cockling in paper and board

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Cockling is often a headache to the Papermakers for a sheet of paper or Board, when severely cockled, becomes useless for all practical purposes, hence the necessity to prevent them.

A freshly formed sheet of paper is a mat of felted fibres all in approximately the same plane and disposed at more or less random angles to one another. The irregularly shaped voids between the fibres being filled with water or water and air. As the fibres dry out they shrink some 9 or 10 p.c. in diameter and much less than this, perhaps 1 p.c. in length. It is clear that there will be a tendency of the fibre mat to contract as a whole due to the diametrical shrinkage of the individual fibres which will be resisted by the longitudinal compression stresses set up in the fibres. In the drying process of a machine a sheet of paper is always prevented from shrinkage to the natural extent hence a strain is dried into it. Part of this dried-in-strain is recoverable in wetting and drying the sheet which presumably arises from the deformation of the cross-section of the fibres. Sheets of paper having dried-in-strains when moistened, result in cockling.

Cockling is, therefore, a name for the form taken up by a sheet where portions of it stretched or contracted in relation to the rest of the sheet. If a portion of a sheet between two points is stretched, the shortest distance between the two points measured in a vertical plane along the sheet surface is longer than the straight line between them and that particular length of the sheet must take up some form other than a straight line to accommodate the greater length, in other words, the sheet departs from place and forms a bulge or hollow to produce cockling.

If we consider a perfect sheet leaving the press section of a paper machine which from point to point is absolutely free from variation in substance, water content, formation, and shrinkage properties, entering a dryer section of a very high quality where the dryer surfaces are perfectly clean, give even heat transmission across the whole width, the dryer felts have even and high tension, and even and low moisture content the cylinders are properly aligned, it will be no surprise for us that the sheet coming off this machine is completely free from cockling. But seldom we have such ideal conditions. The idosychrosis of different machines urge the papermaker to get things adjusted. Therefore, let us consider here the deviations from some of the ideal conditions.

A sheet that has local variation in substance and water content in the form of irregular small areas which are light in weight dry first, on entering the dryer section, having less water to evaporate per sq. cm. Being small and thin and surrounded by large areas, which are not contracting, the light areas are not able to contract and dry with the full dried-in-strain. The rest of the sheet then dries contracting in the usual way. The light parts are left as stretched areas relative to the rest of the sheet and therefore form cockles.

Note that had the sheet not possessed the property of taking up dried-in-strain readily the cockles would not have formed. Had it for exampled, dried with an elastic tension instead of a dried-in-strain the rest of the sheet would have dried and contracted an amount exactly equal to the elastic tension and the final sheet would have been flat with no dried-in-strains.

A sheet which is even in substance and water content but has formed on the wire with irregularly oriented groups of fibres when dried freely will have local variations in length from place to place and must cockle. If such a sheet be made to dry on an M.G. cylinder or even on ordinary dryers, with tight felts, will remain flat by taking up irregular dried-in-strains all over its area and is expected to cockle badly on wetting and drying.

Now a sheet would also cockle in running it slack on unfelted dryers or having slack felts on felted dryers. During the preliminary stage of drying when the sheet is very moist and therefore has a small contraction for a given moisture loss, will probably be fairly even, when the sheet enters the region of moisture content where a small loss of moisture causes substantial shrinkage, small specks of scale or dirt on the cylinder, small and hardly appreciable unevenness in sheet surface will cause differences in the rate of drying from place to place as the sheet passes round the particular cylinder. Now the driest areas will have shrunk more than others and will therefore be the tightest round the next dryer. In the absence of felt or sheet tension the slack areas will bulge

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away from the dryer surface and their drying rate will be enormously reduced by an air gap which may be a millimeter of two across. As a consequence the drying rate will be high on the drier areas and low on the moist areas. The moisture differences will thus be accentuated and not levelled out over this and the following dryers. There is in fact a kind of instability about the drying circumstances. This would not matter if the more slowly drying areas shrank exactly to the same extent as the more rapidly drying areas when they finally did dry. The sheet would have started its passage in a flat condition, would have cockled severely half-way through the dryers and would have flattened out completely as the moist areas dried and their shrinkage caught up at the end of the dryers section. But this of course is not what happens at all. A tight area may be surrounded by tight ribs which cross the surrounding slack areas. These ribs present small areas under some tension to the dryer surface and so themselves have a high drying rate. Being small in area and under tension, they have little opportunity to contract and according dry at more than their proper length that is with a dried-in-strain. When the moist areas dry contracting as they do so, the dried-in-strain ribs have a surplus length and therefore cockle.