last but not the least

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The impact of water in making presentable paper and board is examined here. Water has to be strictly followed from the stock preparation stage to the passing the web through the rollers.

The entire papermaking process may be divided into three segments. Addition of water to the stock, extraction of water from the stock layer (web) and finally passing the web (sheet) through smooth surfaced rollers. This last process is called calendering which plays a vital role in the final sheet characteristics and finish. The present article deals on this last section of paper or board machine. Mainly, defects occurring in the extraction of water from the web is magnified at this and causes various types of problems among which bad finish, bad reeling, creases are few to mention.

Save some special tissue papers, all grades of paper and boards have to be passed through the calender which is situated adjacent to the outlet end of dryer section. A modern calender stack consists of nine chilled cast iron rolls, the largest of which in diameter is called the king roll situated at the bottom, one medium size top roll or queen roll and seven intermediate smaller rolls.

Chilled rolls are manufactured from cast iron with the exterior section of iron carbide, which gives hardness to the roll and is wear resistant. The interior section of the roll is composed of gray iron. A typical analysis of a calender roll is :

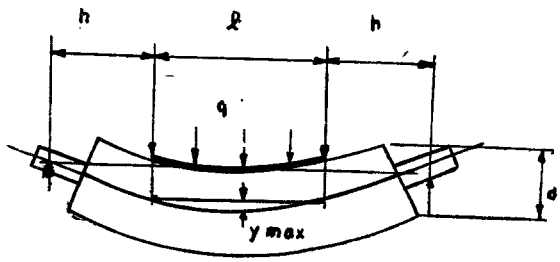
Carbon	3.75%	Manganese	0.20%	Phosphorus	050.%
Sulphur	0.15%	Silican	0.55%	Chromium	0.05%

and the rest is iron 94.80%

Carbon is added to provide hardness and to make the roll wear resistant, but an excess of carbon percentage is not desirable. Chromium and Sulphur help to precipitate the carbon as graphite and the chill depth is increased. The calender roll hardness is to be selected according to the quality of paper : the stack is to press as the hardness of a new roll will increase to a great extent by the action of work hardening. The intermediate rolls which are smaller in diameter are particularly susceptible to work-hardening. Calender rolls go into service with the hardness of 68 to 72 scleroscope. In a new machine operating at 1,400 feet per min. the intermediate rolls are often work-hardened to 78 scleroscope after a period of three weeks and to 82 to 84 S.C. after six weeks of service.

Calender crown :

In machine calender, the bottom roll is crowned and if the top roll is larger than the intermediate roll (in dia) then this roll is also crowned. In super calender both top and bottom rolls are crowned and the intermediate rolls are kept as straight as possible.



For determining correct calender crown following "weights" are to be considered. (a) The weight of the intermediate rolls, (b) weight of their bearings, (c) weight of the doctors, and (d) the loading factor. For open side stack weight factor of the doctors has to be taken, closed stack doctors are supported by frames and so do not add any extra load on the bearings. It appears that exact calender crown for certain stack cannot be calculated or made in one opportunity—readers will be surprised to learn that it is still a trial and error method. The author had an opportunity to work in a famous German paper machine manufacturing factory for some time and a new machine (2,200 feet per min.) was started up before him. The machine had one stack calender (9 rolls) and it was found that exact crown from the satisfactory operation of the stack was achieved by trial method. A calender roll grinder was installed and rolls were ground and replaced. In the first instance the manufacturer calculated the crowns on the basis of customary or most prevalent stack configuration.

With reference to Figure I, mathematical expression for the king roll crown is :

$$Y_{max} = \frac{5QL^4}{384EI}\left\{1 + \frac{24}{5}\left(\frac{h}{L}\right) + 2\left(\frac{d}{L}\right)^2\right\}$$

Where —

Q = Total nip pressure on king roll plus weight of the king roll (pounds per inch).

L = Web width in inches.

E = Effective modulus of elasticity of iron ($=20\times10^6$ pounds per square inch)

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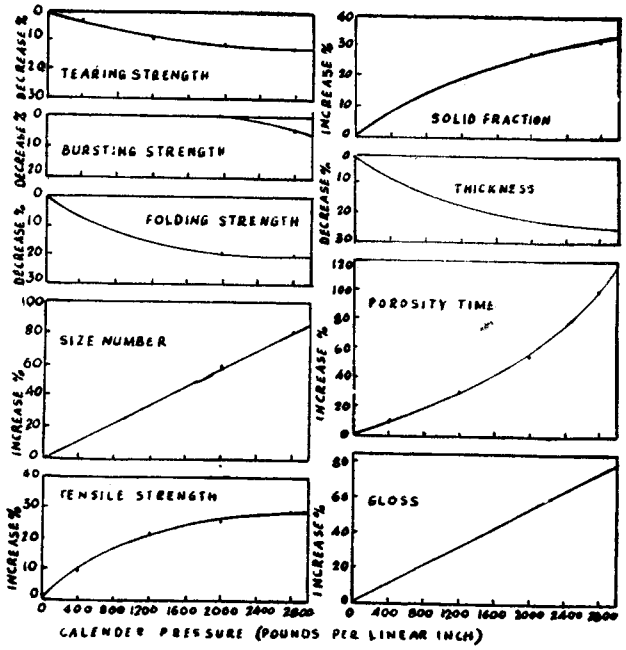
I = Moment of inertia of roll body = inches

