Foils - A Means of Controlled Dewatering

GERRY ROBERTS

The Papermaker usually aims to produce a sheet with minimum two-sidedness, good formation in relation to the standards set with a uniform cross-sectional distribution of fines and filler. In addition, he almost invariably wants to make it faster and at a cost lower than his competitors. Table rolls defeat this objective and foils provide an alternative method which, if used correctly, can fulfil many of the requirements necessary for controlled drainage.

This brief talk is intended to be a general appraisal of foils but it should be noted at the beginning that examples given relate to foils having the shape patented throughout the world by Dominion Engineering and The Ontario Paper Co. In this particular lecture foil blades referred to are manufactured in high molecular weight polyethylene with a fixed angle and have the Johnson patented 'T' bar mounting which enables blades to be changed during normal production. There are other types of foils on the market, but no discussion of these is undertaken.

First, consider the now well-known problems which exist with conventional dewatering equipment on the wire section of the Fourdrinier. Stock issues from the slice where the solids should be well dispersed but within a short distance drainage commences and the filtering process begins. The long fibres bridge the wire strands and on top of these further fibres are laid down forming a primary mat. Fines and fillers are filtered out and if the table were long enough and time available, water would drain through this filter mat due to the static head without carrying away many of the fines present. The table rolls, however, generate suction forces at the outgoing nips formed with the wire and it is this suction or pumping action which causes increased water removal. At the same time, water clings to the underside of the wire and to the table rolls by surface tension and is pushed back into the converging nip creating a pressure rise and washing action on the wire side of the sheet.

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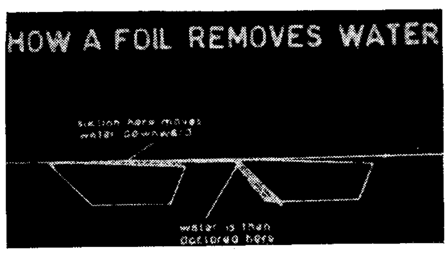
Gerry Roberts, C. H. Johnson and Sons Ltd., Foils Division, Bradnor Road, Wythenshawe, Manchester, M 22 4 TS, England.

SLIDE 1



This shows how a foil removes water and the following points are significant.

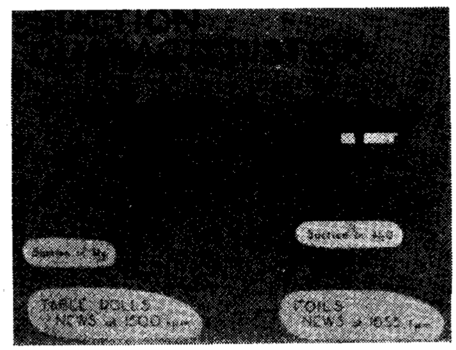
(a) The leading edge of the foil blade contacts the wire creating a seal.

(b) The foil doctors off any water present on the underside of the wire due to normal drainage or the suction head developed by the preceding foil.

(c) The suction generated on the trailing face of a foil blade does not extract water at this point, but it is carried along supported by surface tension ready to be doctored off by the next foil in line.

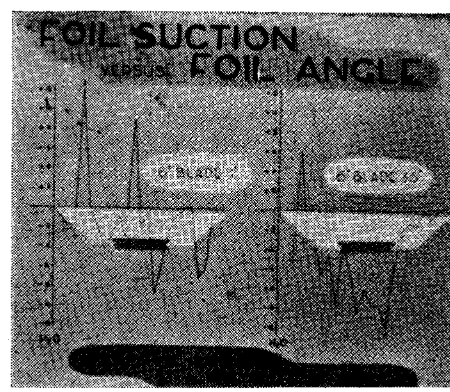
SLIDE 2

This shows the pressure which exists at the in-going nip of a table roll, followed by the high suction in the trailing part of the nip. In contrast the foil alongside shows the suction forces here to be quite low although there are more of them and the pressure points are relatively small, even at the higher speed. Most illustrations show the suction forces created by a foil as a smooth curve



extending along the whole length of the trailing face but our latest experiments lead us to believe that rather than this the effect is one of several suction peaks.

