New Drainage Elements- Hydrofoils And Wet Suction Boxes.

R.S.D. Pandey

Till recently table rolls were considered to be trouble free equipment and were used in most of the installations but they have following discrepancies :

a) removal of water and suction action depends on working speed and the size of the rolls which could not be changed during working. Very strong suction at certain places in the forming zone causes pulling of the fibres and loading particles through the wire. On the other hand during insufficient suction it is not possible to get proper drainage.

At the place of contact of wire with the table rolls there is abrupt change of pressure which causes removal of water clinging to table rolls and under side of wire and paper machine stock.

Small percentage of fines and loading particles in the paper web on the wire side is the result of washing action of the above mentioned water.

Relatively high space requirements especially on wide machines where it is necessary to have a cantilever type fourdrinier table

Lately instead of table rolls hydrofoils and wet suction boxes have been installed in the wire part in combination with table rolls. This removes water more smoothly than the table rolls due to which large percentage of loadings and fine fibers are retained in the web.

By installing hydrofoils and wet suction boxes in place of table rolls several above mentioned defects can be eliminated.

Hydrofoils—

Hydrofoils are similar to deflectors which have relatively wide surface and are inclined downward in the direction of suction couch with back edge touching the wire.

It is anticipated that use of hydrofoils will increase in the following cases :

1. Machines having very short forming zones.
2. Machines where increase in speed is held up on quality grounds.
3. Machines where quality improvements are needed without lowering the speed.
4. On new machines to reduce the working length of wire table. Main advantages of the hydrofoils are—

a) Possibility to regulate the drainage rate of stock at a particular place in the wire.

b) Gentle turbulence during the formation.

c) More drainage from a particular wire section.

d) Possibility of forming the web at low consistency and employ fine mesh wire (less wire mark).

e) Better retention of fines and loading particles on the wire side of the web causing less two sidedness.

f) Gentle suction in flat suction boxes i.e. less wear and tear of flat box surface and less energy to drive the wire.

The hydrofoils may have a little harmful effect on the formation in the absence of microturbulence. Moreover there is much difficulty in selecting the proper type of material for tops in respect of durability and low coefficient friction. Hydrofoil units working with vacuum created with suction pump have large dewatering capacity. Its use has cut the wire length and stock of higher consistency can be used on the wire.

On a machine making newsprint

R.S D. Pandey, Paper Maker
Rohtas Industries Ltd., Dalmianagar. Bihar

at 400–600 m/min. working length* of wire is ordinarily equal to

14 meters—using table rolls

8 meters—using hydrofoils.

The consistency of stock in the flow box in both these cases is as follows :

0.5—0.65 using table rolls.

0.75—1.0 using hydrofoils.

Most important variable in the design of hydrofoil is its shape and size. Hydrofoils may have a curved, flat or inclined surface considering the possibility of their joints. Type of profiles of hydrofoils have been shown in fig. 1.

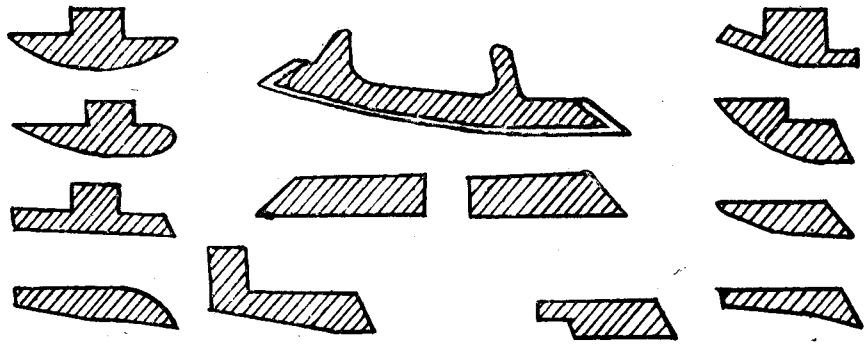

Fig. 1. Surface Profile of hydrofoils.

