Control of Processes using Sliding Mode Controller with Improved Sliding Surface and Controller Optimization

Abstract

This thesis presents the design, implementation and analysis of closed loop performance of sliding mode control (SMC) for a class of non-linear single input and single output (SISO) systems and multi-input and multi-output (MIMO) process using modified forms of sliding surfaces and tuning methods.

The first work is about the design of conventional SMC and SMC with modified PI-D sliding surface, for the control of first order plus dead time system (FOPDT) process. The conventional SMC and SMC with PI-D sliding surface delivered similar closed loop performance.

SMC with I-PD sliding surface and controller parameters tuned using Nelder-Mead algorithm, is applied for the control of FOPDT process. The proposed controller delivered better closed loop performance compared to conventional SMC. The proposed controller also delivered better closed loop performance when applied for the control of unstable FOPDT process. SMC with modified Nelder-Mead tuning algorithm is also proposed.

Experimental investigations are performed for the control of a conical tank process, which is a non-linear dynamic benchmark process. The closed loop response obtained by applying SMC with I-PD sliding surface, in three different operating regions of the process, is much better than the closed loop responses obtained using conventional SMC, SMC with PID and SMC with PI-D sliding surfaces.

A modified Nelder-Mead tuning based SMC is proposed for the control of first order plus dead time system with negative gain (FOPDT-

NG) process. The proposed controller is capable of overcoming the zero dynamics and exhibited improved closed loop response.

An SMC is proposed for the control of two input - two output (TITO) process with elements of process transfer function matrix represented as FOPDT model. Genetic algorithm and simulated annealing optimization techniques are employed to obtain best values of weighting factors in the discontinuous part of the proposed controller.

Fractional order PID and PD sliding surfaces based SMC are designed for the control of two-tank hybrid system. A modified SMC with a fractional-order PI-D (FOPI-D) sliding surface is proposed, which delivered better closed-loop performance than conventional SMC, SMC with FOPD and SMC with FOPID sliding surfaces.