COMMAND AND CONTROL STRATEGIES APPLIED TO HIGH-POWER STEAM GENERATORS

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Abstract - The paper presents the analysis of the actual operation scheme existing for steam generator drum. Following the trend valid for forced circulation steam generator, it is proposed to replace the classical adjustment loops with new regulation scheme highlighting its advantages in steam generation operation.

Keywords: power plants, water level, simulation, control valve, discontinuous controller

1. INTRODUCTION

Technological development and the need for efficient energy use have influenced the philosophy of management of complex systems.

The management of power plants is organized in hierarchical levels. The lower level is the variable that adjusts drives - pressure, temperature, flow, speed - at the desired level. At this level are also implemented procedures for starting and stopping. The next level includes how the components of the plant are driven by changing variables reference points, such as loading and excess air. Functions at this level include full operations optimization by defining the law of variation of operating points and amending their instructions to the lower level. Finally, there is the managerial level - higher education - widely optimizing performance, task allocation between groups, the definition of general criteria and restrictions, all economic quantified.

The main functions are to stabilize the lower level variables in the desired system and to provide dynamic requirements to amend the references.

These algorithms provide safety requirements, in the form of limiting quantities or additional control loops to stabilize certain parameters.

The most important component of the conventional power generation plant for fuel optimization studies is the steam generator. The control of the steam generator to archive optimum performance is a difficult problem that has been studied during the last years.

The main variables which are stabilized due to security considerations at the outlet steam temperature of the steam generator water level in the drum, the drum and the pressure of the live steam, the pressure in the combustion chamber and the furnace - in order to stabilize the flame and the pollutants out of the steam generator. Automation installations with automatic adjustment functions are designed to maintain energy block parameters to operating data for internal or external disturbances that can occur in regimes of exploitation.

The problem of control in industrial applications is one of the most important; it depends on the proper functioning of the installations, operational safety and achieving the desired performance. Despite the rapid evolution of hardware, conventional PID controllers were the most used in industrial control equipment, operating in combination with logical and sequential controllers, switches and other functional blocks. Many sophisticated control strategies, starting and stopping of the operation have been developed around the concept classic PID control.

PID controllers, through the three components (proportion P, I and integrator Derivative D), performs the following functions: adjust output size controller in accordance with desired amplification factor (P), eliminates errors in steady state (I) predicts future behaviour of the process (D). These functions are sufficient for a large number of industrial process control problems, especially for dynamic processes with little or modest performance requirements, [2, 5, 6].

2. STRATEGIES FOR ADJUSTING THE LEVEL OF THE BOILER DRUM TO THE STEAM

As is known from the literature, [1, 2], three strategies are used to adjust the level of the drum designed to set a size, two or three sizes.

Set a scale: it is the simplest strategy that uses one size measured – level. It is only used for small boilers with moderate variations to very slow changes of the load so as not to cause a malfunction due to the effect of shrinkage – swelling (*eng. shrink and swell*)..

Adjusting two sizes: use the boiler with moderate variations of the load, irrespective of their size. The structure adjustment allows the level control and disturbance rejection of the level controller and steam flow disturbance rejection through the feed forward controller. Unfortunately this strategy as the first one can not remove disturbances that occur (pressure and flow) water pipe. Also, because the level controller is awarded to slow dynamic variable level, it can not flow fast dynamic control variable, leading to excess supply of water to the drum, without considering the dynamics of the boiler.

Adjusting the three sizes avoids the disadvantages of the previous regulation. This adds a new control loop for the water flow that will be the reference output of the adder masses.

The flow controller for water used as a water flow measure and reference. The steam flow is processed with the feed forward controller and level variations by the level controller. In this way the drum level is maintained by adjusting the water flow and maintaining mass balance/heat. This structure allows an independent and fair of the regulators depending on the dynamics of the measured values.

The current adjusting structure does not fall within the solutions implemented by companies with tradition and reputation in the field and presented in the literature, [2] and the following disadvantages: a single controller for three sizes measured: level, flow of water and steam flow; measured the three different dynamics sizes (large time constants and low level flow rates) and the mass balance is not achieved in a position control system to allow for the heat balance.