d = Diameter of roll body (in inches)

h = Roll neck " Over hang " i.e. distance from center-line neck bearing to edge of web (inches).

" The first term in the bracket represen s bending due to the uniformly distributed load, the second term is due to the overhang of the neck bearing, and the third term is the deflection due to shear. The magnitude of this latter term is usually around five percent ..... but can reach ten percent..... "

Physical properties like burst, fold, tear, gloss, porosity and caliper are affected by calendering. In figure 2, effect of calendering on sheet properties for a machine making Kraft bond sheet is g ven. These days in India, most of the paper mills are trying to make or already making water finished boards with the help of water doctor at the calender rolls.



The utility and demand for high finish coloured boards are increasing day by day and currently the demand for this product is great. Heavy substance pulp board can be made in a fourdrinier paper machine with some modification, but in case of making water finish (Water doctor) considerable modification is necessary, (specially on the stock preparation). Major trouble faced to manufacture wa'er finish Board is mottling and Blackening.

Paper and Board makers are very much familiar with the problem ; following are the major factors responsible for calender mottling and Blackening.

1. Uneven sheet formation.

2. Dyes.

For heavily coloured water finish boards selection of dyes is very important.

Specially acid dye stuff which gets burnt at the first stage of drying should be avoided. Direct dye stuff should be selected as far as possible.

3. pH value of the stack.

For certain dyes low pH. value is preferred specially in case of Chlorozal Brilliant yellow and Methyl violet. It has been observed that at higher pH. value this yellow turns to reddish yellow and at lower pH. value the same turns to greenish yellow, and Methyl violet turns Bluish at lower pH and reddish at 6.5-7 pH. For water Finish Board pH around 5.5-6 is preferred, and the sizing should be good else water will be absorbed by the Board when it passes through the water doctor and the Board will lose its stiffness. There should be one stack of calender, after the water doctor stack ; the last stack of calender will dry the excess moisture and will make the Board stiff.

It has been seen that in case of making water finish board in a Fourdrinier paper machine much attention is to be given on the stock preparation. The stock on the wire should be fine and free ; with certain amount of water (not water of hydration but water of suspension which is to be added in the mixing box), with this condition the dandy will be able to compress uniformly and a very close sheet is formed. Well compressed and close sheet formation is a must for good water finish board. In a cylinder mould machine with M.G. cylinder this condition is desirable but not a " must ". The reason is that in the latter case the sheet enters the M.G. at a higher moisture content, passes through high pressure getting attached with the glazed surface of the cylinder. In between the pressure roll and the cylinder, there is relative velocity between the paper and the cylinder surface. Finish is a surface characteristic of the sheet and in the latter case grazing is not affected unless and until the sheet formation is very bad. In case of water finish in Fourdrinier paper machine, **the sheet drying is almost completed before it enters the calender stack,** the sheet is subject to ready absorption of moisture and compression, and there is also relative velocity between the paper and the calender rolls. In this case, it has been observed that small amount of uneven and ununiform fibre alignment on the wire causes uneven water absorption at the water doctor and the result is calender blackening wh'ch spoils

the paper. In the M.G. cylinder Board change of pH value very much affects the finish of the Board, pH value round 5.5.6 is being preferred in such machines.

Experience of making water finish Board in Fourdrinier paper machine shows that simply running water at the calender doctors, takes the entire Board making process into the sphere of great complication. This is one of the sides of calendering.

For writing and Printing bad calendering means bad reeling paper which leads to increase of Brokes at the rewinders and cutters.

Air nozzle arrangements are found in the modern calender stack for curing soft and hard places of the reel.

This is the last section of paper machines and to run this section efficiently one has to start working from the Beater House and that is why this is termed as " last but not the least ".

References :

1=Tait, G. Ewing, Metallurgical Factors Affecting Calender roll Performance, Publication of Dominion Engineering Co. Ltd.
2=Calendering and Supercalendering, Page 8/9 Lockwood Trade Journal CO INC. 49 West 45th Street, New York. 1964.
3=Stone, M. D. and Liebert, A. T. Crown Control of paper calenders, Tappi, P. 308, May 1961.