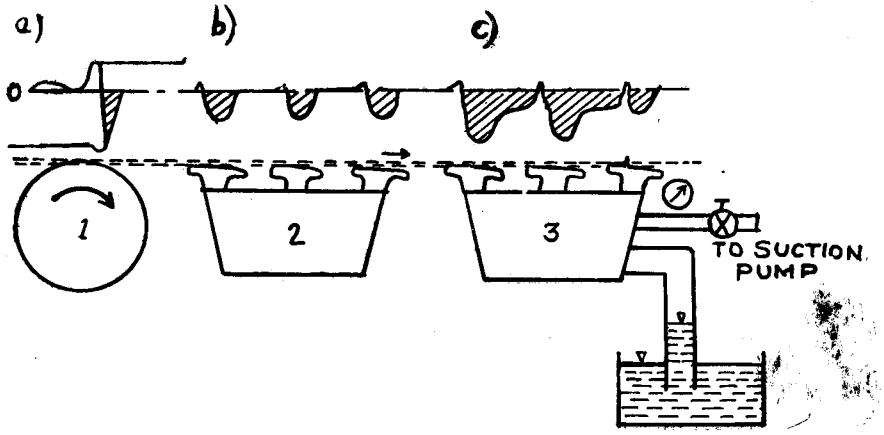

Fig. 2. Distribution of pressure with table roll end hydrofoil

(a) Table roll (b) hydrofoil assembly without vacuum

(c) Hydrofoil assembly with vacuum.

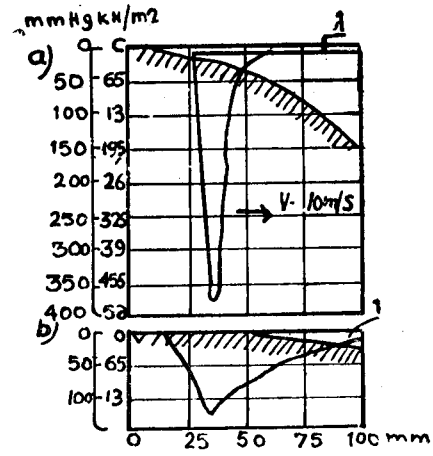

Fig. 3. Suction profile (a) table roll (b) Hydrofoil 1–wire.

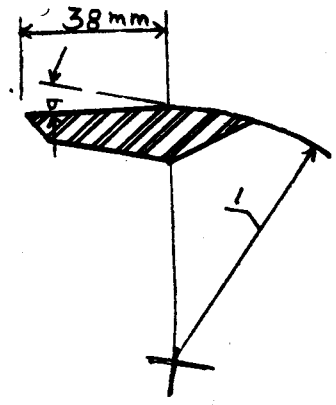

Fig. 4. Hydrofoil of surface length 38 mm and angle of divergence in the range of 0—17° 1-Radius.

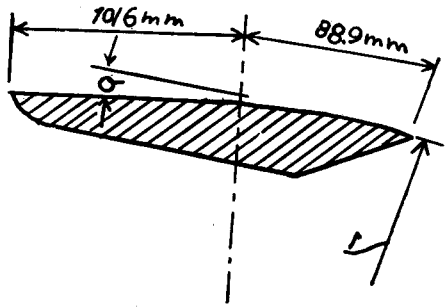

Fig. 5. Hydrofoil of surface length 101.6 mm and angle of divergence in the range of 0—17° 1—Radius

*working length–length between the centre of breast roll to the centre of the couch roll.

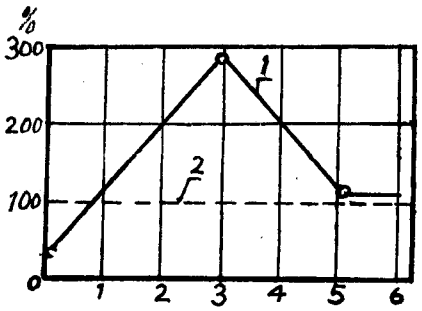

Fig. 6. Effect of changing angle of divergence on drainage rate. 1. Drainage with hydrofoil shown in fig. 5. 2. Drainage with table roll of diameter 305 mm.

