National Conference on Emerging Trends in Computer, Electrical & Electronics (ETCEE-2015)
International Journal of Advance Engineering and Research Development (IJAERD)
e-ISSN: 2348 - 4470 , print-ISSN:2348-6406,Impact Factor:3.134

# Simulating and controlling of power plant super heaters

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***Abstract*-This paper deals with controlling and simulating of superheated steam temperature system using dual loop control concept. Super heaters are heat exchangers that transfer energy from flue gas to superheated steam and are important units of thermal power plant. In industries PID has a wide range of applications. Conventional control of thermal power plant super heaters by using PID controller is known to be efficient. Dual loop PID control is used for two stage attemperation to control the temperature of superheated steam. There is a high non linearity and time delay due to complex and enormous structure of thermal power plant which cannot be compensated easily. So, cascade PID control is extended with an additional function block "Disturbance determination". It is shown that the control performance is greatly improved after addition of this block, by using MATLAB-SIMULINK software. And the results are discussed.**

**Keywords- Superheater, Cascade PID, "Disturbance Determination" block, Time delay, Non-linearity**

## I. INTRODUCTION

Tight super heater steam temperature control is essential to improve lifetime efficiency, and load following in power plants. Low steam temperature reduces the efficiency of the thermal cycle. While high steam temperature is restricted by the strength and durability of materials used in super heaters. Tight Control of super heater steam temperature is important for the efficient and reliable operation of thermal power plants. The standard method of controlling the boiler super heater outlet temperature is by the use of a water spray between the secondary super heater and the primary super heater. Steam temperature is challenging due to nonlinear process model with a long dead time and time constants, and the boiler load and other disturbances. For control of high pressure main stream temperature, two stages of attemperation are provided. There is a probability of corrosion in turbine blades if the steam is not superheated. Due to over-heating of boiler tubes there will be a chance of bulging and rupturing consequences. So, tight temperature control of superheated steam is necessary.

### *A. Steam cycle*

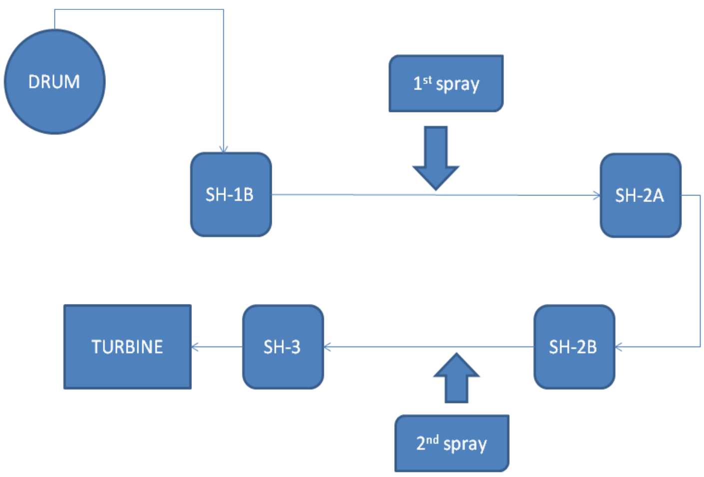



Fig 1: Steam cycle

### *B. Super heater 1B coil:*

Steam leaving drum will enter into super heater 1B. This coil is placed above economiser coils in convective pass. Steam gets superheated by taking temperature of flue gas in the process

### *C. Super heater 2A/2B coil:*

These are also super heater coils placed in Fluidised Bed Heat Exchanger 3 and Fluidised Bed Heat Exchanger 2 bundle chamber respectively. Steam gets more degree of superheat in these coils by taking temperature from the heat supplied by flowing ash in FBHE's. Main advantage of super heaters installed in FBHE is that of proper temperature control at various boiler loads. Ash flow regulation by spiess valves helps in maintaining required super heater temperatures at various boiler loads.

*D. Super heater 3 coil:*

This is final super heater coil installed in convective pass at the top most portions. Outlet from Super heater 3 will be feed to steam turbine. Super heater 3 outlet is provided with a stop valve. Super heater 3 outlet parameters at GIPCL are 390 ton/hour steam flow with super heater temperature of 540 +/- 5 degree centigrade, at 132 kg/cm$^2$. Outlet from Super heater 3 till steam turbine will be called main stream line. Main stream line is provided with safety valve, electrometric relief valve, starts up vents, drains and required instrumentation.

*E. Turbine*

Concept of steam turbine was developed in 120BC.

When steam is allowed to expand through a narrow orifice, its heat energy (enthalpy) is converted to the kinetic energy. This kinetic energy is converted to rotational energy through the impact or reaction of the steam on the blades. As the steam moves over the blades its direction changes continuously & centrifugal pressure exerted on the blades. This motive force is combination of centrifugal force & change of moment and its direction is always normal to the blade surface.

