Color kitchen

Challenges of coloring in paper-making processes

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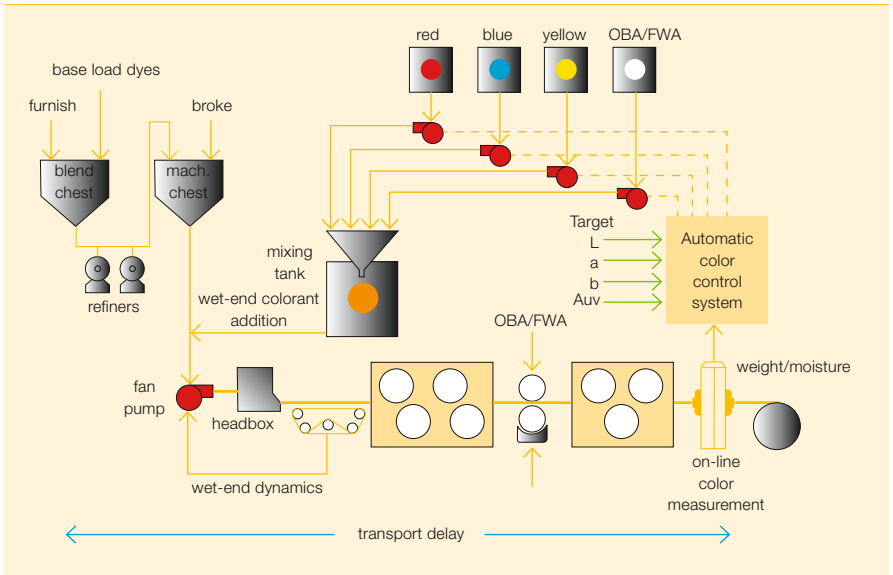
The color of paper is adjusted through the addition of various colorants during the production process. These colorants are dyes, fluorescence whitening agents and pigments. To permit the precise reproduction of color and to keep its varaibility within strictly defined bounds, a high-performance control system is required. Its implementation is made all the more technically challenging by to the long time delays and multiple process steps that can affect the color of the finished product.

Paper color is the result of chemical reaction between fibers and colorants; the reaction degree determining the color shade and depth. This, in turn depends on the base color of fiber furnish, fiber retention agent, the pH of carrying water and other chemistry in the wet-end circulation. Fluctuations in these conditions frequently give rise to unexpected disturbances to the uniformity of paper color shades.

A typical color process plant is shown in 1. The amounts of colorant per unit of fiber, also known as the dye rate between colorants and fiber, is the key contributor to paper color. Colorants can be added at different stages of the papermaking processes.

1 Coloring process of papermaking



2 Color kitchen

3 Well labeled, or color coded valves and connections are intuitive. They speed setup, and reduce mistakes.

To make a very deep shade of color, the majority of colorants are loaded into the blend chest in order to allow the colorants a longer time to bond with paper fibers. This operation is called base-loading and, typically, is not automated.

To adjust paper color, the colorants are usually added somewhere between the inlet to the fan pump and the coating addition on the sheet used to compensate for color disturbances. This is also known as color-trimming or color-dosing and is precisely metered to achieve the subtlety of color shade.

The automated control system needs to model the dynamic response of dosing colorant accurately and implement a complete multivariable feedforward and feedback control scheme.

Color kitchen

Central to the entire dying process is the color kitchen 2 3, where colorants are stored, prepared, metered, and delivered. The color kitchen is usually located so far upstream from the paper-forming process that the response of the colorant has very long time delays and slow dynamics, rendering manual control difficult. The challenge the operators face is further increased by the fact that color disturbances can originate in all parts of the paper machine and also that the chemistry of wet-end, size-press, and coating materials influence the coloring reaction at multiple stages. Compounding these challenges are the transient dynamics of grade change, speed change, and shade change, which induce additional shade variations

An automated color control system utilizing on-line color measurement has become necessary technology to the modern paper coloring processes.

Color control objectives

To achieve a uniform color shade, a precise delivery of colorants is needed. The key goals followed in the automation of a coloring process are the reduction of color variation from reel to reel for the same shade, the reduction of color breaks during shade changes, start-ups, and normal production and the reduction of dye-usage and the costs involved in matching a target shade during production (ie, to reduce metamerism Factbox and two-sidedness[1)] – without resorting to excessive trial and error).

In order to achieve these goals, the automated control system needs to model the dynamic response of dosing colorant accurately and implement a complete multivariable feedforward and feedback control scheme.

Factbox Metamerism

Metamerism is the phenomenon that two samples appear to be the same color under one light source, but different under other sources. Metamerism is caused by different dyes, levels of fluorescence whitening agents, fiber and filler types, etc, and is the second major cause for customer rejects.

There is almost always potential for metamerism between two production cycles. The better the variables that contribute to metamerism are controlled, the more consistent the paper products will be.

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Footnotes

1) The term two-sidedness is used to refer to differences in the thickness or consistency of the coating on either side of the sheet