LINEAR ALGEBRA AND OPTIMIZATION BASED CONTROLLER DESIGN FOR TRAJECTORY TRACKING OF TYPICAL CHEMICAL PROCESS

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***Abstract*— This paper presents a new controller design to tracking trajectory of a typical chemical process. The plant model is represented by numerical methods and, from this approach; the control actions for an optimal operation of the system are obtained. Its main advantage is that the condition for the tracking error tends to zero and the calculation of control actions, are obtained solving a system of linear equations. The proofs of convergence to zero of the tracking error are presented. Simulation results show the good performance of the proposed control system.**

***Keywords*— Control System Design, Nonlinear Model, Tracking Trajectory Control, Numerical Methods, Typical Chemical Process.**

I. INTRODUCTION

The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. The process industries require liquids to be pumped, stores in tanks and then pumped to another tank. An example is the fermentation process with different microorganisms in the biotechnology industry. Chung *et al.* (2005) show some applications, it suggests that periodic operations can give results where the yield and selectivity can improve or make possible the continuous operation. To control liquid level the traditional method PID control is used due to its reliability, simple structure and easy parameters adjust (Tunyasrirut *et al.*, 2006; Gou, 2008, and Liu, 2004). To perform high precision liquid level control and good tracking precision in the presence of the system nonlinearities, it is needed to use nonlinear control method to solve these problems effectively and achieve precise control. Neural network (Hou, 2009; Huang and Chiou, 2006) and genetic algorithm (Tan and Li, 2001; Moshir *et al.*, 2003) based controllers are proposed as effective tools for nonlinear controller design. Limon *et al.* (2010) applies tracking techniques to track processes consisting of four tanks which form a multivariable nonlinear system. They pose a technique based on MPC (model predictive control based on the model) where the plant model is assumed as a linear system with bounded uncertainty to a polyhedral set known, under this assumption the proposed controller is feasible in any changes to the set points and leads the system at this point whenever possible. If the goal is not permissible, therefore unreachable, the system is directed to the nearest point allowable operating. Usually, in literature the goal is find the control actions that combined, result in tracking a desired trajectory.

This paper provides a positive answer to the previous challenging problem.

In this work a trajectory-tracking controller, designed originally for robotic systems Scaglia *et al.* (2009) is applied for trajectory tracking of the four tanks plant (Limon *et al.*, 2010). This simple approach suggests that knowing the value of the desired state, it can find a value for the control action, which forces the system to move from its current state to the desired one. The main contribution of this work is that the proposed methodology is based upon easily understandable concepts, and there is no need of complex calculations to attain the control signal.

Another contribution of this paper is the application of Monte Carlo (MC) based sampling experiment in the simulations. The controller parameters can be computed to minimize a cost index, here being determined by the Monte Carlo (MC) experiment, and the theoretical results are validated by simulations. It’s important to remark that MC experiment can be implemented on line in a real plant.

It is noteworthy that due to the above mentioned characteristics, the computing power required to perform the mathematical operations is low. Thence it is possible to implement the algorithm in any controller with low computing capacity. Furthermore, the developed algorithm is easier to implement in a real system because the use of discrete equations allows direct adaptation to any computer system or programmable device running sequential instructions at a programmable clock speed. Thus, among the main advantages of this approach are the simplicity of the controller and the use of discrete-time equations, simplifying its implementation on a computer system. The proof of the zero-convergence of the tracking error is another main contribution of this work.

The methodology developed for tracking the desired trajectory (h_{1d} and h_{2d}) is based on determining the desired trajectories of the remaining state variables. These variables states are determined through analyzing the conditions for a system of linear equations to have an exact solution. Therefore, the control signals are obtained by solving the system of linear equations. In addition, to complete the previous work of the authors (Scaglia *et al.*, 2009), the proof of the zero-convergence of the tracking error is included in this paper.