From the experiments it results that most important factor for determining the drainage capacity is the length of the hydrofoil. Long hydrofoil with smaller angle of divergence with the wire gives better retention of fines. Hydrofoil of combined design is a compromise considering the different factors affecting the formation of paper. It has been found after employing it on a number of paper machines.

The most important problem is the material of construction of hydrofoil tops. It should not cause much wear and tear to the wire. Hydrofoils working with plastic wire are made of stainless steel. However, hydrofoils working with metallic wires are made of acid proof steel and with plastic tops. These tops should also be very resistant to wear and tear and have less coefficient of friction.If the wear and tear is not uniform there is variation of moisture profile across the web. Tops of polyvinyl chloride wear out quickly. Moreover better service is obtained by cheaper tops of polyuretan and poly-ethylene. Carborundum has still better properties but it is very costly. Very recently tungston carbide tops have been used which have very high life (about 3 years). A mixture of fibre glass and teflon is also used. Beloit makes back edge of hydrofoil with stainless steel and tungston carbide tops. Carbide is then properly polished or chromium plated.

Vacuum generated by single hydrofoil is a function of wire speed and angle of divergence. The vacuum can be regulated by changing the angle of divergence.

Increasing the clearance between hydrofoil and the wire creates suction zone similar to table rolls and is proportional to square of the wire speed but since hydrofoil is stationary suction is less and varies in the range of 1/5 to 1/2 the maximum suction effect of the table roll. Best effect is obtained by employing angle of divergence between 1.1 to 2°. Length of suction zone in the case of hydrofoils is considerable more than the table rolls due to which there is gentle drainage but the amount of water removal is 10–40% than the table rolls. Effectiveness of drainage depends mainly on the drainage surface of the hydrofoil. For example hydrofoil with length 38 mm shows 3 times less drainage than hydrofoil of length 102 mm.

Maximum drainage is obtained in the range of angle of divergence 1 – 3° and by changing this angle it is possible to regulate the drainage to a wide range. Similarly vertical adjustment of the hydrofoil near or away from the wire makes corresponding change in the drainage. On a machine making writing and printing at a speed of 460 m/min best effect is obtained by employing

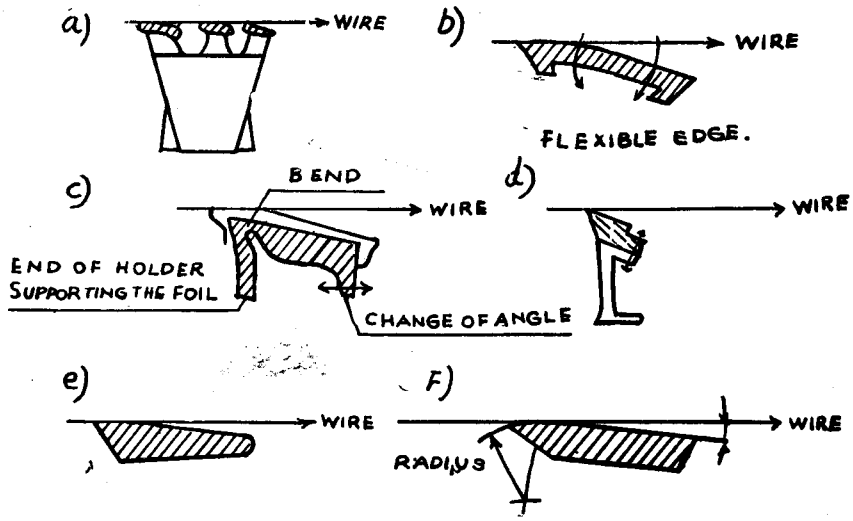

Fig. 7. Shape and size of hydrofoils produced by different firms (a) Huyck (b) Lodding (c) Dominion Company (d) Wagenknacht (e) Walley (f) Beloit (with the regulations of angle in the range of 0—10°)