Upgraded control loops are designed to ensure proper operation of the group to start and load regime change, taking action to this end primarily on the main automation, is regulating the flow of boiler feed water through valves 100% and 40% starting with valves, regulation of the temperature of the live steam injections, the temperature of the superheated steam intermediate, regulating the level in the degasser, regulating the pressure in the degasser, IP bypass system (pressure control and the steam temperature), the bubbles start to adjust the level (power expander) and a purge tank, the regulation of the intermediate pressure steam superheated by the exhaust, the system of the bypass MP-JP (regulation of pressure and temperature), adjust the steam pressure and temperature the labyrinth.

Automation installations with automatic adjustment functions are designed to maintain energy block parameters at operating data for internal or external disturbances that can occur in regimes of exploitation.

In normal operating mode of the steam generator is used in addition to the main parameter adjusted - the level in the drum – additional parameters is used feed water flow signals and the total flow of steam power boiler, thereby preventing a major change in drum level with load variation.

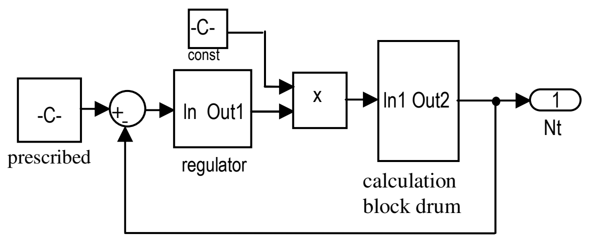


Fig. 1. Drum level control loop - current version

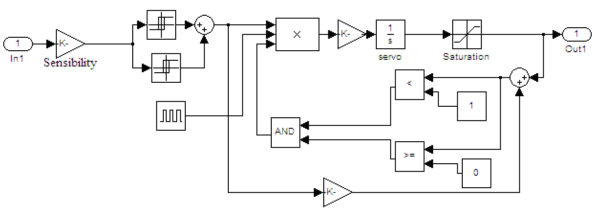


Fig. 2. Level drum regulator

In the Figure 3 is presenting the comparison of the steady state and dynamic conditions system response. At a step change of 10% of the superheated steam flow steam the drum level falls following that later, depending on the sensitivity value that starts to increase and it will stabilizing slower or faster.

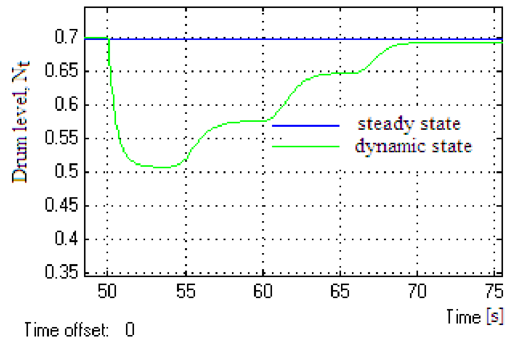


Fig. 3. Provided with system response regulator (sensitivity 150, from 6 [s])

