Objective

Design a controller for simulated moving bed (SMB) plants based on the combination of Nonlinear Model Predictive Control (NMPC), model reduction through the proper orthogonal decomposition (POD) and the wave theory.

Numerical simulation (POD)

It is based on the time scale separation between states. The model is reduced by neglecting the fast dynamics.

The POD technique in three steps [2]:
1. Obtain measurements of the field. FEM simulation
2. Compute the basis functions from these measurements
3. Project the PDE into the basis functions

Dimensionality reduced in more than one order of magnitude

The wave theory

The concentration profiles in SMB travel as nonlinear waves. Two kind of waves are found: Spreading waves in zones I, II and shocks in zones III, IV.

The purity is controlled by modifying the wave velocity (through the internal fluxes) [3].

The PI controller

$$w_{j,i} = w_{j,i-1} + K_{PI} (e_{j,i} - e_{j,i-1}) + \frac{K_{PI}}{\tau_j} e_i \Delta t$$

The NMPC scheme [4]

Minimize the error:

$$J = e_{jII}^T \Omega_{jII} e_{jII} + e_{jIII}^T \Omega_{jIII} e_{jIII}$$

The PI derived in the wave theory is employed
The parameters of the controller are computed using the NMPC scheme
The POD is employed in the NMPC scheme

Conclusions

We presented a new approach to the control of SMB plants, based on the combination of NMPC, model reduction and the wave theory. The wave theory provide us with the controller form. NMPC (using model reduction) is employed to compute the optimal values of the controller parameters. The stability properties of the controller have been tested through a simulation experiment.

References


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