Developments in Forming and Pressing of Paper Web

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ABSTRACT

The size and scale of today's papermaking operations bear very little resemblance to the early machines. There have been enormous developments day by day in all sections of the paper machine. There is also great increase in machine speed, production and improvements in quality of paper and boards. The process is highly automated, with high-speed metering devices, incredibly refined chemistry, and precision built into every aspect of the operation. However the basic principle of the paper machine to form an unbroken sheet of paper over an endless sheet of wire doth, is still the basis for modern paper machines.

INTRODUCTION

Forming Section Developments

Many paper properties are determined in the forming section. For this reason alone, forming sections are an important part of papermaking. Today's highly demanding markets require more than excellent paper quality and properties. The simultaneously require higher productivity with lower expenses. For a mximum return on investment, there is an optimal compromise being made between technological performance, productivity and expenses. Pulp is made into paper by a forming process during which fibres are filtered from a suspension to form a mat. There have been research studies on papermaking over the years, but relatively few of these have focussed on the role of pulp properties in the process. Uniformity of fibre mass distribution in paper, called formation, and is strongly influenced by pulp properties. An advantage of long fibre length and low coarseness, becomes a disadvantage in formation because the fibres tend to flocculate in suspension. As a consequence, they give poorer formation. The fibre flocculation may be avoided or reduced to the minimum by lowering the concentration at which paper is formed, but this leads to the problem to remove more water during the papermaking process. Formers have been developed for faster and more water removal to achieve an excellent formation and paper quality.

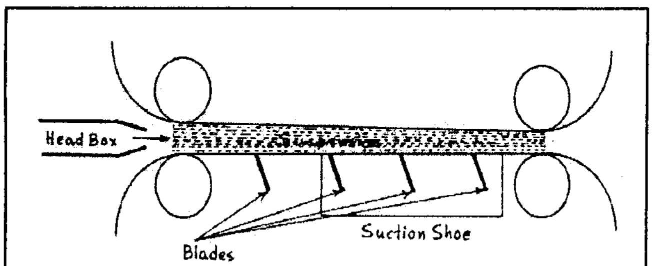

Fig. 1 The Figuer shows schematically the formaing section of a twin wire blade former.

Designing of Forming Sections are changing with high automation according to the type of paper to produce. The followings are formers came into operation gradually with increase speed of the machine and for high quality production. For speciality papers with machine speeds up to 1000 mpm, the DueFormer D, a hybrid former concept, is still a state-of-the-art technology in paper making. A curved suction box and loaded forming blades (counter blades), known as the D-Section of the DuoFormer D, are a prerequisite for excellent formation in the DuoFormer-D. These formers are very flexible in terms of basis weight, furnish and machine speeds up to 1200m/min. For aiming at a machine speeds above 1200 mpm, the DuoFormer TQ or TQv are the preferred forming system.

