Study on the Impact of Various Optimal Process Parameters of a 500 MW Boiler

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Abstract. Power plants face many challenges in today's global scenario, including minimizing costs. Sustained expansion in energy generation capabilities is a sign of a country's expanding affluence. Electricity now pervades practically every aspect of human life. Coal has long been an important source of fuel for power generation. There has been no consideration paid to the contaminants created or the coal quality. The qualities of coal have an impact on the design and performance of thermal power plants, as well as the cost of electricity generation. The cost of coal, as well as the plant's construction, are all determined by the superiority of the coal. Because the worth of the coal has an impact on practically every aspect of plant functioning, care must be taken during coal changeover. In this environment, a comprehensive approach to the optimal operation of power plants is critical for utilities competing in liberalised markets to survive. A plant's control system can considerably improve performance and provide solutions to some of the issues outlined above. In light of this, the authors were inspired to develop a better strategy for dealing with difficulties in a fossil fuel power plant (FFPP).

Keywords: FFPP, Coal, Electricity, Power, plants.

1 Introduction

Due to market forces, the use of fossil fuel power plants (FFPP) in load-following responsibilities has increased [1]. In addition, severe standards for the conservation and life extension of important plant equipment must be met.Control of all these vital parameters in a 500MW thermal power plant is important. The standard controller used in the power plants is proportional, integral and derivative controller. The researcher has clearly mentioned that PID controller will last long for all the industrial process in spite of the new model based controllers[2]. The step response of a process using Z-N tuning method was modified using a new set of rules[3]. The concepts of PID controller, its tuning rules and design are discussed[4].The importance and need of changing the calorific value of coal and the techniques involved to control the essential parameters during fuel switching are explained[5]. The modeling of steam generator and the embedded controller design for the same is designed. The optimal value of controller is also ensured[6]. The improved method of controller tuning

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facilitates the performance of boiler[7]. An innovative method to calculate the accumulation value of the evaporator is performed[8]. The most important main steam pressure is controlled by using the novel methodology involved in the design of controller is employed for an utility boiler for both input disturbance side and output disturbance side[9]. The modified step response method is implemented in an utility boiler[10]. A heuristic model for the furnace of a model is developed[11]. A novel approach is utilized for the lower order model of boiler[12]. The model of a boiler using chemical equations is discussed[13].The reduced order of an utility boiler is designed[14].The performance of the PID controller using different tuning methods are portrayed.[15]. An enhanced technique for the implementation of PID controller in a thermal power plant is summarized[16]. The non linear mathematical model for a boiler is highlighted[17]. The operation of circulation boiler is explained[18]. The entire thermal power plant functioning is described[19].The dynamic performance of a 500MW boiler is analyzed[20]. The mathematical model of a reheater and turbine is developed[21].

Despite the fact that many of the units were built for constant load operation, the changing load need demands from the grid necessitate the following wide range load operation. System load needs or the most cost-effective dispatch options evaluated at energy control centres determine the variable load requirement.

Plant life extension maximizes capital assets by limiting downtime and lowering operating and maintenance expenses. The main cause of a system's operational life being reduced is operation under severe stress. Thermal strains caused by steam temperature and pressure changes are very critical in an FFPP.

A typical FFPP (sub-critical) has a net efficiency of 35–38 percent, corresponding to heat rates of 2860–2460 kcal/kWh. When functioning at loads other than the basic load, the heat rate increases. Heat rate improvement is a critical topic with major economic implications due to fuel use and expense.

The steam generator (or boiler), turbine, and generator make up an FFPU. The functioning of the separate components, such as the boiler, turbine, and generator, is critical to a successful plant operation. The boiler is the most significant equipment in an FFPU in terms of size, energy consumption, and criticality. It's also an important part of the energy conversion process.Its dynamic behaviour is extremely important for the electric utility's overall dynamic features.

2. Circulation System

The circulation system is the King-pin of the boiler and consists of the drum, downcomer and waterwalls. Feedwater, after being heated very near to the saturation temperature in the economizer enters the drum. Water enters the drum through the downcomer and runs down to the bottom of the riser tubes (water walls), which are heated by furnace radiation. This type of circulation system, without a mechanical pump to assist or force the circulation is known as Natural Circulation System.

In a natural circulation system, the circulation is only due to the thermo-syphon principle. The density difference between the water in the downcomers and the steam-water mixture in the risers is the driving force. The friction and other hydraulic losses in the tubes, bends and headers constitute the resisting force. The flow rates in the circulation system get adjusted so that the hydraulic losses balance the driving force.