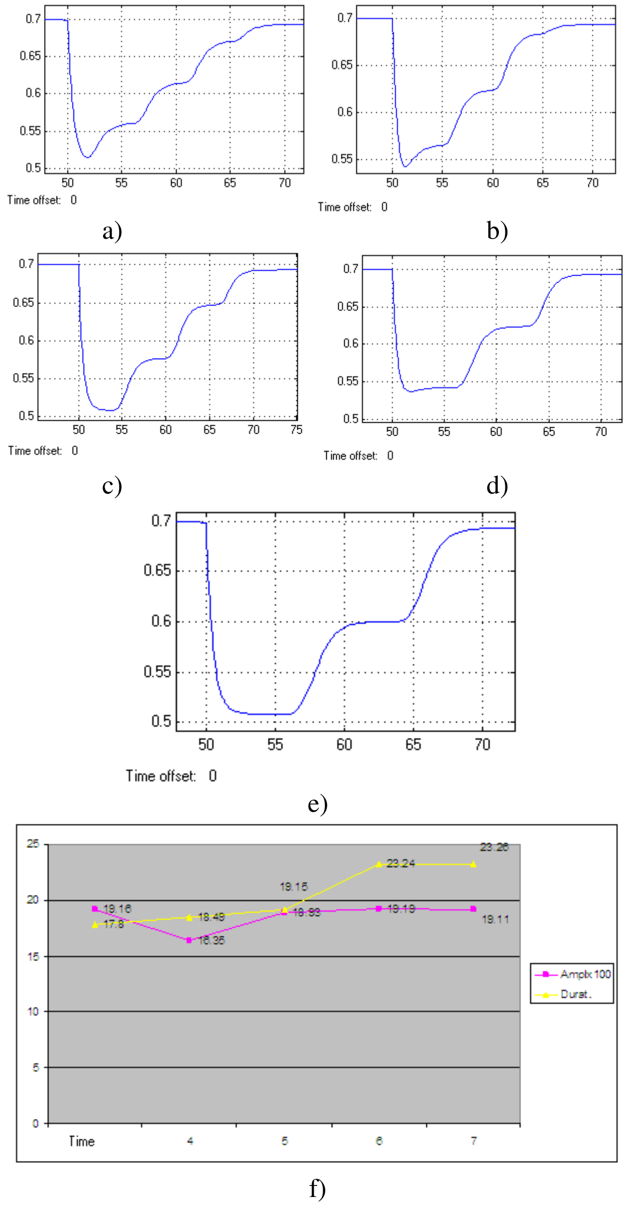
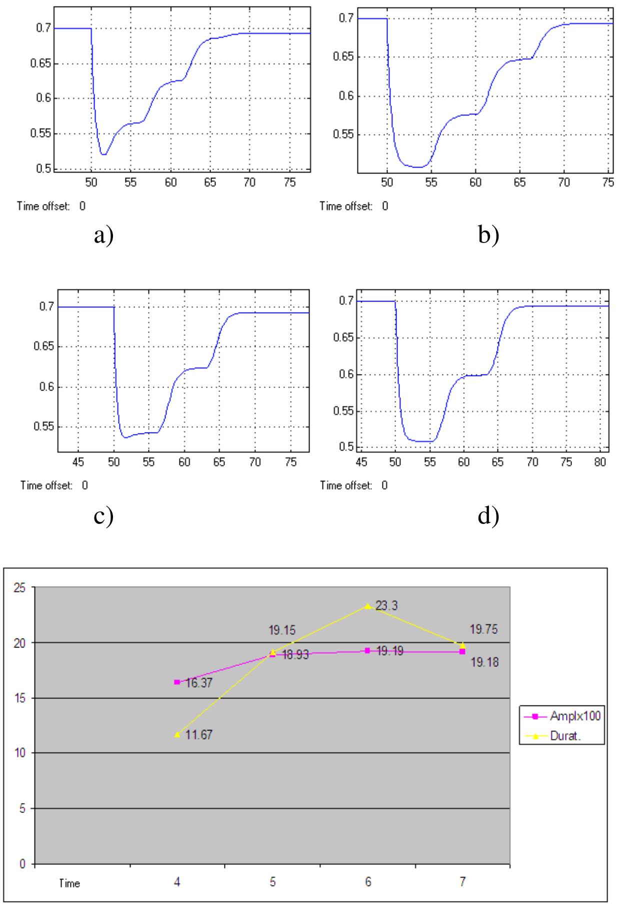


Fig. 4. The regulator system response provided with the variation of time, sensitivity 150

a) period 4 [s]; b) period 5 [s]; c) period 6 [s]; d) period 7 [s];
e) period 8 [s] f) the variation of amplitude and duration of amortization

The controller from the control loop is working at 150 sensitivity. Figure 4, leads to a better system response when is operating for a 5 seconds period. Thus, at this value the amplitude is minimal; the duration of stabilizing is with little deviation from the immediate values.

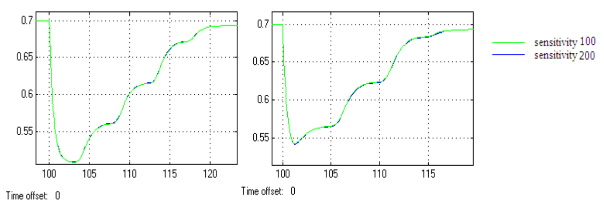


a) b) c) d) e)

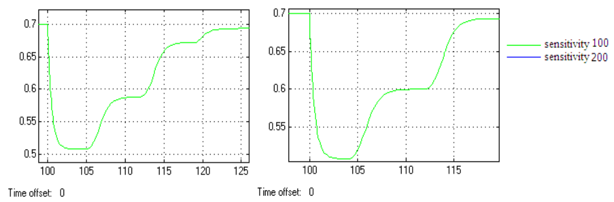
Fig. 5. The regulator system response provided with the variation of time, sensitivity 200
a) period 5 [s]; b) period 6 [s];
c) period 7 [s]; d) period 8 [s]
e) the variation of amplitude and duration of amortization

Figure 5 shows a second case under analysis, sensitivity regulator 200, maximum value. The optimum operating point of the system is achieved at the period 5 second, when both parameters reach minimum values.