## II. SUPERHEATER MATHEMATICAL MODEL

*A .Transfer Function*

The boiler has many variables to be precisely controlled for efficiency and safety among those variables, super-heated steam temperature is one of the important variables. The fifth order model of super-heated steam temperature is used for study[1]-[8]. The analogue controllers were tuned for delay plus first order transfer function model.

$$\frac{1.13205}{3515625s^5+890625s^4+88750s^3+4350s^2+105s+1}$$

*B. PID Controller*

Proportional-Integral-Derivative (PID) control is the most common control algorithm used in industry and has been universally accepted in industrial control. As the name suggests, PID controller algorithm involves three separate constant parameters and is accordingly sometimes called three-term control: proportional, integral and derivative [2]-[3]-[9].

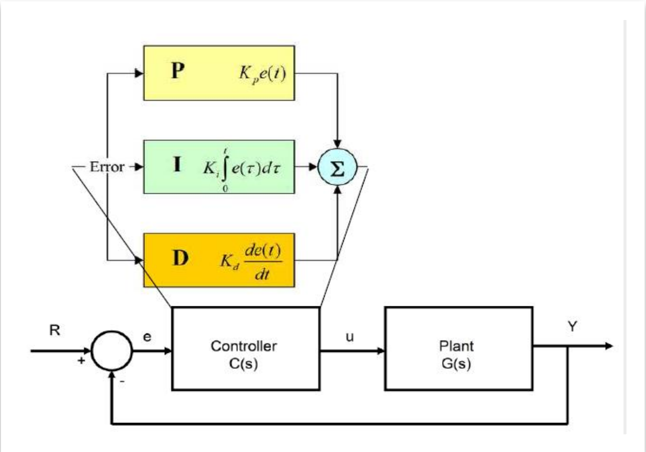



*Fig 1: PID Block Diagram*

## III. SUPERHEATED SYSTEM TEMPERATURE CONTROL USING CASCADE PID CONTROL

In cascade PID control scheme the final outlet temperature of main stream is controlled by spraying water in Attemperator-2. The temperature difference across Attemperator-2 is maintained by spraying water in Attemperator-1 so that the spray valve remains in control range. If the permissible limit of the temperature before Attemperation-2 exceeds, then spraying in Attemperator-1 controls this (Attemperator-2 inlet) temperature instead of controlling temperature difference across Attemperator-2. Both the Attemperator have two spray control valves each. The two valves regulated in the same fashion.