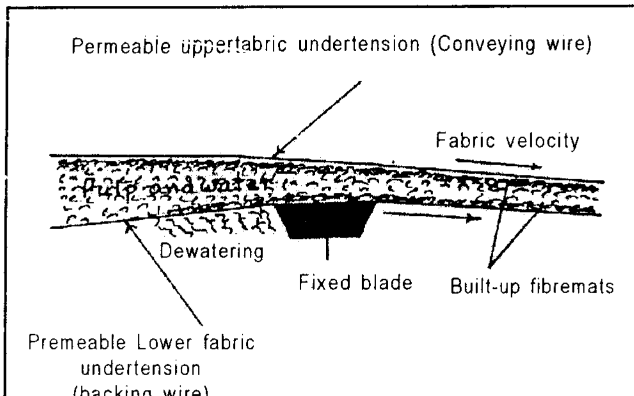

Fig. 2

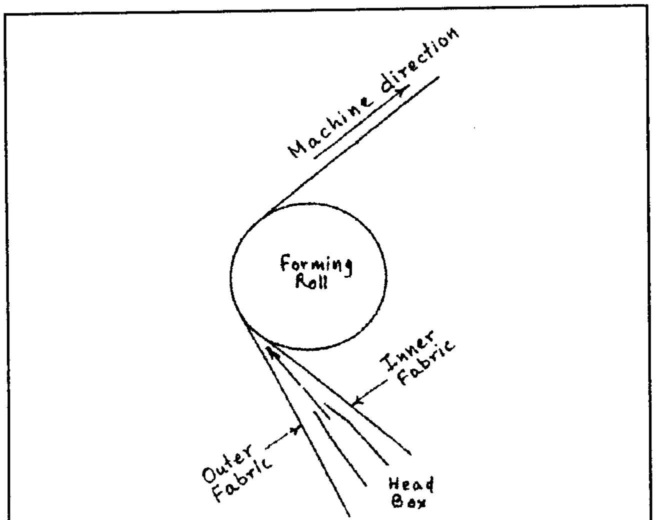

Fig. 3 The figure shows a schematic of a roll former

DuoFormer TQ utilises many components of a fourdrinier or hybrid former, while going for machine rebuiled. This works in a gap former design with a horizontal or inclined twin wire section. The DuoFormer TQv represents the latest generation of Voith gap formers. It is best suited for top quality paper and high speed machines.

The DuoFormer TQv forming system for fast Machines

A ModuleJet headbox delivers the stock into the forming gap created by the top and bottom wire. The initial drainage starts on the forming roll. The forming roll promotes retention and enables headbox to jet positioning. The roll is followed by a specifically designed blade section for promoting formation. A wet suction box,

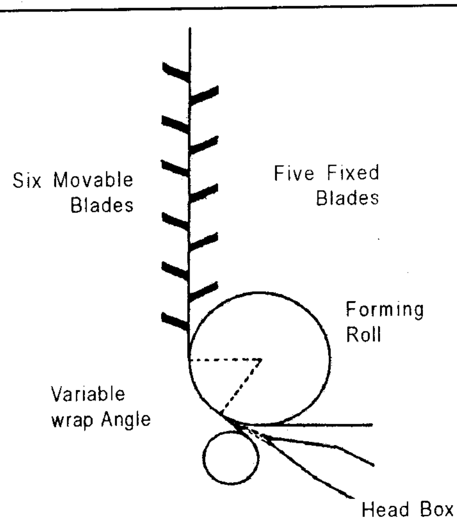

Fig. 4 The layout of a former with roll dewatering followed by blade dewatering with adjustable blades

couch roll and high vacuum flat suction box further increase the dry content before the web arrives at the press section. Due to the vertical arrangement of the forming elements, white water handling is extremely simple. The former is customised for wood containing and wood-free grades paper and works with the Roll and Blade-forming concept. Initial drainage starts at the forming roll, following the blade section, consisting of a curved suction box and forming blades (counter blades). The formation is improved significantly. The stock for wood-containing grades has a normally high drainage resistance and low shear resistance. For this grade of stock, the TQv Former is designed with a large wrap angle and no forming blades.

Gap Former

The key surface properties of paper are established in the forming zone of papermaking. The hydrodynamics of this zone and the flow and pressures in the jet impingement zone is very critical. The Gap Forming Technology is the recent development in the forming zone. The paper produced with this new forming system fulfils the highest quality demands.

In a gap former, pulp suspension is directed by the headbox between two moving, continuous forming fabrics under tension. In a blade gap former, these forming fabrics pass over fixed blades. In a roll former, the forming fabrics pass over a rotating, large diameters roll. In all these formers a dewatering pressure is generated which leads to faster dewatering and excellent formation. The vertical gap former leads to even much faster de-watering and excellent formation, and overcomes two -sidedness of the paper.

Twin-Wire Gap Forming

In the fibre suspension used in paper manufacturing, the fibres tend to form lumps or flocs. Smaller and more evenly spread flocs leads to a much improved formation and are highly desirable to produce a paper of better printing and other high demand quality Including pressure pulses in a twin wire forming zone is a way of attaining this improvement. The pressure pulses cause floc tearing shear forces in the fibre suspension. In twin wire gap forming the pressure pulses are created by different kinds of deflector blades. It is required to know and understand the Mechanics of floc deformation by virtue of experimental study. Therefore with a better understanding of the forming process many types of paper quality may be improved.