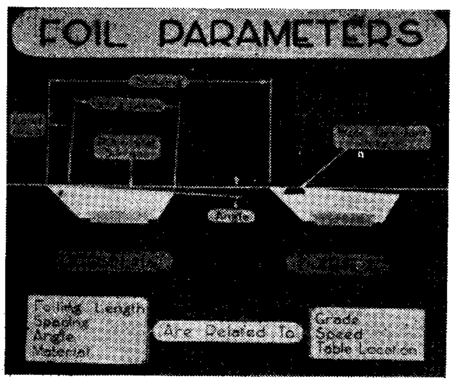
SLIDE 3



The control which is possible with foils is effected by changes in the number of blades on the table, the foiling length of blades and their foiling angles.
This slide shows the different suction forces existing on blades with angles of 1° and 1.5°. These blades are both 6″

wide and results are given for the same position on the table of a newsprint machine with a wire speed of 700 m/min. You will see that the suction pattern for 1° blade is generally lower than that for the 1.5° blade with more irregularities present. These results are reproducible but it is not yet fully understood why these peaks should occur. It could be due to the micro-turbulence induced in the stock by a foil system or simply the intermittent flooding of the foil angle at low vacuum. At speed on this machine the blades do not cause any kick-up or stock disturbance on the wire.

SLIDE 4



This shows the parameters which need to be considered when recommending foils for a particular machine. Foiling length, spacing, angle of foil blade and the material used are determined by the grade of paper, wire speed and the location of the equipment on the table. As foil systems are designed to solve particular problems associated with the wire section it is important that these basic factors are taken into account.

On newsprint machines, for example, at speeds of 750 m/min., there are several problems to overcome resulting from excessive activity as the wire meets the first plain roll. In these cases, foils can remove water from the stock without causing stock jump and the degree of agitation is controlled to achieve optimum formation. Foils would normally be pitched at between 360 mm and 380 mm centres with 12.5 cm (5″) or 15 cm (6″) wide blades having a foiling angle not exceeding 1.5°. Higher angles would cause the wire to deflect downwards because of the suction forces and when released this would return sharply to its normal plane producing the characteristic disturbance. The foiling length of the blade determines the time interval during which the suction forces are applied and it is thus possible to compensate for the reduced number of widely spaced blades on such machines. The DURAFOIL blade shown is relevant to newsprint machines where good wear resistance over long periods is required.

On fine paper machines at speeds of 300 m/min., the foil centres are closer together and angles chosen depend on the particular quality produced.

SLIDE 5

The next group of three slides show the effect of foils on stock activity and illustrates how this can be controlled by changing foil blades.

The first slide shows too much activity caused by high angled blades creating suction forces which drag the wire down as previously described. At this stage there are two steps which could be taken.

(1) Reduce the angle of the foil blades.

(2) Increase their spacing by removing intermediate foils.

SLIDE 6

This slide shows the table with foil blades having lower angles.

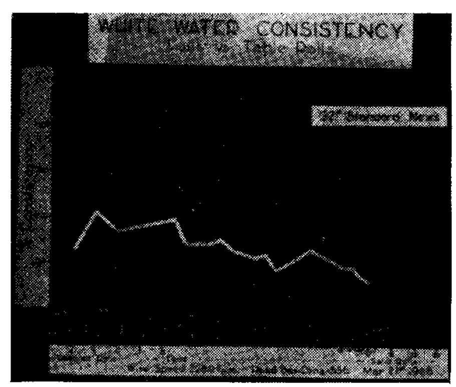
Compared with the first slide, where there was considerable stock jump, the table is now very smooth and this does not normally give a good sheet unless the fibre distribution in the headbox is extremely uniform. Therefore, it is necessary to control activity by using blades with angles somewhere between those shown on the previous two slides.

SLIDE 7

The table appearance then achieved is shown here. This work must be done by the Papermaker observing the table under operating conditions and then taking remedial action by removing or replacing foils to produce a satisfactory sheet.

