ABB highlights multivariable CD control applications

Many paper machines today are equipped with multiple sets of cross-machine direction (CD) actuators. One set of actuators may influence multiple sheet properties and one sheet property may be affected by multiple sets of actuators. There is no easy way to coordinate the actuators through independent single-input/single-output CD control applications.

Modern multivariable control techniques have been gradually adopted in the paper industry as the use of personal computers and the OLE for Process Control (OPC) communication standard has opened opportunities for new ways to control paper machines. In a paper from ABB Ltd's QCS R&D department in Dundalk, Ireland, the authors suggest that a multivariable approach is needed to optimize profile control. They present applications of multivariable CD control on a number of machines.

Modeling multivariable CD process responses. A paper machine is a multi-input/multi-output process at different levels, Fig. 1 illustrates an example of a process where profiles may come from several machine locations and control actions are applied to many sets of CD actuators, such as slice screws, steam boxes, water sprays and/or induction profilers. In some sections of a machine, the sheet width may change and the sheet may oscillate sideways, so the scan limits may be different at each frame. The threading distance between each frame and actuator is different hence transport delays vary. Sensors on different scanners may not be synchronized and profiles may not be updated at the same time. Therefore, profiles from different frames may have different sizes, may not align ideally and may not update simultaneously.

Having CD actuators in different sections of the paper machine compounds the complexity of measured profiles. Each actuator set consists of a different number of zones across the web with different zone widths. Zones among different sets may not be aligned and may have different edge references.

Advanced control of this multivariable process needs good models and alignment relationships for each input and output pair to describe the responses of each actuator zone. The model of each zone consists of both spatial (CD) and temporal (machine direction — MD) responses. The MD response is typically modeled as first order dynamics with transport delay. Depending on actuator types, the CD response could have different response characteristics.

Control objective and constraint handling. Multivariable control must achieve multiple objectives. The primary goal is to produce a paper sheet where all profiles are uniform. The primary control objective is to minimize the variance of the profiles with respect to their target profiles.

Multivariable CD control schemes have intuitive priority factors allowing users to make the trade-off among different profiles. In practice, not all profiles and all actuators are always used in one multivariable control configuration. Depending on different process conditions, a subset of the full multivariable control may be more appropriate. The multivariable CD control is flexible enough to accommodate these requirements.

System architecture. The seamless integration of multivariable CD control with modern control systems is done through open communication standards such as OPC and server/client architecture. The paper illustrates the network layout of ABB's Multivariable CD Control. The control resides in an OPC server called Advanced Multivariable Control Server (AMCS). AMCS communicates via the standard Ethernet to various OPC servers to obtain data ranging from frame information and measured profiles to machine speed and grade data. After the multivariable CD control derives desired control actions, it sends set-point outputs to the various actuator systems via OPC. The multivariable CD control can be integrated with many existing QCSs and AMCS can be installed on nearly any system that supports standard OPC communication.

Human system interfaces (HSI). Users need to interact with multivariable CD control so it must display multiple profiles and actuator arrays in a single window for operators. Fig. 2: The plots of profiles and actuators (left) give operators a bird's-eye view of the entire process. The statistics and priorities (right) provide the operator with precise results and the flexibility to make trade-offs among profiles. Other displays like setpoints and control parameters are set up and configure a multivariable CD controller.

Application examples. I: Weight/moisture control on a dust-headbox linerboard machine. A linerboard machine often has two or more headboxes, each with a set of slice screws to control both weight and moisture profiles. These might also be other CD actuators such as a steambox and a water spray. Fig. 2 illustrates such a machine with four sets of CD actuators. The slice screws from primary and secondary headboxes have been selected to control both the weight and moisture profiles. The trade-off between weight and moisture allows the moisture profile to be more tightly controlled.

II: Weight/twist profile control on a multi-headbox machine. The headbox slice opening shape influences weight and fiber orientation simultaneously. Fiber orientation determines the twist characteristics of a sheet. Multivariable CD control can effectively control both weight and twist, which is derived from fiber orientation measurements. Fig. 3. The control utilizes multiple headboxes to balance the control of multiple profiles so that the sheet properties are fully optimized.

III: Supercalender gloss and caliper control. It is crucial for supercalendars to obtain uniformly high gloss on both sides of the sheet and maintain a specified caliper profile for good reed building. Multivariable CD control achieves these goals with two induction CD actuators on a supercalender. Pi ABB Ltd, www.abb.com