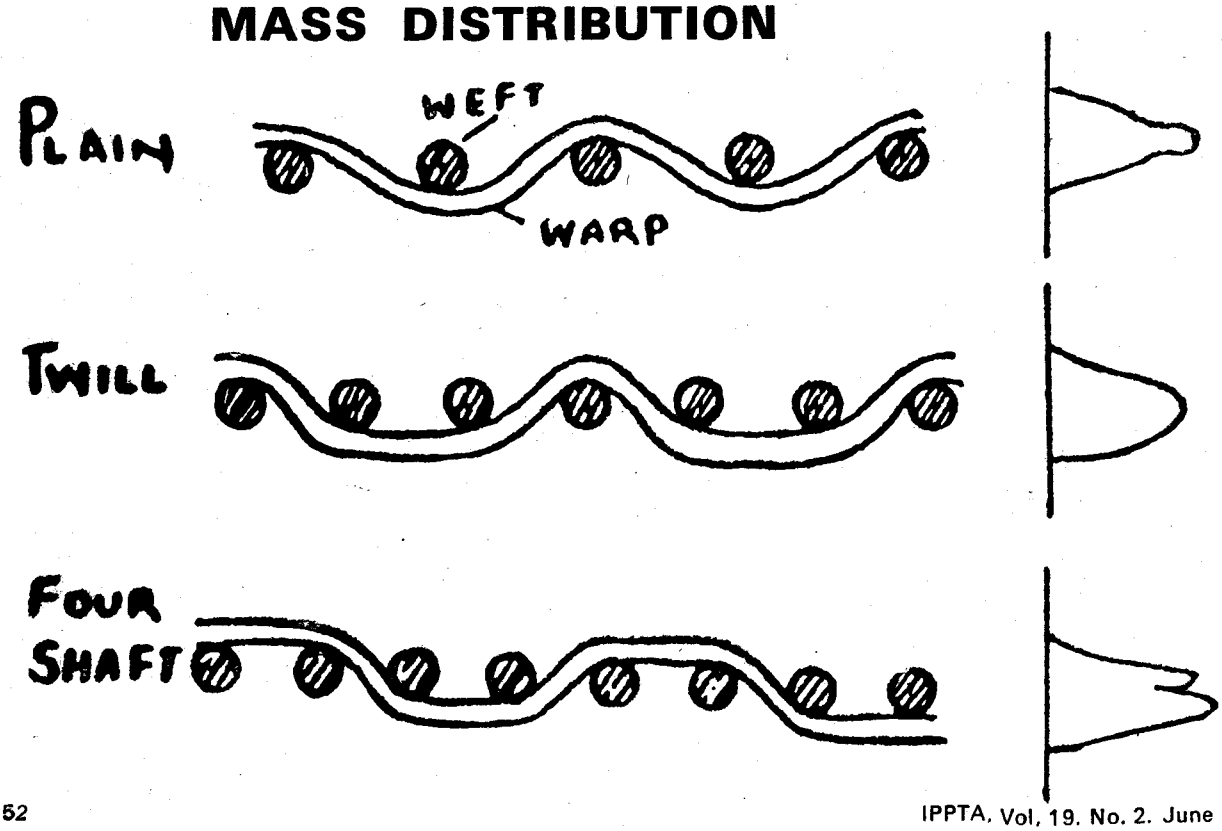
(a) **HIGHER WARP AND WEFT DIA** :—

As discussed earlier under development of four shaft wire. it is observed that diameter of both warp and weft wire in four shaft wire is higher than twill wire. Thus the wire life is more.

(b) **MASS DISTRIBUTION** :—

Figure 4 below shows the mass distribution in Plain,

MASS DISTRIBUTION



Twill and Four Shaft wires.

In a Plain Wire the distribution of mass is 50-50% over and below the centre line (shuttle line). In Twill at the under side distribution of mass is much more higher. Thus it is evident that more material is available at the wear at the bottom side of the wire. Microscopic analysis of worn-out wire reveals that in case of four shaft wire both warp and weft wires at the bottom while in twill wire mostly warp, wire wears.

5. SIDE EFFECTS OF FOUR SHAFT WIRE :

So far only two side effects of four shaft wire have been reported.

(i) Accumulation of fine on suction box.

(ii) Its wire weave mark.

(i) The accumulation of fine on suction box has been controlled by varying the number of weft wires. This problem was faced at a Mill in Orissa with the initial trial of wire which has been totally eliminated on wire supplied subsequently.

(ii) In few cases wire weave mark has been reported which are related with weaving of the wire. Wherever this has been brought to our knowledge, it has been either eliminated or reduced to a great extent.

Thus it can be inferred that leaving minor side effects, four shaft wire has an edge over twill wire which is more pronounced in Indian working condition. However, it should be made very clear that four shaft wire is not the answer for all the problems but definitely is the answer for many of the problems which have been experienced in recent past on twill wire. Its application and success would largely depend upon detecting and understanding of problem of a Paper Maker.

We had been making earnest effort to identify the particular problem and bring out a solution which had been possible so far in close co-operation and understanding with Technical Executives of paper Mills. We are confident that Paper Industry in general would reap the benefit of this understanding in the days ahead to come.