3. Water and Steam path

The heat generated when the coal is burned in the furnace is used to heat water and generate steam. The generated steam is further heated to the required temperature in the superheaters before it reaches the turbine blades.

The path taken by water and generated steam can be classified as follows:

- Feed Water
- Circulating System
- Superheaters

The feed water channel includes the boiler feed pumps, High Pressure (HP) heaters, feed control station, and economizer.The circulation system comprises of boiler drum, down comer and upriser tubes.The superheating section includes the Low Temperature Super Heater(LTLH), the panel and platen(final) superheater.

4. The Model

Mathematical modeling of circulation system has been dealt by many researchers in the recent past. For dynamic modeling of the drum, down comers and risers, the physical model approach, utilizing the conservation of mass, energy and momentum is employed. The following assumptions are made:

- Drum is in the saturated state at all times.
- Drum is perfectly insulated.
- Energy storage in the drum material is neglected.

This research uses a nonlinear mathematical model created and validated for a 500 MW unit at BHEL's Centre of Excellence for Simulators, Corporate R & D, Hyderabad. The performance of the boiler has been examined after conducting dynamic simulation experiments for various disturbances.

5. Simulation Results

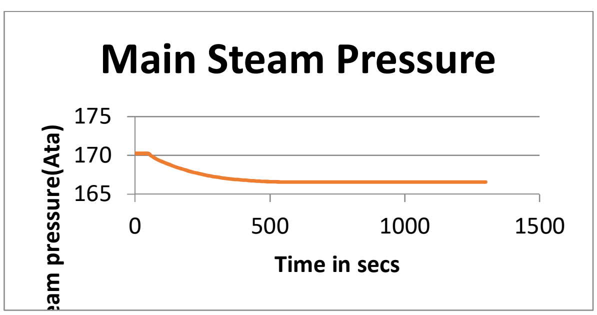

Fig 1. Open loop response of Main Steam Pressure

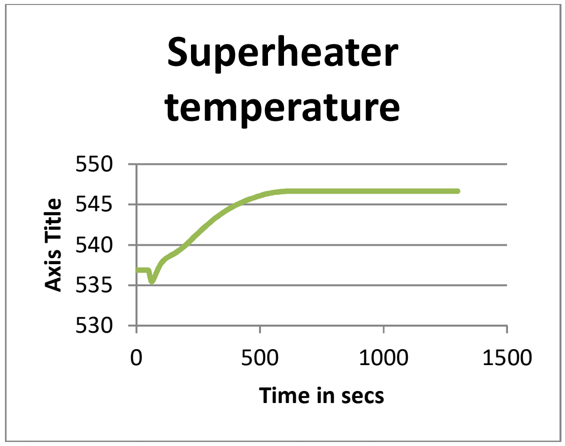

Fig 2. Open loop response of Superheater temperature

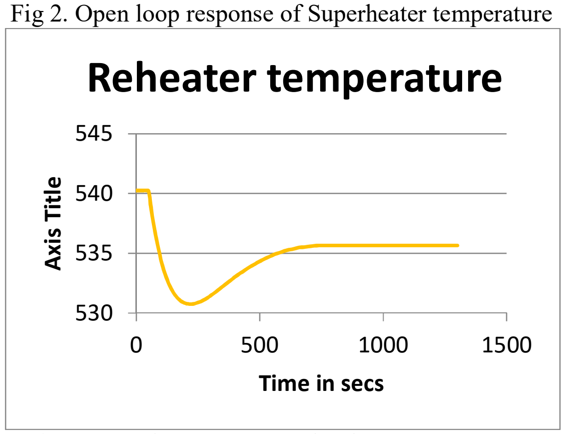

Fig 3. Open loop response of Reheater temperature

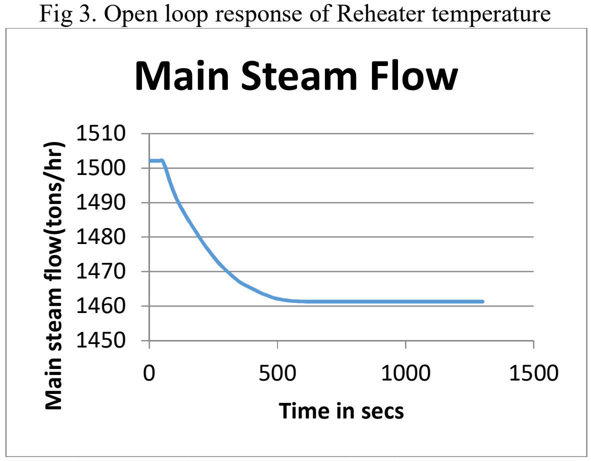

Fig 4. Open loop response of Main SteamFlow

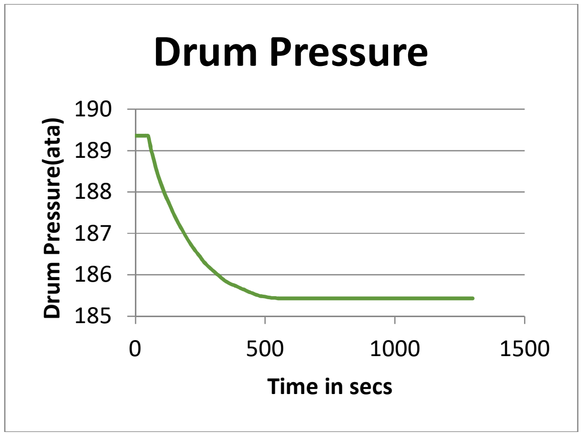