In a twin-wire paper forming (TWF) machine the jet of furnish from the headbox is directed into the narrowing gap between two forming fabrics. The basic principle of twin-wire forming is that both sides of the suspension is

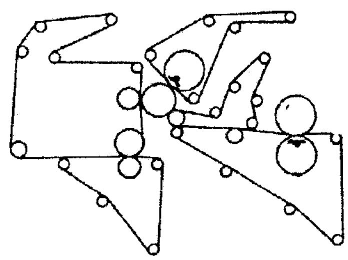

Fig. 5 Liner board and corrugation medium
After the pressing the solid content is 40-50%

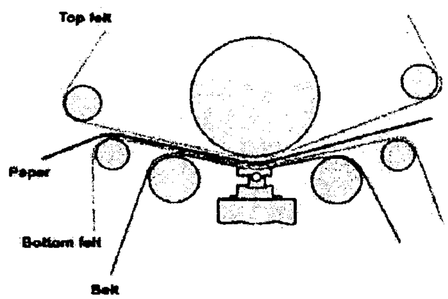

Fig. 6 Shoe Press

in contact with the wire at all times. Water is removed in both directions. Drainage is achieved by creating a positive pressure difference in the region between the wires and the surroundings. The wires are pre-stressed and have an inner tension. As long as drainage takes place, the resistance to flow through the fibre mat and the wire generates a pressure drop across these layers, resulting in a local curvature of the wire. There is a pressure difference across the mat and the wire, neglecting the bending stiffness of the fibre web and the fabric. The sheet becomes "set" very rapidly within a gap former, therefore the uniformity of furnish emerging from the headbox is very critical. Compared to Fourdrinier forming, twin-wire forming yields cònsiderably higher dewatering rates. This is due to the fibre mats building up on both the wires simultaneously. In addition, the flow resistance through the mate and wire on either side is significantly less than that of a single wire and mat, after the same amount of total drainage. Another advantage is that the bi-directional removal of water tends to produce a sheet whose two sides have a more equal structure than in Fourdrinier forming. The rate of water removal may be enhanced by passing the pair of forming fabrics around a roll, over blades, or over vacuum elements.

Twin-Wire Blade Gap Forming

In twin-wire blade forming, pulp suspension discharges from the headbox into the gap between two moving pemeable fabrics, which follow an overall straight path. These fabrics are under tension and locally defliected by fixed (obstacles) ceramic blades, which are appled across the full width of the wires. The principle of blade application is two wires pass a series of three blades of which two are applied to the top fabric and one to the bottom fabric. The deflection of the wires causes a pressure, built up in the region between them. TWBF paper is superior to both twin-wire roll forming paper and fourdrinier paper because in the blade forming process, pressure pulses are generated the pulp suspension passes over each blade. These pulses do two things: they cause rapid local dewatering of the pulp suspension, and they cause shearing of the pulp suspension, which improves sheet formation. It is seen that the pressure pulse formed at a blade is a strong function of the drainage resistance of the pulp fibre mat, built up on each fabric. Consequently, in order to understand the dewatering and sheet formation improvements that occur in TWBF, it is very important to have a good idea and knowledge of the pulp fibre mat drainage resistance.

Schematic of a Blade Gap Former

The following figure focuses on processes occurring in the vicinity of one blade in the former. As the fabrics

