CHAPTER 1

INTRODUCTION TO CIRCULATING FLUIDIZED BED COMBUSTION BOILERS

This chapter emphasizes the significance of Circulating Fluidized Bed Combustion (CFBC) boilers and provides a brief review of literature, and the system description corresponding to the present work.

1.1 INTRODUCTION

Generation, Transmission and Utilization of power are three major areas of power sector. Increase in the power consumption creates a necessity to increase the generation. Among the different power plants, Thermal Power Plants contribute substantially. The complexity involved in the power plants increases with increase in demand. Hence the need for proper modeling and control exists in order to meet the system requirements. The CFBC boilers are predominantly used in many of the countries. The number of CFBC boiler units in India and in the world and the MW power production are depicted below.
The depletion of coal resources and the availability of poor quality coal make it mandatory to look for an alternate boiler to the conventional Utility Boiler. Burning of low grade fuel feed leads to the increase in pollutant gases like NOx and SOx emissions. This leads to the development of Fluidized Bed Combustion (FBC) boilers. To increase the combustion efficiency and to reduce the emissions, Circulating Fluidized Bed Combustion Boiler (CFBC) has been considered.

The main advantages of using CFBC boilers are reduced NO\textsubscript{X} and SO\textsubscript{X} emissions, flexibility for usage of multi-fuels, high efficiency, capability of burning low grade coal, and finally pulverizers are not required. Flexible usage of multi fuels plays an important role in the CFBC boilers. Solid fuel, liquid fuel or combination of these fuels could be used. Bio-fuels usage has been increased in the case of CFBC boilers.

Source: S.Balasubramanian, K.Sudhindra, SurendraBhat, Tata Consulting Engineers, Bangalore

**Figure 1.1  CFBC boiler units in India and World**
1.2 LITERATURE REVIEW

The main thrust areas of Circulating Fluidized Bed combustion boilers are the design and the control. The first thrust area is the design of combustor which involves the design of hydrodynamics, heat transfer and combustion related to CFBC boilers. It involves the design of the furnace, cyclone separators, loop-seal arrangement for solid particle flow, the heat exchanger like super heaters and Re-heaters. Increase in ash circulation rate, modification of cyclone separator, increase in bed inventory and particle size distribution improves the efficiency of the system.

There are five categories of fluidized beds, they are: fixed bed combustor, Atmospheric FBC / Bubbling FBC, Turbulent FBC, Fast bed / Circulating FBC and transport bed FBC. Among the five categories as described by (Grace 1986), the circulating Fluidized Bed Combustion boilers are considered for the research work. As per Raico et al. (1995), there are four regions namely: fixed bed combustor, Atmospheric FBC / Bubbling FBC, Turbulent FBC, Fast bed / Circulating FBC except Transport FBC. The flow rate is low in the ‘fixed bed Combustor’ and the fluid penetrates through the void spaces in between stationary solid particles as in Kunii, D (1991). In the case of ‘Bubbling Fluidized Bed combustion boilers (BFBC)’, the velocity is greater than the minimum fluidization velocity and this leads to the formation of bubbles. Then the solid particles behave like a boiling liquid. ‘Turbulent Fluidized Bed combustion (TFBC)’ as suggested by Basu. P (1986) lies in between circulating bed and the bubbling bed. When the bubbles collapse, turbulent fluidization occurs. Enhanced burning rate is obtained in the case of turbulent fluidization as the Carbon burns in a much faster rate.
The solid particles with higher velocities that are thrown out of the combustor are circulated back to the furnace bed through cyclone separators and they are called ‘Circulating Fluidized Bed Combustion Boilers’ [CFBC]. Basu and Fraser (1991) defined that the CFBC boiler as a steam generator which produced steam by burning fossil fuels or biomass in a combustion chamber which operates under special hydrodynamic condition. The solid particles in the CFBC were transported at a velocity greater than the terminal velocity.

If the velocity further increases beyond the terminal velocity, then they are called ‘transport bed’ Waqar Ali Khan (1999). The difference between the BFBC and CFBC boilers lies with the hydrodynamics of the boiler. The bed temperature of both CFBC and BFBC are the same. However, when the height of the furnace is increased, the bed temperature of CFBC boiler remains constant whereas for the BFBC it is differs. Similarly the gas to fuel particle velocity remains same for both. But the fluidization velocity is more CFBC.

As the fluidization velocity increases, the size of the bubbles formed increases as confirmed by Bo Leckner (2003). Therefore, the area of the cross section of combustor needs to be increased. Since the heat transfer is mainly due to particle convection and is higher for CFBC than BFBC boilers. The combustion efficiency is also higher in CFBC because of the recirculation of solid particles. When the limestone is added to CFBC boiler, it reduces the SOx and NOx.

M. Miccio, F. Miccio (2009) used liquid fuels, liquid bio oil produced from biomass could be used for the same. Hence the usage of fuel flexibility exists in the case of CFBC boilers. Design changes introduced in
the component levels described in the following paragraphs give an account of such design modifications as appeared in the literature. Design change includes the implementation of new design as well as modification in the existing heat exchangers, riser, cyclone separator. Modification in the fluidizing nozzle Jong-Min Lee (2003) leads to minimization of pressure. The changes in the cyclone separator, nozzle and ash reinjection system improves the performance of the CFBC boiler such as combustion efficiency, stability etc. The hydrodynamics and heat transfer in the CFBC boiler has been consolidated by Thenmozhi .G et al. (2013)

“Cell model method” was proposed by Li Zhao, Xiangdong Xu (1999) which differentiates the furnace into three regions with different velocity. The high velocity region is the combustion region; the low velocity is the heat transfer region and the medium velocity region is the suspension region. The differential velocity CFBC combustor improves the efficiency of the combustion.

