

## Improved Auto-tuning PID Controller of Level in Condenser of Turbine in Thermal Power Plant Using Saturation-relay Feedback

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**Abstract:** - Properly tuned controllers should ensure correct and unobstructed functioning of the system, i.e. process. Using ideal relay as nonlinearity in process of auto-tuning gives significant errors in estimates of the ultimate gain and ultimate period. In this paper mentioned lack is overcome by introduction saturation relay, where control system of condensate level in condenser of turbine in thermal power plant Gacko is used as a model. Due to the constant striving to reduce energy consumption, above settings are implemented in the system for which is proposed strategy which provides energy savings, i.e. includes frequency regulators.

**Key words:** auto-tuning, PID controller, ideal relay, saturation relay, frequency regulator

### I. INTRODUCTION

Tuning PID controller is dedicated great attention due to constant striving for the satisfactory behaviour of the object. A significant progress was made by introduction nonlinearities in the form of an ideal relay in the process of controller auto-tuning [1]. However, practice has shown that in such a way, significant errors in determining the ultimate gain and ultimate period are present, because of simplifying the mathematical description of ideal relay output. Improvement was achieved by replacing the ideal relay with saturation relay, whose output is more accurately described by sine function and significantly reduced errors [1]. In this paper, model of control system of condensate level in condenser of turbine in thermal power plant Gacko was used and it was carried out simulations of auto-tuning controller parameters using the saturation relay [7]. The resulting controller parameters are applied in the simulation system for which is proposed energy saving strategy, which includes frequency regulators. So that responses (levels as function in time) of mentioned control system were obtained for the parameters which were calculated using the ideal relay and saturation relay. In this way, the discussions about validity of some parameters in relation to the others are enabled.

#### A. Description of Object (Condenser)

Thermal power plant Gacko works on Clausius – Rankine principle (cycle). It is a steam cycle. The main elements of this plant are: boiler, turbine, condenser and pump, each coupled with pipes and armature.

The purpose of the cooling system in thermal power plant is the removal of condensation heat of steam expanded in the turbine and other auxiliary cooling to the environment. Its main components are the condenser, cooling tower and pumps. Condenser is firmly connected to the turbine and relies on springs to take its weight. In this part the exchange of heat is carrying out, under constant pressure. When there is no mechanical interaction between steam and cooling water. Condenser is made as surface heat changer, in which the steam condensation is performing on the cooling surfaces, which consist of a numerous cooling tubes through which cooling water passes. In addition, condenser is place for condensate accumulation, which forms level that should be controlled to be constant. In the process of heat delivering to the environment a substantial part of the water evaporates and it is compensated from the reservoir, where water is brought from an artificial lake Klinje.

Level in the condenser depends largely on the amount of fluid that come into condenser and drains off it, as shown in Fig. 1.

Technical and exploitation (nominal) data of condenser are [3]:

1. pressure: 0,035 (bar),
2. temperature: 41 (°C),
3. cooling water flow: 36000 (m<sup>3</sup>/h),
4. condensate level: 1,2 (m),
5. dimensions: length x width x height= 8,75 x 8 x 6 (m).

### II IMPROVEMENT OF CONTROL SYSTEM OF LEVEL IN CONDENSER BY INTRODUCING FREQUENCY REGULATORS

Level in condenser depends on the amount of steam which comes from turbine (directly and from heater for regenerative heating), supply of demineralised (DEMI) water, drain condensate and working of vacuum pumps for obtaining vacuum in condenser. Level control is achieved using two closed-loops. In first closed-loop there is the level control over valve for condensate drainage from the condenser, while in the second loop mentioned control is





