Article

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Model predictive force control of hardware implementation for electro-hydraulic servo system

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Abstract

This manuscript introduces the application of Model Predictive Control (MPC) for high force control precision in a real industrial electro-hydraulic servo system (EHSS). Moreover, it presents a fractional order control (FOC) and conventional controllers (CC) based on genetic algorithm (GA). The GA technique has been used to tune the parameters of FOC and CC approach. In order to verify the ability of the proposed controller applied to the hydraulic press machines emulator using EHSS, a hardware implementation of a test press system is also suggested and setup to be used in this research. As a result, the study has been investigated using a simulation model then verified via the experimental implementation. In fact, the EHSS plays an important role in many industrial applications, especially in flight simulators, aircraft landing gear system, material testing machine and hydraulic press machines for which the high accuracy and fast response of the force or pressure control are exceedingly necessary. Real-time experiments on the EHSS are carried out to evaluate the proposed control approach in a large system parameters variation of working environments. Considerable improvement in the performance generated by the designed MPC controller is compared with the traditional and fractional order controllers. Moreover, the results show that the performance criteria in terms of settling, rise times, system overshoots, system parameters variation and applying different test signals are good values in case of applying MPC over using FOC and CC in this study. As a general conclusion, one can conclude that the MPC has the priority of applying it in the field of the industrial EHSS. The obtained results are promising in the field of mechatronic.

Keywords

Hydraulic, fractional order, genetic algorithm, MPC

Introduction

The electro-hydraulic servo system (EHSS) is widely used in industrial and machinery applications for the high-performance position and force tracking control (Merritt, 1967). For example, flight simulator, hydraulic excavators, tunnel boring machines and hydraulic presses. It has proven to be a promising choice for these applications owing to its high power to weight ratio, good dynamic performance and its ability to tolerate abrupt and aggressive loadings (Merritt, 1967). The control problems for the hydraulic systems could be categorized as position, velocity and force control (Essa et al., 2016). As a result of this classification, a force control of the EHSS has been investigated in this research for a hydraulic press machine emulator as a real industrial application.

In general, presses could be considered as one of the most commonly utilized machine tools in industrial field for the formulating of different materials. In the past, the mechanical presses were more commonly used for the pressing process in the industrial field. Even though, nowadays hydraulic presses take superiority owing to their advantage in that it can present a good lubrication and force control via programmable devices. In addition, it can be made for very large force requirements (Reif, 2014).

In fact, force control of the EHSS is widely required in many industrial applications such as presses, plastic injection machines, and so forth. The force control methods are characterized by a great computational complexity that enables force control at every piston position of the actuator. Therefore, many types of researchers give attention to position control or force control for a real industrial hydraulic press application.

In Wonohadidjojo et al. (2013), a method of the control strategy has been implemented by employing a fuzzy logic controller (FLC). Additionally, its parameters such as scaling factors of the inference system have been optimized using particle swarm optimization (PSO) technique. While the performance analysis of different controllers for a two degree of freedom (DOF) electro-hydraulic motion simulator platform is given in Ghosh et al. (2013). The used control strategies in

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