Wet Pressing

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SUMMARY

Based on the state-of-art survey aspects of Wet Pressing relating to strength development and water removal during papermaking have been critically analyzed. It is concluded that replacement of limited beating with wet pressing will produce an equal or stronger sheet and at the same time greatly improve water removal rates.

INTRODUCTION

During papermaking, a web is first formed on a moving wire by the free drainage of water from a slurry containing papermaking fibers (which are well dispersed). The web is then passed through between rolls under pressure to squeeze out more water (wet pressing). Finally the left over water in the web is removed by drying. Wet Pressing, as such, forms an important integral part of papermaking in terms of sheet strength development and water removal.

EFFECT ON SHEET STRENGTH

Several workers ([1-12]) have demonstrated the increased Wet Pressing results in improved strength properties of the sheet (Fig. 1). The improvement is attributd to an increase in fiber bonding ([11]) but improved tensile strength of fibers and decreased Young's modulus have also been reported during Wet Pressing ([13]). The action of Wet Pressing on the cell-wall structure has been visualized as the result of a compressive force perpendicular to the fiber axis. This deforms the walls in the lateral directions and packs the fibrils in the B direction (Fig. 2) at the same time pushing them apart along direction A. This is hypothesized to produce slightly changed fibrillar angles.

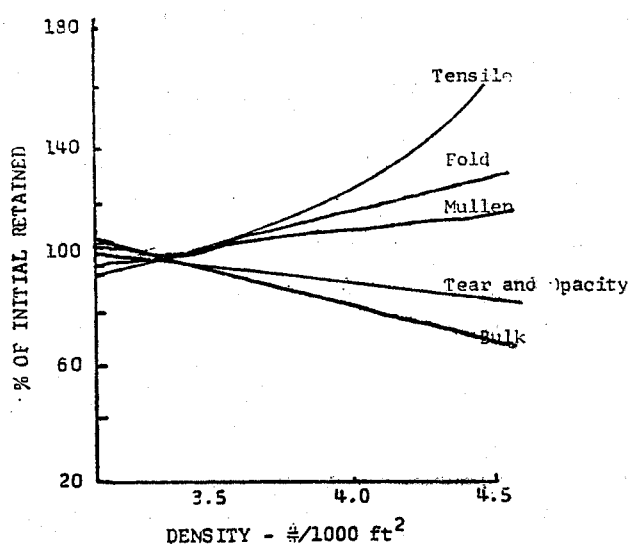

Fig. 1. Generalized Graph to show effect of Wet Pressing on paper.

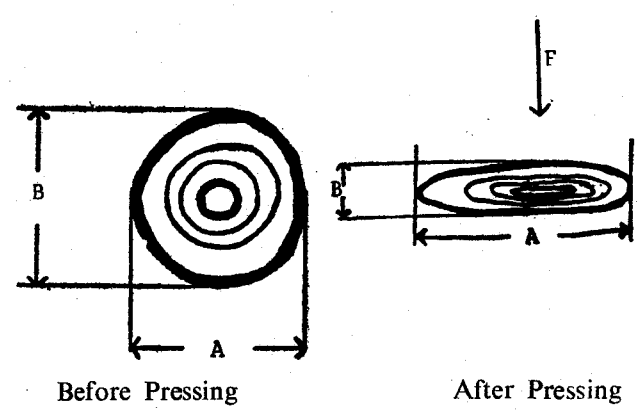

Fig. 2. Effect of Wet Pressing on Cell Wall.

The effect of Wet Pressing is less pronounced or uncertain on summerwood fibers, high yield fibers, and unbeaten fibers ([13]). The level of an effect on sheet properties at a particular pressure is dependent on freeness ([1, 9-12]). Completely unbeaten pulps have been reported to be less responsive to Wet Pressing. At low degrees of beating, beating and Wet Pressing are additive. Pressing has little effect on properties of paper made from highly beaten pulps. The latter continue to increase in sheet density but the tensile strength declines.

There is a general agreement among majority of workers in the field that Wet Pressing can be substituted for limited refining in developing sheet strengths. However there appears to be an optimum amount of refining for maximum gain in dry sheet strengths as a result of Wet Pressing ([9, 10]). Also, there is a

maximum effect beyond which more passes and higher pressures give little improvement [1]. Pressing to a moisture content of about 50% appeared to be the maximum for Douglas fir kraft pulp [1].

Lindman [14] has reported from an extended study of the sheet strengths at points along a paper machine drier section that excessive Wet Pressing could lower dry sheet strengths.

