Promising Features of Recent Developments in Wet Pressing Technology for Newsprint

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SUMMARY

Wet pressing is the best way of water removal from paper web. This can be promoted by reducing the viscosityy of water which is best redaced with heating, which in turn has multiple beneficial effects on almost all economic factors.

The increase in temperature in wet pressing for newsprint is around 2.5 times more beneficial compared to other grades. The other promising features are–energy savings, possibility of using more high yield furnish in place of chemical pulp with improved runnability, better printability in addition to speed increase etc. It is strongly felt that increasing the temperature of web during pressing has commercial adaptability even with the existing presses with no additional gestation period.

Author exposed the importance of temperature increase using factor, which is a constant for particular furnish under specified conditions.

TEMPERATURE AS A VARIABLE IN WET WEB PRESSING

Now-a-days, almost all the Newsprint machines are high speed with advanced wet end giving 43-45% maximum dryness off press section taking into account every feasible utility of variables other than temperature. Now it is the turn of the most important variable, the temperature to be operated for the increase in dryness out of the press.

The water removal in hot web pressing can be considered as the combined effect of :

i. Mechanical consolidation.

ii. Evaporative Web drying by increasing the temperature.

It is found that the combined mechanism will show aneconomically feasible change in water removal and sheet characteristics, especially for high yield furnished low or intermediate basis weight paper grades like Newsprint.

The recent studies advanced the technique, which operates at different levels and called by different names like High temperature pressing, Hot pressing, Impulse drying, or press drying etc, depending upon the intensity of the individual mechanisms operating, web condition and method of heating.

The dewatering limit in room temperature pressing is set by the compressibility of the web. At the point of maximum compression the web is saturated but there exists no driving force or gradient for actual movement of the intersticial water out of the sheet. Variable temperature introduces a new dimension to wet pressing by varying surface tension, liquid tension, steam pressure gradient etc. which may push intersticial water out of the sheet. Hence the amount of water removed is no longer related to the compressibbility of the web alone. Dewatering time has little effect once it exceeds a critical value. Short residence times appear to be sufficient for relatively thin and porous webs containing more high yield furnish due to high rate of water removal at higher temperatures. Very high water removal rate observed will in turn allow dryness increase over a wide range of entering dryness content.

This important variable, the temperature in wet pressing and its special effects on newsprint,

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can be studied systematically as follows :

I—The effect of variable temperature on :

a) Water removal and dryness

b) Sheet characteristics

c) Economy

II—Practicability :

a) General View b) Evidence

I. The Effect of Variable Temperature on :

a) Water Removal & Dryness

Rise in temperature of the stock by 9-10°C increases dryness of the paper from 2-3%. Affect of temperature on drainage and drainage rate during pressing can be briefly explained using one of the important relations between water viscosity and temperature. Rise of temperature of 1°C in the range of 20-60°C reduces the viscosity of water by 2-5% or heating the water from 20°C (68°F) to 50°C (122°F) reduces the viscosity by half.

The net water removed from the sheet can be promoted by reducing viscosity of the water which in turn is best reduced with heating.

$$\mu \propto \frac{1}{T} \quad \text{... (as assumption)}$$

$$\text{i. e. } \mu = \frac{C1}{T} \quad \text{... (C1 is equation const.)}$$

Substituting this value of 'μ' in the equation (1) we get :

$$B = (K1/C1) \triangle P. t. T \text{ ... } (K1/C1 = K2)$$

$$\text{i.e. } B = K2 . \triangle P. t. T \quad \text{... ... (2)}$$

The equation (2) shows the direct positive effect of temperature on water removal during pressing. In addition, there are other beneficial effects on water removal and sheet characteristics.

1. Reduction in surface tension and liquid tension forces by increase in temperature.
2. Compressibility of the web increases with increase in temperature, due to plasticizing effect on fibre components.

Effects	Temperature °F					
	40	60	80	100	160	212
Viscosity, Cps	1.55	1.12	0.87	0.69	0.4	0.28
Surface Tension dryness/cm.	75.0	73 5	71.9	70.3	65.6	61.7

Because of its inverse proportionality, viscosity has more weightage than other variables for the net water removal in press according to the formula of the following general type valid for Low Reynolds nos.

$$B = \frac{k_1 . \triangle P . t}{\mu} \quad \text{... ... (1)}$$

where 'B' is net water removed from the sheet :

K_1 is equation constant depending upon several internal related factors–including.

i) Press design and operation

ii) Pulp furnish and web structure

iii) Speed of the machine and rewetting etc.