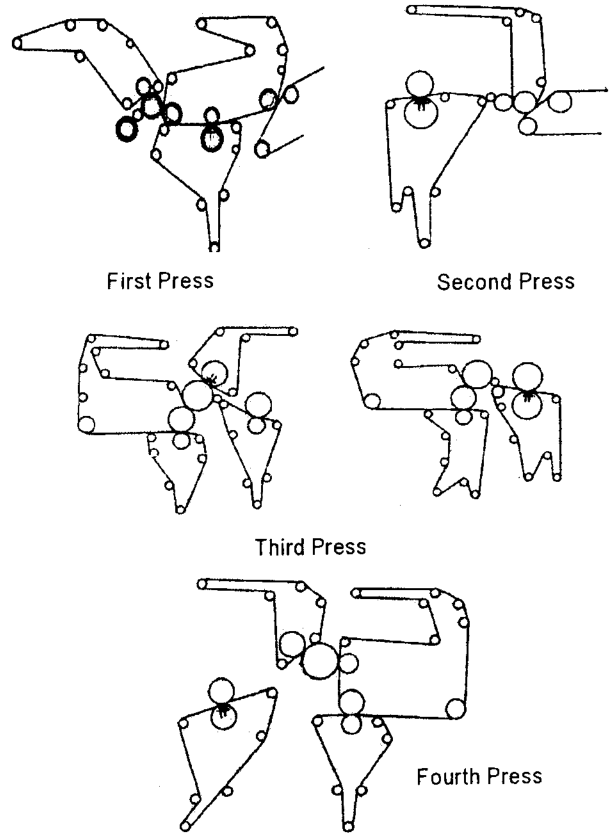

Fig. 7 Shoe Press Locations

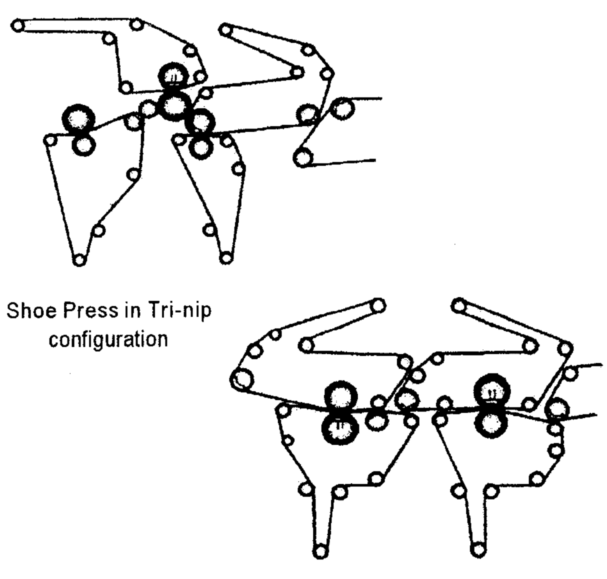

Fig. 8 Shoe Press Locations

under tension pass over each blade, the static pressure between the fabrics builds rapidly, to counter the component of the fabric tension force acting normal to the blade. This builtup of static pressure causes dewatering to occur rapidly in the vicinity of the blade.

Roll Gap Former

In a roll former, the forming fabrics pass over a rotating, large diameter, roll. During roll forming, the wires are deflected over the cylindrical roll, and hence a dewatering pressure is generated. In the process, the static pressure between the fabrics achieves a constant value, equals to fabric tension by the roll radius. Early twin-wire formers achieved drainage in this way. By using a roll with permeable surface, two-sided dewatering can be obtained. Roll forming is a quite gentle method in the sense that the amplitude of the dewatering pressure is rather low and in that the pressure gradients in the machine direction are not severe. This yields a good retention of the fibres and the additives in the suspension, which at higher pressure levels would follow the water through the wires in a larger extent. Since the pressure gradients play an important role in breaking up fibre flocs, their absence yields flocculation and will result bad formation. therefore the dynamics of roll forming is highly complicated.

A combination of roll and blade forming with fixed and adjustable blades

The roll section maintains comparatively an even drainage pressure between the two wires, that provides high retention. The intensity can be varied by applying different pressures by the adjustable blades. The drainage distribution between the roll and the blades can be adjusted by varying the outer wire wrapping angle on the forming roll. This provides significant increase in drainage at the blades which follow the roll. The best results are achieved by placing the adjustable blades against the outer wire. The flow design of the headbox plays an important roll. This new technology was introduced by STFI after several experiments and study.

Pressing Section Development

There are different kinds of presses, for example conventional and wide-nip presses.

Shoe Press Technology

Shoe press technology is an exemplary paper-making technology that improves the dewatering capacity of the conventional pressing section by extending the nip residence time in the wet pressing section, increasing the dryness of paper or board sheet before the drying section and reduces the need for evaporating drying. The amount of water removed in the pressing section is proportional to the magnitude and the duration of the pressure applied to the paper sheet. In conventional roll presses both the pressure applied and the nip residence time were constrained. Pressure could not be increased to unlimited, because the paper sheet would be damaged especially at higher machine speeds. Nip residence time decreased with increasing machine speeds. The constrained press impulse of conventional roll presses was overcome by shoe press technology.