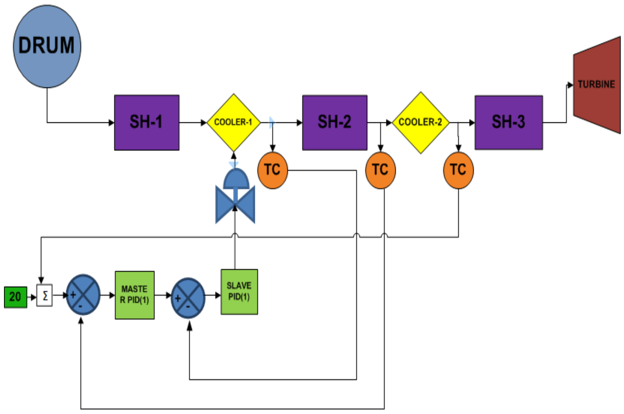



Fig 2: cascade PID loop for cooler-1

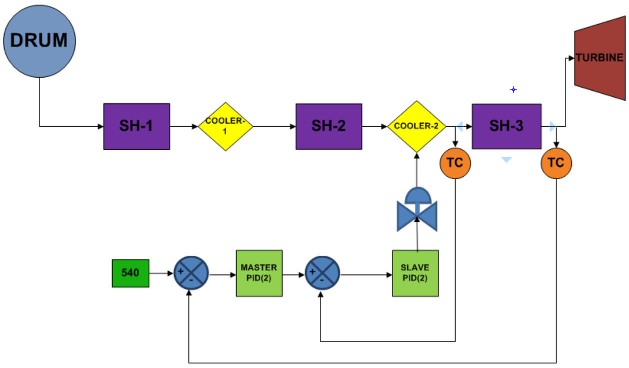



Fig 3: cascade PID loop for cooler-2

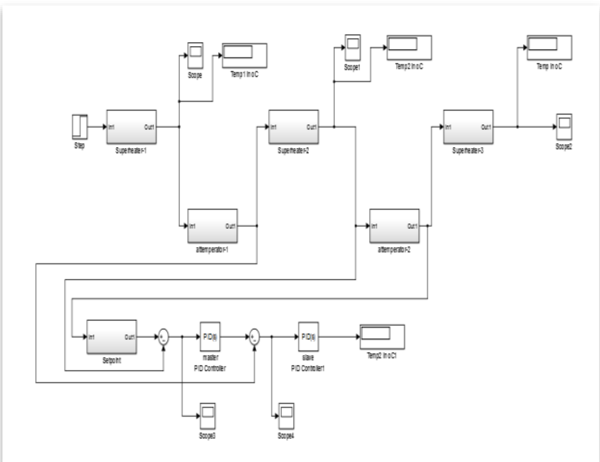


Fig 4: Cascade PID control (MATLAB)

## IV. SUPERHEATED SYSTEM TEMPERATURE CONTROL USING CASCADE PID

## CONTROL WITH "DISTURBANCE DETERMINATION" BLOCK

Cascade PID control with Disturbance Determination is used for two stage attemperation. The dual loop control is employed for a process with long time response like superheater spray control. Disturbance during the heating of steam in superheater coil results in increase or decrease in the outlet temperature. Magnitude of this heating disturbance is feed to "Disturbance Determination" block. The disturbance determination block output is then used in the control deviation for final control of the process.

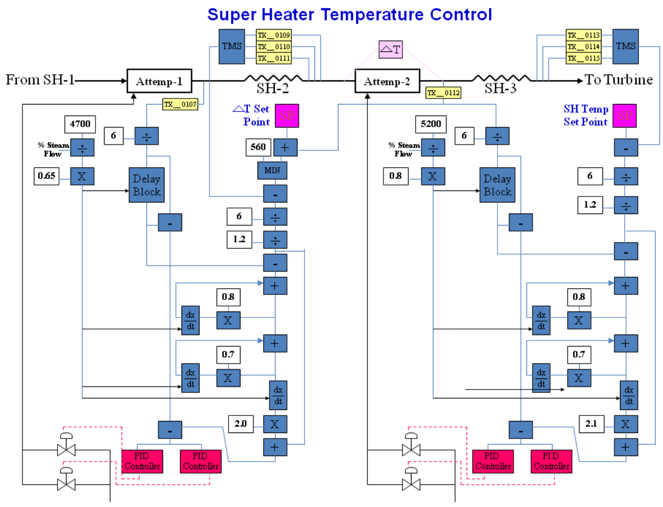
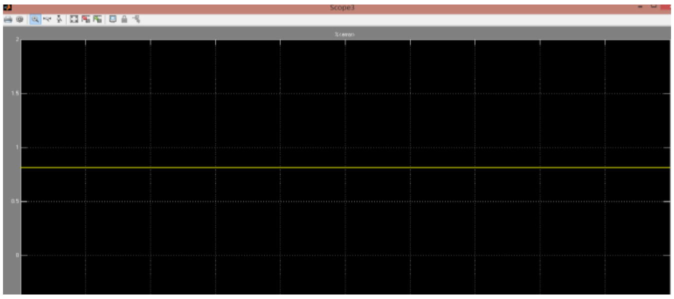



Fig 5: cascade PID loop for cooler-1 and cooler-2 with "Disturbance Determination" block

## V. SIMULATION RESULT

Here graph of error signal which is fed to the PID controller is presented. when design specifications are as follow.

| LOAD | SH-3 O/LTEMP | CV-1 | CV-2 |
|---|---|---|---|
| 125MW | 540.47 | 7.2% | 6.7% |



.Fig 6: error signal entering into PID for cascade PID scheme

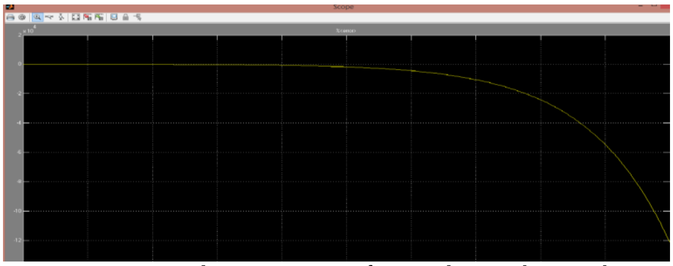


Fig 7: error signal entering into PID for cascade PID scheme with "Disturbance determination" block

## VI. CONCLUSION

Magnitude of the heating disturbance of superheater is feed to "Disturbance Determination" block. "Disturbance Determination" prior estimates the disturbances, and its output is then used in the control deviation for final control of the process. From which we can conclude that cascade scheme with "Disturbance Determination" block will give more precise control compare to cascade scheme without this block.

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