The three slides show a practical example of how control of stock disturbance is in the Papermaker's hands. In our experience, this activity, sometimes referred to as micro-turbulence, is a characteristic of foil performance and not of the weave pattern of particular bronze or plastic cloth.

SLIDE 8

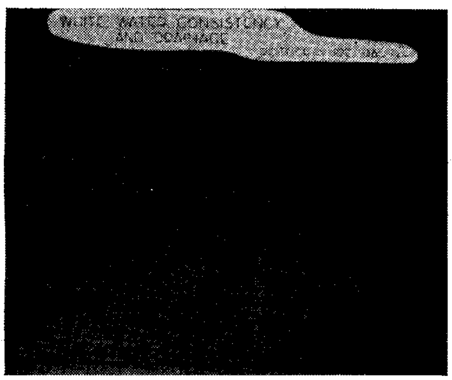


This shows white water consistency figures for foils and table rolls on a machine making 32 lb. standard newsprint at wire speeds between 600-700 m/min.

The top curve shows the results with table rolls and it can be seen that the consistency is quite low until the stock passes over the solid rolls when the sheet is broken up and stock jump results. It is this loosening of fines and filler, which then pass through the wire, that produces the high peak in the curve at the centre of the table. This diminishes in the latter half but the white water consistency is still quite high.

The bottom curve shows the same machine with foils installed in the centre part of the table and the white water consistency is very much lower than that experienced with table rolls in this position.

SLIDE 9

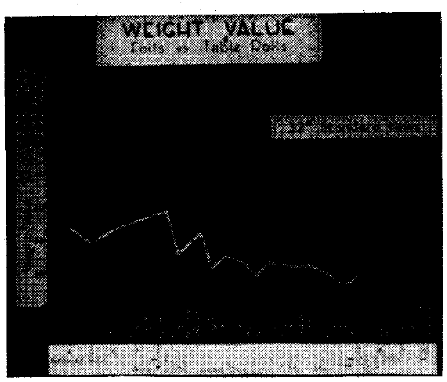


This table shows white water consistency and drainage figures in a comparison of foils and table rolls.
This machine has 6 foils in the first part of the table and 6 foils prior to the vacuum boxes. These figures show that the first unit removes 31 galls/ft. (462 litres/metre) of machine wire width per minute, with a white water consistency of .146%, the unit taking up the space of two table rolls. By comparison table roll No. 4 removes approximately 6.75 galls/ft./min. (30 litres/m/min.).

These figures also indicate that table rolls remove very much more fines and fibres than foils in the same position. In the area of the fourth table roll for example, where the stock consistency on the wire is relatively high, the percentage of solids in the white water is .206% whereas for a much greater amount of water removed in the area of the 6-1° blades, with a stock consistency approaching that in the headbox, the percentage of solids in the white water is only .146%.

At the other end of the table it becomes increasingly difficult to take water away and at table roll No. 13 the quantity of water removed is only 3.21 galls/ft./min. (48 litres/m/min.). Extrapolating this for rates at the end of the table, the last two table roll positions, No's 16 and 17, would together remove approximately 6 galls/ft/min. (27 litres/m/min.) of water. However, by putting foils at this position the quantity of water removed is 16 galls/ft/min. (72 litres/m/min.) almost three times as much. At the same time, it should be noted that at the 13th table roll the consistency is .152% and yet at this last foil box it is only 0.068%.

SLIDE 10

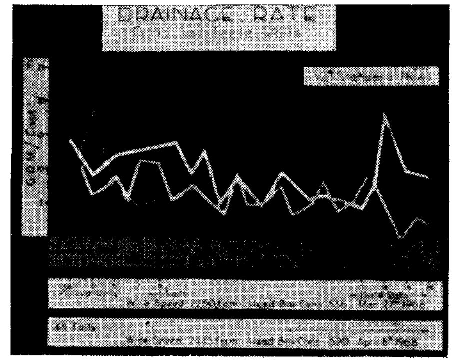


This slide emphasis the improvement in overall retention achieved by a table of foils compared with table rolls. The weight value is shown as Gallons x Consistency and emphasises the actual weight of fibres and filler taken through the wire into the white water. As a reduction in backwater consistency will automatically lead to a lower headbox consistency at the same flow rate, the possibility of achieving a good formation is improved.