P is the hydraulic pressure gradient/effective gradient of dewatering existing between sheet and felt in the nip.

t is dwell time.

μ is viscosity of water.

3. Temperature reduces the adsorption or easily removes adsorbed molecules due to "heat of adsorption".
4. The affinity of hydroxil group (—OH) of cellulose towards water molecule is inversely proportional to temperature So the hydrophilic nature of cellulose and in turn layer of molecules bound on fiber surface decreases with increase in temperature.
5. Conduction of heat and generation of vapour in turn enhances transport of water of the sheet by means of the steam pressure gradient.
6. Since, the temperature of web remains higher than that of left nip dewatering increased and rewetting of the web in diversing nip is reduced to a remarkable degree mainly due to reduction of surface tension.
7. The effective dwell time increases with temperature due to higher rate of water removal.
8. Part of the heat in the paper web is naturally transferred with the water into the press felts

which facilitates the water removal from felts. etc.

Apart from the higher drainage obtainable due to reduction in viscosity, it is now seen that the effective pressure gradient and time of pressing; this when stated in the form of an equation becomes :

$$P.\,t.\ \alpha\ T^{\alpha}$$

$$P.\,t. = C2T^{\alpha}\ \ldots\ (C2 \text{ is equation const.})$$

and 'P t factor' is a constant for a particular furnish under specified conditions.

Substituting this value of P. t in equation (2) we get :

$$B = K2\ C2\ T^{1+\alpha}\ \ldots\ \ldots\ (K2\ C2 = K3)$$

i. e. $B = K3\ T^{1+\alpha}$ ... ... (3)

The dryness out of the press 'D' is directly proportional to get water removed 'B' for a constant ingoing web dryness.

$$D\ \alpha\ B \quad \text{or} \quad B\ \alpha\ D$$

$$B = C3D\ \ldots\ \ldots\ (C3 \text{ equation const.})$$

substituting this value in equation (3) we get :

$$D = (K3/C3)\ T^{1+\alpha}\ \ldots\ (K3/C3 = K4)$$

i. e. $D = K4.\ T^{1+\alpha}$ ... ... (4)

Let $D = K4T^{1+\alpha 1}$ ... For other grades, and

$D = K4T^{1+\alpha 2}$ ... For Newsprint

It is stated in literature that (B. No. 6, 1)

(a) The average gain in dryness for different grades is 1.0 to 1.3% for 10°C rise in temperature, i. e. 18°F rise will give 1.0 to 1.3% dryness gain ∴ 10°F 0.6%

(b) Mr. Wahlstrom reported a moisture reduction for newsprint from 66.5 to 65.0% i e. again in dryness of 1.5% for a temperature rise of 10°F.

Considering these two statements and substituting in the formula mentioned above dividing each other, we get,

$$\frac{0.6}{1.5} = \frac{T^{1+\alpha 1}}{T^{1+\alpha 2}}$$

i. e. $T^{1+\alpha 1} = \frac{(1.5)}{(0.6)}\ T^{1+\alpha}$

i. e. $(\alpha\ 2 = (2\,5)\ \alpha 1)$

It can therefore be stated that :

"INCREASE IN TEMPERATURE OF WEB DURING PRESSING IS 2-3 TIMES MORE BENEFICIAL ON NET WATER REMOVAL IN CASE OF NEWSPRINT COMPARED TO OTHER GRADES".

This additional benefit in case of Newsprint may be due to

i. Fiber coarsenss and stiffness in addition to higer web porosity.

ii. The higher lignin content which is water repellent in nature, present in newsprint furnish may reduce absorption, hydrophilicity, hydration, and in turn rewetting to a certain extent.

