Problems Connected with Paper-making Wire on High Speed Machines—Methods to Increase Its Life

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The increasing speed of Paper Machines in the last few years has considerably reduced the life of a long wire and thereby the wire cost has become an important factor in contributing towards the increased cost of production. I have endeavoured to discuss in this paper the various possible mechanical and chemical factors that influence the wire life by citing an example of one of the fastest machines in Europe producing magazine paper with 25% ash-content and running at a speed of over 400 m/min. Methods to increase the wire life are also discussed at length.

Introduction :

Since the discovery of paper nearly 2000 years ago, the long wire has become an indispensible tool to the paper-maker for the drainage of paper-making stocks. The long wire has many more functions than just drainage of the stock, They are :

1. Properties of a driving belt;
2. Resistance against abrasion;
3. Resistance against corrosion;
4. Stability of surface area;
5. Good sheet-formation without wire marks;
6. Optimum drainage properties; and
7. High flexural strength.

Wire Damage :

There are many factors which affect the working of a wire and which contribute towards its wear and tear. These can be divided into the groups :

(a) Normal factors :	Machine speed
	Material of the frictional surface
	Vacuum
	Tension on wire
	Chemicals
	Loading
	Other operational conditions
(b) Abnormal Factors :	Pumps, cracks, holes
	Border slits
	Breakage of seam
	Other damages.

I am citing here a working example of one Paper Machine in Europe which produces magazine paper with 25% ash-content (furnish is 80% groundwood and 20% chemical pulp). This machine has a width of nearly 4 m. and runs at a speed of 400-450 m/min. The shocking truth of the requirement of 80-100 wires per year (on an average 3 to 3.5 days per wire) gave us the impetus to look for improvements on the wire part of this paper machine.

Abrasion Theory of Friese :

The problem of wire life had been intensively studied by the consolidated corporation of U.S.A. as well as by Pulp and Paper Research Institute of

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Canada. The final theory accepted for measurement of the wire abrasion is of Friese.

$$\text{Percent abrasion} = \frac{B-A}{B} \cdot 100\%$$

The abrasion of the wire is measured by measuring its thickness at different positions.

A wire is said to be practically completely worn out when the warp wire loses 58% of its original diameter. The abrasion of a wire is proportional to the total wire length. That is why the time of run of a wire is not to be expressed in terms of hours and days, but in terms of total number of rotations for comparison.

The first step in such a study is to collect data on a number of wires run on that machine and form an abrasion curve with the running time (in terms of total number of rotations) on the abscica and percent abrasion on ordinate. Such a curve was drawn for the above machine and it was found that the abrasion points lie on a straight line whose slope is determined by tan α; if the straight line is extrapolated to the ordinate, the intercept gives a measure of the condition of drive of the suction couch.

The slope of the line, tan α represents the behaviour on the suction boxes.

Machines of longer wire life show a shorter intercept with the ordinate and a flatter curve.

For example, in the case of the above machine under discussion, the life of the wire was only 3 days. After the 3 days period, the wire was found to be full of cracks on the entire width; also the abrasion was as high as 45%. This alarming wire-abrasion cannot be understood by Friese's theory. Friese's theory is based on the idea that the wire is like a driving belt. The driving load that is to be carried is given as a function of the relative motion of the suction roll.

The wire becomes spun (tension) on the suction couch as it goes embracing. The removal of load results in a shortening of the wire through a creeping motion on the suction couch. As much is the braking pressure on the wire (caused mainly by the suction boxes) so much more is the driving load that is carried over to the suction couch.

Let us denote the braking pressure as S_L and the wire tension as S_0, then the highest tension before the suction couch would be S_0+S_L. On that particular machine, if the tension on the wire (S_0) is reduced, wire life was reduced through higher abrasion. If S_0 is increased, then the wire life was improved; but for a small break or localised abrasion anywhere on the wire, the entire wire tears off due to the high overall tension on the wire.

Changes on Suction Couch :

A study of the suction of different fast running machines has revealed an important fact that the wire life is higher wherever the open area on the couch roll is smaller.

In the following table such data on three high speed machines is presented:

Paper: 60/70 g/m² Magazine paper with 20-25% Ash		Factory 1	Factory 2	Factory 3
Speed	m/min.	410	430	370
Open area	%	61	53	10
Closed area	%	39	47	90
Wire life	Days	3-3.5	4-5	6—7
	Rotations	60,000	20,000	1,10,000
Abrasion (Friese)	%	50	46	46
Vacuum zone width of Suction Couch Roll	mm.	375	350	280
Vacuum	mWS	6/8	7/8	6/7.5
Diameter of suction couch	mm	1000	1000	1000

Also by selecting a softer rubber for covering the suction couch of a P & J hardness of 30 points, a lower abrasion by the same creeping motion and a possible reduction in the wire tension through an increase in the frictional co-efficient were found.

Rubber-covered Suction Couch

From the theory of Friese, the rubber covering of suction couch should double the wire life. But in practice it was not found so. In this case of the machine the increase in wire life is nearly 30%.

Abrasion-profile :

Thus while searching for other causes of abrasion on the wire, we first of all decided to find the abrasion profile on the entire width of the machine. The graph is given in Fig. 2.

The peaks observed at the edges show a very high abrasion compared to the rest of the wire. So work was concentrated on the edges: firstly to find out the factors contributing to it and secondly to reduce it.

(a) *Replacement of slotted suction box by perforated suction box* :

The specific frictional surface on the edges of a slotted suction box is higher than with a perforated suction box as the wire bends more in the former case. So the result of replacing slotted suction boxes by perforated boxes is that the abrasion peaks on the edges were considerably lowered.

(b) *Border sprays* :

Change of border water sprays by compressed air do not seem to have any effect.

