BOILER DRUM LEVEL CONTROL USING FRACTIONAL ORDER PID CONTROLLER WITH DCS SW APPLICATION

By
Baher Soliman Ismail Moway

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

in

Electrical Power and Machines Engineering

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Under the Supervision of

Prof. Dr. Ahmed Bahgat Gamal

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Title of Thesis:

Boiler Drum Level Control using Fractional Oder PID Controller with DCS SW Application.

Key Words:
Boiler Drum level control; FOPID Controller; DCS SW.

Summary:

This research work aims at developing a control scheme for boiler drum level in steam power plant. A conventional Proportional-Integral-Derivative (PID) controller and Fractional Order Proportional-Integral-Derivative (FOPID) controller are used to regulate the drum level for a three elements scheme. SIMULINK package is used to simulate different models and controllers for different disturbances. A distributed Control System (DCS) SW package from ABB has been used to simulate the controllers and the boiler drum level process. Graphic display have been developed to visualize the results and tuning of controller parameters. Results indicate the effectiveness of FOPID over PID controller in improving the dynamic performance.

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List of Abbreviations and Symbols

ASME	American Society of Mechanical Engineers
CFE	Continuous fractional expansion
DCS	Distributed Control System
DDC	Direct digital Control
FAT	Factory Acceptance Test
FCV	Flow control valve
FM	Flow meter
FOMCON	Fractional Order Modeling and Control
FOPID	Fractional Order Proportional Integral Derivative
GUI	Graphical user interface
HMI	Human machine interface
HW	Hardware
ISA	International Society of Automation
I/O	Input/output
K_{cr}	Unlimited gain
K_c	Controller Gain
K_p	Proportional Gain
K_i	Integral Gain
K_d	Derivative Gain
LAH	Level alarm high
LAL	Level Alarm Low
LT	Level transmitter
LTI	Linear Time-Invariant
OIS	Operator Interface System
PI	Proportional Integral
PID	Proportional Integral Derivative
P_{cr}	Ultimate Period Of Sustaining Oscillations
PSE	Power series expansion
PV	Process Variable
SP	Set Point
SW	Software
TF	Transfer function

T_i	Integral Time
T_d	Derivative Time
T_s	Settling Time
UFB	User-defined Function Block
λ	Integral order
μ	Derivative order

Abstract

In thermal steam power plant, the Boiler drum level control has become more important, as the boiler load is being varied to meet needs, rather than wasting fuel and steam and operating at full capacity. The effects of feed pressure surges and steam flow disturbance on drum level dictate more complicated controls. The purpose of the drum level controller is to maintain the level at constant steam load and bring the drum up to level at boiler start-up.

This work provides a study for boiler drum level control using Fractional Order PID (FOPID) controller. A comparative study is made on the performance of the FOPID controller and conventional PID controller to obtain better control performance.

MATLAB software is used for model testing and response simulation using FOPID and conventional PID.

As the Distributed control system (DCS) is widely used in many industrial sectors and thermal power plants, this research work presents the implementation of the ABB Freelance DCS SW at the two levels: Direct Digital Control (DDC) and Operator Interface System (OIS) for the Supervisory Control and Monitoring of the Boiler Drum Level Control. The DCS SW has been utilized to emulate the Boiler Drum Level and the associated field units. The DCS SW is used to implement FOPID as well as the conventional PID controller. Different graphic displays on the OIS have been designed to enable tuning of controller parameters, monitor the performance of the control loop and to introduce supervisory control actions.

Comparison between the obtained time responses on the OIS with MATLAB simulation results is presented.

According to the simulation results, FOPID controller gives better response than conventional PID controller as there is improvement in control parameters like error, settling time and maximum overshoot.

Also, this work shows the effectiveness of using commercial DCS SW in implementing advanced controllers, studying and monitoring the control loop, and emulating the process dynamics.