Fig 5. Open loop response of Drum Pressure

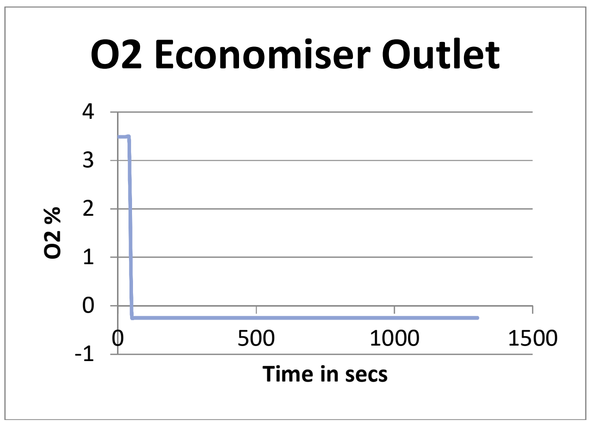

Fig 6. Open loop response of O2 Economiser Outlet

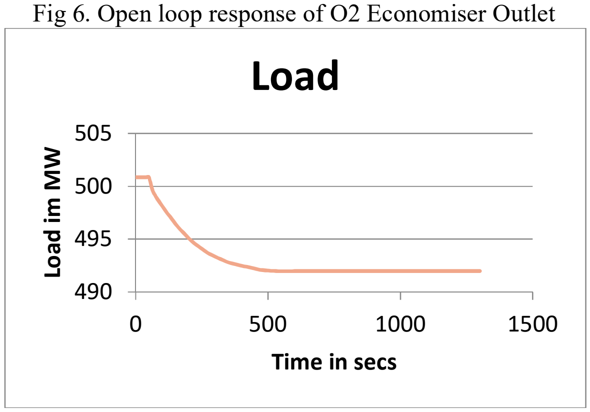

Fig 7.Step input variation of Load

6. Results And Discussion

Figures 1 to 6 represent the open loop response of the various parameters of 500 MW Utility boiler like Main steam Pressure, Super heater temperature, Reheater temperature, Main steam flow, drum pressure, O2 economiser outlet when it is subjected to step variation of load. The load is given a step change(Fig. 7) and the variations are plotted.

In Fig 7, the variation in load is plotted. The load is varied from 500 MW to 192 MW at 500secs.This is depicted in Fig 1.When the load reduces, the main steam pressure also reduces. It changes from 173 ata to 166.5 ata. The superheater temperature is raised from 535 to 546 °K as shown in Fig.2. .The reheater temperature changes from 540 to 535 °K as portrayed in Fig 3. . The main steam flow changes from 1500 to 1460 tonnes/hour which is shown in Fig 4. The drum pressure also changes from 189.5 ata to 185.5 ata as highlighted in Fig. 5. The O_2% at economizer output decreases from 3.5 to 0%(Fig.6).

7. Conclusion

This work focuses on improving the method for analyzing and obtaining various key characteristics of a 500 MW utility boiler, such as main steam pressure, temperature, and so on. The steady state data is gathered and simulated. Furthermore, specific open loop experiments were carried out for a period of time to acquire the transient responses. These responses can be used to calculate the process's time constant and time latency. This can also be used to compute the ideal controller parameters and acquire the system's closed loop response.

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