



# **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**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
GIZA, EGYPT  
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Under the Supervision of

**Prof. Dr. Ahmed Bahgat Gamal**

**Prof. Dr. Hassan Mohamed Rashad**

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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

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

|                             |                             |
|-----------------------------|-----------------------------|
| <b><math>T_i</math></b>     | Integral Time               |
| <b><math>T_d</math></b>     | Derivative Time             |
| <b><math>T_s</math></b>     | Settling Time               |
| <b>UFB</b>                  | User-defined Function Block |
| <b><math>\lambda</math></b> | Integral order              |
| <b><math>\mu</math></b>     | 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.