INVESTIGATION INTO THE PERFORMANCE OF STUDY BY FRACTIONAL ORDER CONTROL SYSTEM ON UNSTABLE PROCESS

Abstract

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ABSTRACT

A very new and developing area of control theory that has attracted a lot of attention recently is fractional order control. Compared to standard integer-order (IO) controllers, fractional order (FO) control can employ more degrees of freedom to achieve better performance and resilience.

In this thesis, two distinct benchmark unstable processes as single input-multi output (SIMO) inverted pendulum and continuous stirred tank reactor (CSTR) are taken into considerations to test the efficiencies of various control strategies. It is challenging to control the inverted pendulum towards its desired upright position. Controlling concentration and temperature of CSTR smoothly is another challenging task in presence of disturbance. Despite efforts to provide a necessary speed of action, different traditional control schemes are unable to achieve a smooth performance on set-point tracking and noise rejection, which are crucial factors for investigating control actions on unstable processes. Due to its limitation to real numbers, the traditional scheme basically fails to accurately depict the behavior of the system. Thus, this thesis proposes various novel standalone, and augmented FO control strategies, taking into account MRAC (model reference adaptive control), IMC (internal model control), smith predictor, proportional-integral-derivative (PID), and backstepping schemes. This thesis aims to investigate the significant impact of FO control schemes over traditional schemes. It also aims to investigate the most effective and trustworthy FO control strategy among various proposed topologies. Lower integral errors, total variation (TV) of control efforts, overshoot, and settling time are preferable. An indirect novel improved biquadratic exact phase FO approximation method is proposed as the most efficient alternative over the popular indirect Oustaloup, continued fraction expansion (CFE) , and other direct methods offering more steady, flat, and ripple-free approximated result.

In order to attain global stability, proposed standalone and augmented FO Lyapunov (FOLY) rule of MRAC is found to be more effective than proposed fractional order Massachusetts institute of technology (FOMIT) rule by choosing an appropriate

Lyapunov function and controls inverted pendulum more swiftly and gracefully compared to existing schemes. 2 DOF FOPI augmented FOLY produces robust noise rejection with lower error metrics.

Consequently, various novel FOIMC-series cascaded control structure (SCCS) with dead-time compensator, dual-loop FOLY-FOPID, FOLY-IMC FOPID, and FOIMC-FOPD predictor strategies are proposed for CSTR in order to explore each of their noteworthy impacts individually. The robust servo-regulatory action and noise rejection are attained by FOIMC-SCCS dead time compensator over reported traditional cascaded schemes and the substantial benefit of proposed dual-loop strategies is also addressed. FOIMC-FOPD predictor produces a fairly decent outcome in terms of stability under noise and disturbance. To fine-tune the control parameters, a combination of in-depth simulation studies and optimization techniques are used.

Despite offering lower performance indices by the different proposed fractional order control strategies, still there is a major scope of improvement on producing a more trustworthy control action by offering fastest speed of action, zero overshoot, and lowest integral errors.

Finally, standalone fractional order backstepping (FOB) strategy is proposed as a productive alternate to reported augmented conventional backstepping schemes and the aforementioned proposed fractional order strategies to control the nonlinear systems using strict-feedback recursive technique linking an appropriate Lyapunov function. The proposed simple and straightforward FOB rule is explored as the most trustworthy strategy by offering lowest error metrics without needless overshoot, and fastest speed of action on inverted pendulum and CSTR systems.