Plantwide Controllability Analysis of TMP-Newsprint Process

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Introduction
Variability due to inherent limitations in process design, and internal interactions between sub-processes has never been approached by an “open-loop” approach such as controllability analysis. Controllability in this context is a property of the process that accounts for the ease with which a continuous plant can be held at a specified operating regime despite bounded external disturbances and uncertainties, and regardless of the control system imposed on such a process. As for newsprint-mill processes, the strong and many times unfavorable interactions between pulp and paper sub-processes impose tighter restrictions upon achievable variability reduction. Accordingly, papermaking efficiency is strongly affected by the process variability associated with the upstream operations of the paper machine, in particular the thermomechanical pulping (TMP) mill. Nonetheless, the extent to which controllability characteristics and internal interactions limit variability reduction is as of yet an unexplored matter.

Main Objective
The main objective of this research is to develop a controllability analysis-based methodology that can be applied to existing mills to quantify and reduce variability, resulting in the improvement of key plantwide control objectives (KPCO) and plant performance. This Methodology will be illustrated by a case study at an existing thermomechanical pulping mill (TMP).

Potential advantages
- Open loop approach to address the problem of variability. Unlike the closed-loop approach, we propose to study the inherent process controllability independently of the control system in order to determine the potential for variability reduction.
- The capability of an existing thermomechanical pulping (TMP) process to operate with reduced variability is yet to be investigated from the controllability perspective.
- Introduction of the concept of controllable operating windows to explain the various conditions at which reduced variability of the Key Plantwide Control Objectives (KPCO) can be attained.

Méthodologie
1. Data collection – Mill survey
2. Definition of Key Plantwide Control Objectives (KPCO)
3. Modeling
4. Variability analysis
5. Controllability analysis and determination of controllable operating windows
6. Validation of results and generalization
Preliminary results

△ Proposal of methodology.

△ Modelling of a TMP refining section. The model predicts motor load and pulp quality as a function of plate age and different nominal conditions of screw speed, hydraulic pressures, and dilution flowrates.

Controllability analysis of TMP-Newsprint refining process. Article submitted to Control Systems 2004, Québec City, June, 2004. The analysis of the internal interactions and process resiliency in TMP refining systems is critical as it provides an insight into some of the plant’s inherent control limitations. In this work, a model of a TMP refining section has been developed upon which a controllability analysis has been performed. As a result, the effects of the most important variable interactions upon pulp quality are underlined and lead to the proposal of a decentralized regulatory control configuration taking into account such internal interactions.

Conclusions

A semi-empirical model of a TMP two-stage refining section of an existing integrated newsprint mill has been developed and validated using routine data. The model describes fundamental aspects of the pulp refining process such as: wood density, production rate, motor load, consistency, steam production, specific energy, refining intensity, and pulp quality. In particular, two modeling procedures have been proposed to predict motor load and pulp quality:

(a) **Motor load.** This procedure uses robust outlier detection and steady state identification techniques, uncompressed data from operations, and long-term averages to extract the most representative nominal regimes and static relationships between motor load, the manipulated variables, and plate age. Thus, it indicates how motor load gains vary - in magnitude and sign - at different steady state conditions. This consideration is extremely important in the characterization of internal interactions at different operating regimes.

(b) **Pulp quality.** The procedure makes use of available laboratory tests, routine PQM data, comminution theory, and other empirical correlations. In addition, a factor is introduced to account for the effect of refining intensity on fibre size distribution. The prediction of fibre fractions after both refiners in terms of PQM values allows the evaluation of the entire operation - latency chest included - using a single fibre distribution standard.

We have proposed a steady state controllability-based stepwise procedure intended for existing plants. The procedure uses real operation data to extract information on how a given plant operates at the supervisory level, in order to keep its own output variability within desired limits when trying to reach alternative specifications. In doing so, setpoint changes requiring low input action can be identified. We have applied the proposed procedure to an actual TMP-Refining plant to analyze the controllability of its supervisory operation. Results indicate that the supervisory operation is highly interactive as the control of the corresponding quality objectives (freeness and long fiber content) act in opposition to each other. This may be the reason why refining plants focus their operation on controlling one objective, namely *freeness*, over long fiber content, which is typically controlled afterwards during pulp screening.
Future work


References