angle of divergence in the range of 1.1 – 2°. With small rounding of the edge of the hydrofoil causes light impulse to shaking fibre mat which improves water removal from already dense fibre mat. Number and method of installation of hydrofoil assembly depends on the type of paper produced. Only from experimental results it is possible to say the number, shape and the combination which can give best results. In order to get increased drainage we should employ minimum 15–30 hydrofoils starting from the side of breast roll and may go upto suction boxes and few table rolls should also be inserted to shake the fibres. Number of blades in one hydrofoil assembly is selected from the basic characteristics of the stock. It is generallay from 3 – 8 placed at a distance of 2 – 6 centimeters. During manufacture of newsprint 5 – blade hydrofoil assembly has been used. On machines making illustration paper of 60 – 70 g/m² at 500 m/min. 6 blade hydrofoil assembly was used. In one case after substituting 3 table rolls of diameter 423 mm by 3 hydrofoil units following advantages were obtained :

increase in drainage by 20%

increase in retention by 3%

increase in speed by 10%

Between hydrofoils at least one table roll should be installed in order to create vibration in the web and loosen the structure of the fibre on the wire.

In hydrofoil assembly fixed before table rolls last hydrofoil blade should be flat to eliminate throwing of water on the table roll.

The hydrofoil units are getting increasingly popular day by day on paper machines in our country also. No. 3 Paper machine of J. K. Paper Mills, Rayagada has installed hydrofoil and wet suction box assembly in its wire part. West coast paper mills, Tribeni Tissues and Shri Gopal Paper Mills have also installed hydrofoils. Some mills like Ballarpur and Rohtas have introduced indigenous deflector-cum-hydrfoils to enhance the forming zone and improve quality.

Wet Suction Boxes

These are also known as forming boxes and are new drainage elements which are fitted in the forming zone. They are similar in construction to flat suction boxes but lighter and made of stainless steel lined with thin sheets of laminates and have 70 – 90 percent open surface fig. 8. These boxes are provided with barometric legs or connected with Vacuum pumps. Regulation of vacuum is done by sucking large amount of air to the box. Wet suction boxes differ from traditional suction boxes in the respect that air does not pass through the forming web if the suction box is installed before the dry line.

Top surface of the box should not work as scrapper in order to avoid excessive drive load in the suction couch. Water drop legs must have sufficient capacity so that box is not filled up with water because in that case suction profile along the width of wire will be non-uniform and water may splash into the wire causing damage to the web structure.

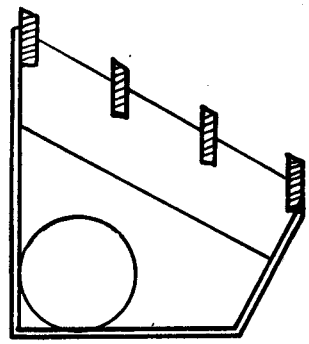

Fig. 8. Wet Suction box.

There was a belief from experiments conducted earlier that wet suction boxes do not give favourable effect in respect of formation as it had very small open surface, no regulation of vacuum and very small outlet for drain water.

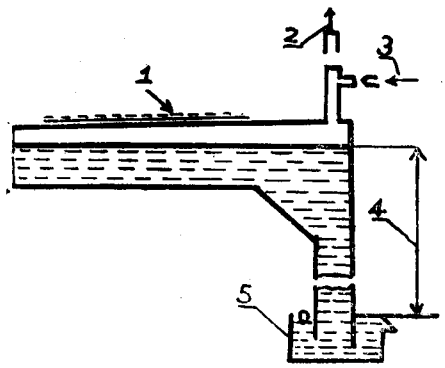

Fig. 9. Action of wet suction box.
1. Wire 2. To suction pump
3. Sucking of air 4. Suction head
5. Water seal.

From the experiments the drainage from a wet suction box may be represented from the following formula :

$$Q_n = c.\ n.^{\alpha}\ (0.1 \triangle P)^{\beta}$$

where:—

Q_n—Total drainage from the unit surface of the wet suction box in $m_3/m^2 = m$

n —number of slots on the surface of the box.

$\triangle p$ —Vacuum in the suction box in KN/m^2*

c —Constant depending on filtration resistance, consistency of stock and speed of the wire.

$\alpha\ \beta$ —Constants depending completely on the conditions of drainage process.