(c) *Deckelstrap* :

The deckel strap plays an important role in the abrasion of the wire on the edges. Normally for any stockflow, there is a whirling motion of the stock at the middle and this in the case of a bad deckelstrap produces angular waves at the edges.

Replacement of the original metal strap with outside rubber straping by a stable plexiglas sheet with smooth surface brought a clear levelling in the abrasion peaks on the edges.

The following explanation serves to account for the above observations: The edges are always found to be poorer in ash-content. Though the bending of waves, the stock collides many times with the deckelstrap and gets itself washed out. Thus the back water under the table rolls contains more ash on the edges than in the middle. This penetration of ash through the wire produces a stronger frictional surface on the edges which accounts for the higher abrasion at the ends.

Thus the effect of replacing slotted suction boxes by perforated boxes and changing the metal deckelstrap by plexiglas on the abrasion profile is shown diagramatically in Fig. 3.

Effect of Dandy:

To see the effect of the dandy, studies were made on various machines with wires from the same manufacturer with and without dandy. This study did not show any variation in the wire life conclusively.

Effect of Suction Boxes with Carborundum:

Th replacement of wooden suction boxes by suction boxes made of vulcanized fibre with perforations did not affect the wire life.

In Canada astounding results were achieved by incorporating carborundum tops with perforations for the suction boxes. Some mills claimed as much as a 100% increase in the running time. The old wooden suction boxes of this machine were also changed and new suction boxes with carborundum tops were placed instead. The increase in wire life was, however, not appreciable (nearly 15%).

Effect of Table Rolls :

The high ash content of the back water together with the strong stream flow abrases the wire very much.

Effect of Changing the Bending Stress:

A decrease in the bending stress by the elevation of the suction couch has a marked effect on the wire

life. The change is pictorially represented in Fig. 4A.

Also in the machine there was a regulating roll just before the couch roll as shown in Fig. 4 A which was taken out as the wire was under maximum tension at that point.

These two changes resulted in an increase of 15% in the wire life.

Corrosion and Material of Wire:

The most corrosive material in any pulp stock is the residual bleach. If it is an oxidizing bleach like hydrogen peroxide or a reducing bleach like sodium hydrosulfite, still it has a very strong corrosive effect on the wire and consequently on the wire life. Other contributory factors for wire abrasion through corrosion are: PH value, salt content, temperature of suspension and specially presence of electrolytes in the stock.

Experiments were conducted on different types of material of wire: normal copper wires, bronze wires, bronze wires with tin coating on the weft, wires made out of special alloys etc. The last two materials withstood the corrosion effect for a slightly longer period, but the cost is found to be prohibitively high in comparison to the effect obtained.

Among wires of 24, 25, 26 and 27 of warps/cm, no difference was observed on the time of running.

Chemical Additives to Improve Wire Life

Lately many chemicals have entered the market for inhibiting wire corrosion and thus increase the wire life.

These chemicals are mostly organic in nature, with two components:

(a) A corrosion-inhibitor and

(b) A film-building amine.

The action of these chemicals is two-fold:

(1) To split the anodic and cathodic corrosion reactions and

(2) To reduce the friction between the wire and the supporting areas on the wet end of the paper machine through a film formation.

One such chemical, a NALCO product, which is a Mercaptobenzothiozol, was used on the above machine and the increase in wire life obtained was around 20%.

Summing Up of the Different Changes on the Wet end:

The increase in wire life expressed as percentage to the normal run for each change made on the machine is given below:

Wire life under conditions prevailing before changes	100%

Increase Obtained:

(1) Through rubber-lining the suction couch roll and decreassing the load on wire	35%
(2) Through changing the decklestrap and replacing the slotted suction boxes by perforated boxes.	15%
(3) Through carborundum tops on suction-boxes.	15%
(4) Decreasing the bending stress	15%
(5) Through the addition of NALCO	20%
Total increase in wire life:	100%

Thus by effecting all the above changes, the wire life was ultimately doubled, thus decreasing the consumption of wires from 80-100 level to 35-45 level per year.

This is an enormous saving in itself. In some other mills in Europe, the results were still better.

Plastic Wires:

The problem of wire life can be attacked from a different angle, i.e. changing the material of the wire. These days there are some long wires in which the warp is of a flat plastic wire and the weft is from bronze.

A few trials with plastic wires were conducted on the above machine and the conditions of working and results are given below:

Conditions: Paper: Magazine (with 20-25% clay)

Basic weight: 65 g/m²

Speed: 410 m/min.

Stretch on the wire guide roll: 2%

Observations:

Already after 30 minutes run, the wire stretched itself by 1%.

The tension dropped down automatically from 3.5 kg./cm. to 1.5 kg./cm. Therefore the tension had to be increased very often to bring it to the original level.

As a result of the stretch along the length of the wire, there was a cross-wise contraction and the volume of the pores diminished so that water had to be reduced on the machine to get the wet web out of the couch roll onto the presses. This had considerably affected the formation.

After 3 hours, after a stretching of 2.5%, the wire attained a dimensional stability in the machine direction.

Ever since the beginning clear seam marks were observed on paper; in addition, as a result of the crosswise contraction, there were numerous bumps on the wire.

After nearly 20 hours of run, the trial had to be stopped for reasons of quality.

Abrasion	*Plastic wire*	*Bronze wire*
Both after 20 hours run	10%	20%

Thus plastic wires have the following main disadvantages:

(1) 2-3% of stretch on application of tension;

(2) The seam must be woven so fine that no marks are observed on finished paper.

If these two problems are solved, plastic wires of plastic wrap and bronze weft will have a very promising future in the wire industry and shall undoubtedly replace the conventional wires.