(534e) Model Predictive Control of a Nonisothermal and Nonisobaric Membrane Reactor for Water-Gas Shift Reaction Applications

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Modern hydrogen production units are tasked with producing the most hydrogen possible while dealing with flow variations caused by changing power demands. Classical methods for hydrogen production by the water-gas shift reaction are governed by equilibrium limitations that take effect at high temperatures and high concentrations of H_2. The implementation of a membrane reactor with temperature control enables the hydrogen concentration and temperature to reach an equilibrium at a higher concentration of H_2 [1]. Another challenge that is prevalent in this process is thecyclical input flowrate of the syngas produced from changing upstream reforming process conditions [2]. These cyclical changes in syngas production can cause drastic temperature changes within the reactor. These challenges can be addressed by the implementation of advanced controllers that can cope with dynamic changes associated with different conditions, such as temperature oscillations and mitigation of hot spots [1].

maximize the production of hydrogen by considering the temperature control performed by manipulating the flow rates of the coolant entering the cooling jacket at different reactor zones. The control strategies considered for this application are: Dynamic Matrix Control (DMC), Quadratic DMC (QDMC), Nonlinear MPC (NMPC), and a Biomimetic-based controller cast as MPC (BIO-CS as MPC) [3]. The coolant usage is constrained by the use of quadratic programing (QP) or sequential quadratic programing (SQP) formulations, depending on the employed MPC type, to match industrial standards. To mimic industrial cycling conditions, the flow rate of the syngas is changed around ± 10% from its operating steady state [2]. The MPC results that will be discussed show an increase in the production of hydrogen due the temperature control under cycling process conditions.

References:

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3. Mirlekar, G., Li, S., and Lima, F. V. (2017). Design and Implementation of a Biologically-inspired Optimal Control Strategy (BIO-CS) for Chemical Process Control. *Industrial & Engineering Chemistry Research*, 6468-6479.

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