Experiments conducted in Stockholm Central Paper laboratory helped to calculate constant values C. α and β under the manufacturing conditions of papers like newsprint, Natron paper, Semiparchment. Value of c varies from 0.115–0.31, α from 0.60–0.70 and β from 0.59–0.65.

Larson gave the following formula for drainage rate from the wet suction boxes.

$$Q^2 + AQ = B\ (0.1 \triangle p)^{\propto}$$

where

Q—Amount of water removed in one second from one meter width of wire.

P–Vacuum in KN/m^2

A and B–Constant.

$\propto \leq 1$

With the rise in vacuum total drainage and drainage rate increases. The drainage rate does not rise much with the increase of speed.

The wet suction boxes, like ordinary hydrofoils, dewater the stock very gently due to which back water contains very little amount of fibre and loading particles, which is not the case with table rolls.

Drainage resistance of fibrous mat increases in the wet suction boxes with the rise in number of slots between the blades and amount of vacuum in the box. This rise is dependent on the quality and condition of the stock. Rise in drainage

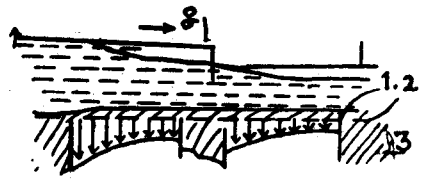

Fig. 10. Cause of drainage from the wet Suction Box.

1. Suspension 2. Forming web, 3. Wire, q_n—lowering of height of stock suspension on the wire

resistance on the wet suction box causes compression of fibre mat and closing its pores on the wire side which helps retention of fractions.

Inspite of slower drainage rate than the table rolls, amount of water removed by wet suction boxes is more due to larger suction zone. Actual advantage of wet suction boxes on the wire table, requires its proper location in relation to remaining drainage elements. Wet suction boxes are used where drainage conditions under the wire are comparatively wet. With the use of wet suction boxes the wire length may be considerably reduced especially for higher substance and lower machine speeds. Some turbulence is necessary during the formation and also the turbulence from the flow box should have time to settle and KMW recommends equalisation of distance between flow box and wet suction boxes and to use either a foil or table roll between the two.

Wet suction boxes may replace 3–6 table rolls. If we want to get maximum advantage from the higher drainage capacity of wet suction boxes, we should find out the mutual benefit of wet suction box and table rolls. This problem is specially important in case of wet stock. Wet boxes should not be put very near to the flow box and should not be very wide. A large number of table rolls should be installed between the boxes in order to loosen the structure of the web and reduce the drainage resistance. Defective positioning of wet suction boxes may lower the drainage capacity of the entire wire section.

Wet suction boxes give very good drainage effect in case of free stock and on slow speed machines (where table rolls have little effect) and also in case of papers of higher substance. Some of the major advantages of wet suction boxes are as follows :

1. Higher and controllable drainage with wide range of adjustment during operation.
2. Stabilised drainage without disturbance.
3. Lower head box consistency resulting in better formation and strength.
4. High retention.
5. Uniform distribution of filler in the sheet.
6. Simple to incorporate.

The vacuum system is very simple and inexpensive. A fan supplies the

*2-4 meter water colum = 20-40 KN/m^2

necessary vacuum. Each box is fitted with a vacuum gauge and adjusted individually.

References

1. Kikicwicz–*Podstaway Obliczen Maszyn Papierniczych*—Part II.
2. Szwarcsztajn E., "*Technologia Papieru*" Part II.
3. Aggarwal R., *IPPTA Vol. VIII No. 3.* July, Sept. 1971 pp. 137.

ULTRAPHORS

OPTICAL WHITENING AGENTS

USED IN PAPER INDUSTRIES IN INDIA AND ABROAD

DYESTUFFS

FOR

PAPER INDUSTRIES

Marketed By

ROYCE DYESTUFFS CO.

Head Office :

16-Nandanvan Co-op, Society,
BARODA-5

4-Mandir Street,
CALCUTTA-7

Branches :

Jhaveri Bhavan, Katra Tobacco,
DELHI-6