Increase in sheet strength obtained by additional Wet Pressing will avoid slowing down the stock used with refining. Drying capacity is also likely to improve as the web entering the driers will have higher solids than before.

WATER REMOVAL DURING WET PRESSING

Normally the web enters the wet press at about 16 to 20% solids and leaves at about 30 to 35% solids, after having passed through two presses. Within this range of solids, the web is composed of water and fiber only [1]. It is a liquid-solid system in which the solid is relatively uniformly dispersed as discrete particles throughout a continuous phase. As the wet web passes through a press nip, it is subjected to increasing and then decreasing pressure. The pressure used in wet pressing is opposed by the resistance of the fibers to deformation and the resistance of the water to the flow through the capillaries of the web.

Detailed considerations of water removal in the wet presses has been discussed by Campbell [15], Ingmanson [16, 17] and Wrist [18]. Most of the experimental data on the compression properties of wet fiber mats have been obtained under essentially static conditions. The mathematical relationship

$$C = M P^n \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

where C = mat density
P = compacting pressure
M, N = compressibility constants

have been proposed extensively to describe the experimental curves [15-17, 19]. This equation is suggested to be satisfactory over normal press roll pressure ranges for practical purposes when the appropriate empirical constants are fitted. Most of the data are analyzed in terms of M and N. M and N are reported to be unchanged with beating [17].

Compressibility, under dynamic conditions, is less documented. Wilder [20] studying the time dependency of the compressibility of wet fiber mats has shown that the degree of compression varies with the logarithm of time over an interval from a few seconds to many minutes as per equation (2) :

$$C = (M' + M'' \log t)\, pN \quad \ldots\ldots \quad (2)$$

Kurath [21] studied the dynamic shear modulus of wet fiber mats at frequency of 100 cycles/second and found the shear modulus varied with the consistency as per equation (3) :

$$Cp = M^{*}G^{*N} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

where Cp is the consistency corresponding to pressure P given by equation 1. The values found for the constant N in his experiment were very nearly the same numerically in both equations (*1*) and (3). This suggests that the compressibility equation of Wilder may also extend for time during duration down to 1/100th of a second. Over successive compression-recovery cycles, the values of M and N change until about six cycles in the case of wood pulps, when they approach a constant value [20]. The recovery portion of each cycle could be described by equation (1) but with different values of M and N than those found in the compression phase.

Beating has no effect on equilibrium consistency but it decreased the rate at which the equilibrium condition is reached [22, 23]. Beating also decreased the extent to which the pulp recovered towards its original caliper when the loading was released [23].

The removal of water at the presses is governed by (1) pressure applied per square inch contact area (p), (2) length of time pressure is applied (t), (3) number of presses, (4) type of press (suction or plain), (5) absorbency of press felts, (6) viscosity (due to changes in temperature of water (n) and (7) porosity of wet web. According to Campbell [15], the effect of variables on sheet consistency over a considerable range above 12% can be expressed by :

$$\frac{pt}{W^2S^2n}$$

where W = basis weight,
and s = specific surface of the stock.

Water is more easily pressed out of the sheet at higher temperature than at low temperature. Stamm[24] found that raising the temperature of the wet sheet from 65 to 85° F during pressing reduced the moisture content going to the driers by 2 to 3%. Patents [2, 3] dealing with the use of preheaters between pressing stages claimed improved water removal and stronger sheets.

The porosity of the web is important in the removal of water at the presses. As the web is compressed, the resistance to liquid flow becomes increasingly greater because of the reduction in the size of the pores. Drainage aids coagulates the fines during drainage on the wire, producing a porous web going to the presses. During pressing of such sheets, a greater amount of water is removed as reported by Ellis *et al.* [25].

CONCLUSION

An optimum condition exists where limited beating of fibers can be replaced by increased Wet Pressing. Such treatment may have better strength properties than obtained in the present set-up. The wet web is characterised by its compressibility, creep and recovery behaviours during increasing and th endecreasing pressure at the presses. The pressure applied in Wet Pressing is opposed by the resistance of the fibers to deformation and the resistance of the water to flow through the capillaries. Raising the temperature of the web as well as a more porous web helps in greater removal of water during pressing.

Beating has no effect on the equilibrium consistency but slows down the rate at which it is reached. Beating also reduces significantly the degree of recovery.

Replacement of limited beating with wet pressing will therefore produce an equal or stronger sheet and at the same time greatly improve water removal rates.

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