NOTE :

To determine the optimum temperature, the assumed contants, ' K4" and 'α-factor', are to be analysed. These are complex in nature due to inter relation again with temperature in addition to several other variables and constants. It is out of scope of this paper. However, the challenge is to raise the K4 and α - Factor along with temperature and other variables.

b) Sheet Characteristics

The wet strength after press as well as dry strength of paper increases to a considerable degree by increased temperature. This may be based on following facts :

1. Higher dryness level obtained by the intense mechanical action rather than evaporation.
2. Higher compressibility and inturn densification of the web because of efficient pressing operation.
3. Release of 'LATENCY', by the combined action of high rate water flow shear forces and hydraulic pressure in addition to the plasticization lignin encrustant at high temperature, give more cohesive bonding.
4. The part of the hemicelluloses turned plastic in the press and new bond formation between fibers.
5. Later, the lignin debris filling in the pores and gaps to solidify the sheet.

The tensile strength is considerably increased to give fewer web breaks intrun better runnability on high speed machine. The sheet densification and opacity reduction are negligible when compared to the higher bulk and opacity obtainable by the more utilisation of high yield pulps rather than costly, loss opacque, lower bulk, hydrophilic chemical pulp due to increased strength.

The paper printability is no way affected adversely or on contemplation, we can state that the gain in strength properties with high yield pulp definitely improves printability, opacity, and bulk, or atleast compensates the adverse effect of densification and stratification.

c) **Economy**

The operation of heating the sheet to raise the temperature may require high grade energy, yet it may be economically advantageous due to following factors :

1. It may permit substantially higher speeds due to higher rate of drying and runnability
2. It requires less energy than conventional drying because
   a) All water need not be evaporated and overall energy loss per point increase in dryness is very less compared to the conventional drying
   b) The heated paper web need not be reheated that much, at the beginning of the dryer section :
3. It may be easy and cheaper installation on existing machine within a short period and may elimioate capital costs for bulky dryer sections, the associated building, piping system and even a boiler house in future.

II. PRACTICABILITY

a. General View

The most efficient way to heat the sheet is by condensing steam in it. This way it may be possible to raise the temperature from present levels of 30—40°C to 80—90°C with again in dryness after press of 5%—10% or even more depending upon the grade of paper and design, configuration, condition of press etc.

Steam can normally supplied through steam boxes placed just top of the sheet for convective heating or suction zone of a suction roll for condensing heating. The most efficiency heating may be achieved using vacuum to pull steam into the sheet. This may not be possible for heavy sheets because of their impermeability but it is possible and are beneficial in case of New-print.

The high efficiency, high temperature heating device is yet to be developed; but the steam box in the press section serve the purpose to a certain extent. To minimise the steam consumption and to ensure its efficient use, it is practical to first remove the excess water by pressing To achieve best results, heating the web ahead of each press is appropriate. It is believed that the intensive pressing including web heating; decreases adhesion/ cohesion of fines or fibers to top roll compared to estimated value because the rate of adhesion/ decreases by 1/4 times than the expected value by pressure application; with increase in temperature.

b. **Evidence**

Let us review in brief the investigatory practice carried out at RAUMA-REPOLA'S—FINLANT (B. No. 8) with a steam box in the press section of their PM 3, built with twin wire former, and press section designed for high speed (1200 m/min.) operation. It has variable crown stainless steel grooved rools in the Ist bottom and 3rd positions. Maximum and normal operating pressures in the 1st, 2nd, 3rd nips are 70, 80 and 110 kN/m respectively.

The steam box is installed after the first nip opposite the low vacuum area in the suction roll. The box has 29=separately controllable sections across the machine and has been used from the beginning 1980s) to raise the temperature from 27°C to 54.5°C and found to give a dry solids content of newsprint after the press section increased from 40.8% to 45% In trials with two web heating devices a steam box ahead of the 2nd press and an infrared heater ahead of 3rd press, reports, the dry solids content of wood free paper after the press section increased to 48% from 40% without heating. One study concluded that the increase in dry solids content of a web heated by a steam box does not depend on the dry solids content of the web entering the second press

Reduction of about 12—20% total steam consumption, with nearly 20% strength increase, 6% decrease in density, improved runnability, reduced roughness and oil absorption, and possibility of CD Moisture profile control were observed; in addition to high rate of dewatering and increased machine speed, in a trial run

It has been found that the effect on granite roll may be remarkable and corrective, measures like stone grinding under the same conditions as in the paper machine etc may have to be taken to eliminate vibration or difficulties with the granite roll doctor.

Overall result of investigation found to be extra ordinary and encouraging.

CONCLUSION

Promising features of recent trials operating the variable temperature in wet press, reveal that is universally adaptable for Newsprint and to some extent on other grades as well.

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