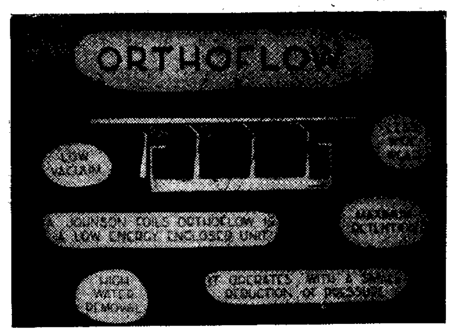
If a further reduction in headbox consistency is required the dewatering capacity of the table can readily be increased by selecting the appropriate number and angle of drainage element.

SLIDE 11

The three curves on this slide show how the drainage rate is influenced by the use of foils. The points of interest are that the product is the same but the machine speed increases, as we put more foils on the table, from 2170 ft/min. (661 m/min.) to 2,445 ft./min., (745 m/min.) and yet the headbox consistency is reduced from .776% down to .52% when the table is fully equipped with foils.

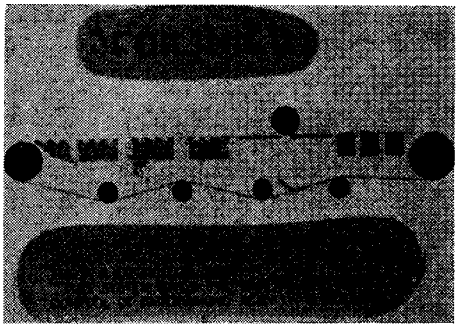


SLIDE 12



There are many disadvantages which can arise in the vacuum box area and it is generally desirable from a papermaking viewpoint to reduce the vacuum to as low a level as possible. A high vacuum has a tendency to pull fines and filler away from the bottom side of the sheet but there is little alternative with conventional boxes which have apertures approximately 5/8″ (16mm) wide and very strong forces are required to change the direction of flow of stock. The result is pin-holing and two-sidedness with the attendant problems of wire wear. Following the foil line-up it is therefore, now common practice to install low vacuum equipment to allow more time for water removal with high flow rates and maximum retention. This slide shows in diagramatic form the ORTHOFLOW or CONLOVAC unit.

SLIDE 13



This last slide shows a layout of units on the wet-end of a machine where all table rolls and some of the conventional vacuum boxes are replaced.

The specially designed forming unit with replaceable blades is followed by foil equipment in the forming area then the low vacuum units. With this machine the Papermaker controls the full length of the table being able to change the number, angles and spacings of blades and the final moisture content at the dandy or boxes by use of fine control on the low vacuum equipment. A conventional wet-end is now modified to such an extent that it is termed a FOILINIER.

Summing up, it is now well known that the action of a rotating table roll is to produce a suction of relatively high magnitude in the outgoing nip and a pressure at the ingoing nip as water is pushed back into the stock. This suction force on the trailing side, following the disturbance which has preceded it, tends to remove excessive quantities of fines and filler.

From an engineering viewpoint, a rotating roll has obvious disadvantages compared with a stationary element which can be maintained during normal production.

The Papermaker has only limited control over the dewatering capability of the table roll, either removing it or replacing by one of the grooved variety. A non-rotating roll reduces the quantity of water removed but obviously this can be only a temporary solution and such action would be detrimental to the wire, roll and the dewatering capacity of the table.

The flexibility of foils and the ease with which the number, angles and widths of blades can be changed gives a wide control of stock activity and dewatering with the benefits in sheet quality associated with improved retention and the removal of undesirable stock disturbance. As a result, it is now possible to design a foil/low vacuum installation which provides the Papermaker with a practical and proven method of overcoming some of the problems associated with traditional paper machines.

Presented by Mr. Gerry Roberts at the IPPTA Annual Meeting held at New Delhi on Nov. 8 & 9, 1971.