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Research area: Product aims
Paper, paperboard and board // Technical specialty papers

Key words:
Dimensional stability, hygroexpansion, hygroexpansivity, wet expansion, curl, moisture sorption, elastic modulus

Title: Reducing hygroexpansion and wet expansion of printing and speciality papers

Background/Problem area

Dimensional changes of paper due to changes in its moisture content or direct wetting can affect the processability and/or product quality of papers. These dimensional changes are the result of moisture sorption (hygroexpansivity) or water sorption (wet expansion) of the cell wall of the fibres. Papermaking causes anisotropic changes in the dimensions of the individual fibres which in turn result in anisotropic changes in the dimensions of the paper. The greatest expansion is noticed in thickness, the least in the machine direction. Generally speaking, neither factor leads to processability problems. In most cases, cross dimensional changes are responsible for problems connected with dimensional instability.

Changes in the in-plane dimensions of paper affect nearly all types of printing or speciality papers, e.g. inkjet papers, filter media, wall papers, offset printing or decorative papers. This effect can cause drastic impairments of product quality, especially in layered materials. If paper is part of a two- or multilayer laminate, strong out-of-plane phenomena (e.g. curling, waviness) can take place unless appropriate dimensional stability is provided.

Objectives/Research results

The research project focused on two main topics. The first objective was to further clarify the reasons and mechanisms involved in hygroexpansivity and wet expansion. General recommendations for producing dimensionally stable papers or paper products were formulated in a second step. These recommendations are intended to help papermakers or converters to avoid or at least reduce phenomena such as curling, cockling or waviness.

A new method for measuring in-plane dimensional changes caused by climatic changes (relative humidity, temperature) was developed to allow high sample throughput. The changes in length of paper specimens were registered by an optical scanner placed in a climatic chamber and linked to a simple image processing tool.

The dimensional changes of samples of commercial papers and papers produced on a laboratory-scale paper machine were examined in the machine direction, cross direction and thickness direction. In laboratory-scale papermaking trials, the manufacturing parameters (raw material, grammage, fillers, dosage of chemical additives, wet pressing and machine calandering) were varied systematically. Effects of hysteresis (cyclic variation of relative humidity) were considered. The moisture content and changes in elastic modulus were measured simultaneously. The kinetics of moisture sorption was measured for papers coated with polyolefines and paper stacks.

The stress-strain behaviour (elastic modulus E) of fibres has a dominating influence on the dimensional stability of papers. Although the stress-strain behaviour of the fibres could not be measured directly, measurement of the elastic modulus of the paper and the gathered model of hygroexpansion provide evidence of that. Appropriate restrained drying of papers raised its elastic modulus, prevented dimensional changes due to total humidification and even constricted moisture sorption. None of the chemical papermaking additives used led to a reduction in hygroexpansion. Impregnation of papers with large amounts (>10%) of resin reduced hygroexpansion by covering fibres with a stiff polymer matrix unaffected by humidity. Wet strength resins and sizing agents led to a significant reduction in the amount and/or the kinetics of wet expansion by stabilizing the contact area of the fibres and/or slowing down the water sorption rate. Refining damaged fibres lowered the elastic modulus and thus led to a significantly higher hygroexpansion of papers.

Negligible differences were observed between the equilibrium moisture content of different bleached hard- and softwood kraft pulps (market pulps). Due to the differences in the degree of crystallinity, polymerization and hemi-cellulose content, dissimilarities in the elastic modulus of the fibres (influencing dimensional stability) were assumed.

Application/Economic benefits

The paper grades mentioned above, especially multilayer papers, are products with high added value. Hygroexpansion and/or wet expansion greatly affect its processability and quality.

This is important in particular for small- and medium-sized enterprises to enable them to produce these paper grades on smaller and slower paper machines efficiently. Excellent dimensional stability enhances competitiveness compared to nonwoven products made from synthetic fibres and plastic materials.

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Remarks

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