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Simulation and control of a complex nonlinear dynamic behavior of multi-stage evaporator using PID and Fuzzy-PID controllers

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HIGHLIGHTS

- Highly complex nonlinear first order dynamic model of multi-stage evaporator system linearized and state space transfer functions developed.
- Transient response of system for a set point change in product concentration using conventional PID controllers explored through simulations.
- PID controlling displayed noticeable overshoot, undershoot and integral square error, that may collectively influence black liquor product quality.
- An intelligent Mamdani type Fuzzy Logic-Proportional-Integral-Derivative controller designed to control product quality efficiently through better controller tuning.

Abstract:

The dynamic model of heptads' stage evaporative unit employed in concentrating black liquor in paper industry show tremendous complexity. In this work, linearization of such a complex nonlinear model consisting of 14 first order nonlinear differential equations and determination of the system transfer functions has been explored through an exhaustive state space representation technique. The transfer functions that relate the product concentration change to liquor flow rate deviation have been evaluated and presented through this work for the first time. These serve as an input to design a PID controller and study its response for a set point change in product concentration. The response analysis indicated a noticeable overshoot, undershoot and Integral Square Error (ISE), that may collectively influence the product quality. To overcome this issue