Early shoe presses utilized open loop configuration that is best suited for board grades with machine speed up to 1000 meters/minute. More recent development of closed type shoe presses has made possible of its installation for writing and printing grades with speed in excess of 1500 meters/minute. Closed shoe presses have now become the standard for all types of paper production. There are now well over 300 shoe presses around the world in operation, out of which roughly about 80 are open loop shoe presses. About 30% of the remaining enclosed shoe presses are in use for writing and printing grades machine. The shoe press concept lowers paper manufacturers' costs by allowing more water to be removed in the press section, as well as improving sheet characteristics, while using less costly raw materials. In modern paper machine shoe presses have dramatically increased the wet web dryness which was not possible to achieve by conventional roll presses. The combined effects of higher press loading and greater residence time in the press nip, boost the sheet dryness levels from 42% to 52% before entering the dryers. The benefits include significant energy savings for drying, improved machine runnability and operating efficiency resulting higher wet web strength, and improved paper properties.

The nip of a shoe press consists of a stationary shoe, which is loaded against a press roll. A stationary, concave shoe press replaces the conventional bottom roll. Felts designed for shoe press are used for transporting the water from the press. A belt or sleeve forms the shell that runs between the mechnical press and the bottom felt. Oil is supplied on the inside of the belt to act as a load transfer medium and to provide lubricant between the stationary shoe and the moving belt. (Picture on page 10). The shoe presses are equipped with sensors, which measure the pressure distribution in the press nip, the temperatures in the press roll and the temperature at the roll surface. The shoe press has exchangeable shoes, the length of which can be varied between 170 and 320 mm.

Shoe Press Fundamentals

So far newsprint machines have been able to achieve up to 52% sheet solids after the press section at a speed of up to 1670 mpm. The increase in dryness is due to the high press impulse obtained with a shoe press. The press impulse is about 4 to 7 times higher with a shoe press compared to a roll press. The nip width of a roll press varies between 20 and 50 mm, while most shoe presses have a nip width of 250 mm,. Presses with 150 to 220 mm shoes are also available today. Most fine paper machines in operation today load the shoe press between 500 and 700 kN/m, the difference in peak pressure between a roll press and a shoe press is significantly greater. The low flow rate helps to reduce the movement of fibres in the nip and can contribute in minimizing sheet two sidedness caused by a diference in fiber stratification betweent the two sides. Pressing at low peak pressure over a long nip time reduces the hydraulic pressure in the nip and produces a lower flow.

Advantages of Shoe Press Installation

The major advantage of the shoe press is the higher dryness achieved after the pressing section. Depending on the grade produced, the increase is about 5 to 10% compared to conventional pressing. The higher dryness leads to an increased production capacity (about 10 to 20%), when a shoe press is put on a existing (limited dryer) paper or board machine. When a shoe press is implemented on a new paper machine, the drying section can be shortened thus reducing capital expenditure.

A second advantage is the demand for steam is reduced in the drying section . This may lead to an improvement in energy efficiency in spite of the increased electricity consumption.

A third advantage is improved product characteristics. The pressing section is important for paper properties because most physical and surface characteristics are in some way related in to the density of the sheet. Pressing causes densification . The effect of a shoe press on paper properties differs among the grades produced. Installing a shoe press on a board machine includes a favourable increase in strength properties. This permits savings in refining, the use of lesser strength additives, and the use of cheaper furnishes. The installation of a shoe press on a paper machine leads to a higher dryness without reducing the thickness of the sheet. This results in cost savings by reducing the amount of fibre needed.

CONCLUSION

For the next generation of paper machines, both fourdrinier and hybrid formers will have limited application because of their inherent free surface instabilities which intensify with speed. Gap formers do not have this limitation; their machine-direction and cross-direction basis weight stability is independent of speed. It is expected that more paper machines in the future will have the capability of stratified sheet forming, in which two or more stock flows merge together in the flow channels of the headbox. With this forming method, the top and bottom layers of the sheet can be optimized for smoothness, brightness and reduced linting.

Technology in the years to come can produce paper with the machine speed much higher than 2000 mpm. Speeds are a result of significant advances in supported web-technology, shoe-pressing technology and the ability of surface treatment sections to deliver superior sheet runnability with high efficiency. Future paper machines may be produced with much more maintenance free and controls will continue to get more and more sophisticated.

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