Thus, comparing Figures 4 and 5 can conclude that for optimum response in dynamic operating system, the regulator control loop must be characterized by maximum sensitivity and the period around the lower value of the variation allowed.



a) b)



c) d)

Fig. 6. Feedback of regulator system with constant period and variable sensitivity capabilities
a) period 4 [s]; b) period 5 [s]; c) period 6 [s]; d) period 7 [s]

A final analysis of the loop level control from the drum was made keeping constant the period instead it was changed the sensitivity of the controller. From the four graphs presented in the Figure 6 it is shown the perfect overlapping of the response signal observed for periods of higher values (6 and 7 seconds), which is not so affected by variation in sensitivity. For closed periods to the lower limit appears on the graphic allure slight modification of the response curve of the system, observing here that the amplitude and duration of the signal damping minimum values for 5 seconds.

In the current version of operating system for automatic water level in the drum type using a proportional regulator and a discontinuous action actuator element whose command execution is pulsed with a total duration of working time of about 6s and with a working time of 2s - the valve as integrator element. In this structure the transfer function is performed by a PI.

Using elements of control and the current scheme with drum of steam generator is provided, leads to the following observations: diagram using discrete electronic circuit devices; theoretical adjustment for controllers is not proved adequate under practical operation; FEA equipment in the system is not longer made or replacement of defective parts; any transition from manual to automatic requires the operator to stabilize the first to come to the reference value and then pass it automatically; control diagram does not take account of changes in the level due to variations in temperature or pressure of the drum.

3. THE PROPOSED VERSION

The proposed version uses a digital controller with component integration, leading to reduced error stationary and sampling period of 0.1 s eliminating any delay in answering disturbance. This version produces an impulse actuator control variable duration (minimum 0.5 s - up to 4 s) which depends on instantaneous deviation - difference between set point and actual value level.

We propose to use a digital system adjustment scheme (DCS) with safe equipment, with control of external and internal functional elements microsecond level with the manual removal of the loop on the occurrence of any defect.

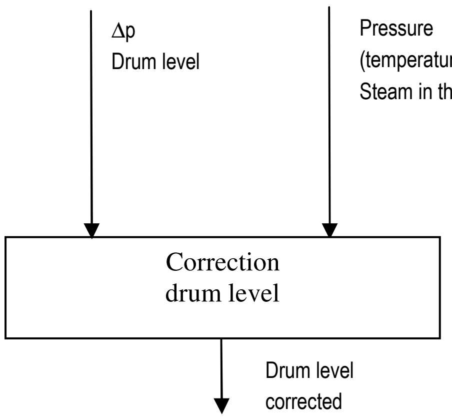


Fig. 7. Working binary DCS using specific algorithms (redundant processors)

The advantages of such a scheme is reflected in the processing of all the binary signals on the band, using specialized algorithms, precise, without discrete components, using redundant processors, any processor failure involving a takeover by the other processor without a break, providing real-time coefficients and regulators - without switching to manual adjustment.

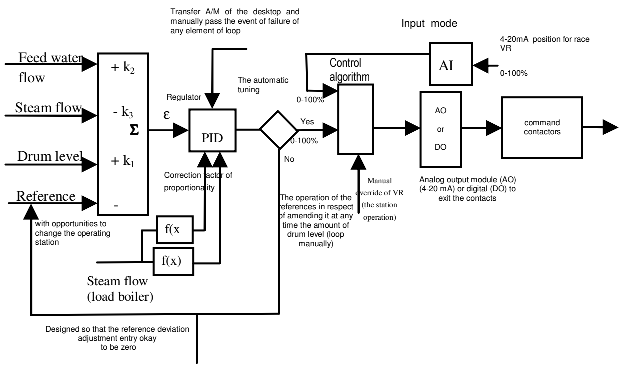


Fig. 8. Adjustment scheme proposed – drum level, [7]

Diagram uses adaptive controllers allowing parameter-band correction and time integration according to boiler load (including dependent firepower).

Control algorithm may have functional limitations including crossing to manual control if it exceeds the limit.

4. CONCLUSION

System uses safe equipment microsecond-level functional and diagnostically control of external and internal elements, allowing switching to manual control loop when any defect occurs.

Measuring transducers are with functional diagnostics and maintenance central. Process parameters, like level, pressure correction and temperature are measured.

Applying this diagram to exploit the cogeneration plants will lead to increased safety in operation, in the same time ensuring fuel savings and reducing pollution.

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