**Abstract**

The objective of this thesis is to improve the performance provided by the conventional methods used in the identification, modelling and synthesis of controllers to control industrial processes with pure delays. To this effect, the main contributions were articulated on the development of a new fractional model with pure delay, i.e. **FMLODT** (Fractional Multi-Low-Order plus Dead-Time) where the last having an additional fractal power carried on their transfer non-integer order. The optimization of its parameters was founded on genetic algorithms, which ensure the good minimization of an objective function formulated via the root mean square error generated by the distance between the prediction model and the real system. This resulting model was factored into two sub-models namely: fractional model without delay, which has been used for the controller synthesis stabilizing the control loop and a delay fractional model with the proposed fractal power. The model-system set was associated using the Smith predictor principle. However, the output of the model has been compared with that provided by the real system which generates a modelling deviation added in the feedback chain of the looped system. This requires the synthesis of a robust controller that is the subject of a second contribution. For this purpose, a second contribution was proposed in the synthesis of the robust non integer order controller based on the Smith's Predictor principle. The parameters of the latter were provided analytically using the **TTFOR** (Three Terms Fractional-Order Reference) reference model based on the adaptive control principle.

Another contribution has been proposed for the synthesis of the fractional order controller **FOPIλDµ** where its parameters have been optimized by GA genetic algorithms. The optimization was based on the minimization of a cost function, defined graphically by the Simulink's graphical interfacing. It then represents the ITAE criterion (Integral of Time and Absolute Error) where the optimization was achieved by obtaining five optimal parameters constructing the desired fractional controller transfer. Finally, a validation was performed to confirm the effectiveness of this new ordering strategy. The latter has been applied on two systems namely: an electric vehicle and a hydraulic process. The simulation results confirm the efficiency of the new configuration of the proposed Smith predictor compared to the performance provided by modelling using an integer order transfers or synthesis based on the integer order conventional controllers.

**Keywords**

*Smith predictor; Fractional order system; Fractional order control; Genetic algorithm; Fractional order PID control; Parameter tuning; optimization; fractional identification system.*