Horizontal CFBC model was developed by Q. H. Li, Y. G. Zhang, A. H. Meng (2009). There are two combustion areas namely primary combustion chambers and secondary combustion chambers. Besides, it also consists of cyclone separator, heat recovery area, burnout chamber loop seal etc. With the multi pass flow, the solid entrained enters into the primary, secondary, third chamber, cyclone, loop seal etc and finally into the dense bed.

Sung Won Kim et al. (1999) defined CFBC based on the solids flow characteristics in the loop seal. The pressure drops across the down comer and riser increases if the solid circulation increases and gas velocity gets decreased. Increase in aeration rate causes drop in the pressure of solid inventory and increase in voidage. In P.Basu and L.Cheng (2000), the solid
particles which are accumulated in the cyclone separator drops into the loop seal chamber due to pressure difference in between the riser and standpipe.

Fluid-to-particle heat transfer, particle-to-fluid heat transfer and bed to wall heat transfer exist in CFBC. Efficiency of the combustion system has been determined by heat transfer between the medium and surface. As far as the heat transfer is concerned, gas to particle heat transfer coefficient can be calculated Gelperin, N. I., and Einstein (1971) using the Nusselt’s relation,

$$\text{Nu} = 1.6 \times 10^{-12} (\text{Re} / \varepsilon)^{1.3} \text{Pr}^{0.33}$$  \hspace{1cm} (1.1)

where $\text{Re}$, $\text{Pr}$ are defined in the table. The heat transfer between the fluid and particles are given in two forms by Roy et al. (1970).

For Gas- solid system,

$$h \frac{D_p}{k} = 0.015 \left( \frac{D_p}{G/\mu} \right)^{1.6} \left( \frac{C_p \mu}{k} \right)^{0.67}$$  \hspace{1cm} (1.2)

For Liquid- solid system,

$$h \frac{D_p}{k} = 0.016 \left( \frac{D_p}{G/\mu} \right)^{1.3} \left( \frac{C_p \mu}{k} \right)^{0.67}$$  \hspace{1cm} (1.3)

Heat transfer has three components namely Particle convection, Particle radiation and Gas convection. Here the particle convection and radiation gain importance whereas; the gas convection is generally ignored due to lower density of gas than that of solids. Andersson and Leckner (1994) explained that the overall heat transfer co-efficient is convective heat transfer co-efficient and radiative heat transfer co-efficient is due to suspended particles Baukal, C.E., (2000).
Werdmann and Werther (1993) have established a correlation for the convective heat transfer coefficient and radiative heat transfer coefficient (HTC)

\[ h_c = 7.46 \times 10^{-4} \left( \frac{k_g}{d_p} \right) \rho_s^{0.562} \left( \frac{D_b \rho_g \mu_g}{\mu_g} \right)^{0.757} \]  

(1.4)

Neglecting the heat radiation and convection in the dilute phase, the overall heat transfer coefficient to the water wall of a CFBC Werdmann C C&Werther J (1993) is given by

\[ h = 5\rho_s^{0.391} \tau_b^{0.408} \]  

(1.5)

The overall heat transfer coefficient from bed to wall at the bottom dense zone is given Basu, P., and Nag, P.K., (1996) as

\[ h = 40(\rho b)1/2 \]  

(1.6)

where \( \rho b \) is given by

\[ \rho b = \rho (1-\varepsilon) + C \varepsilon \]  

(1.7)

Heat transfer from bed material to wall tube is given by

\[ Q_{bw} = hA_w(T_b - T_w) \]  

(1.8)

The structure of the riser as core and the annulus has been described by many authors. If the temperature of the core is higher than the annulus, then heat transfer between the thick wall and the annulus is less than
the heat transfer between the thin walled annulus and the core Wang, Q., (1999). If the bed is denser, the heat produced is more.

The next thrust area of CFBC boiler is the controller design and selection. Most of the systems and components in the CFBC boiler which are to be controlled are non-linear and the parameters of the same are expressed as a function of load and inputs. There exists different controllers and control algorithms for controlling all the variables of the CFBC boiler. The different control algorithms and controllers are explored and their possible implementations are discussed in this chapter and in chapter III. Application of different controllers like PID controller, cascade controllers, Fuzzy controller and neural networks to Circulating Fluidized Bed Combustion boilers has been shown widely by many literatures.

PID controllers give an efficient solution for plants which are under control and this holds good both for steady state and dynamic conditions. Hence the PID controllers are popular. Hence P, PI, PID and P-PID, PI-PID (cascade) controllers are widely used. In order to improve the performance of an analog controller, different tuning methods are being adopted which has been detailed in chapter III.

As per the references Åström, K.J. and Hägglund, T. (2001,2004,2006) and Cominos, P. and Munro, N. (2002), Ziegler Nichols tuning and Cohen-coon methods are widely used for tuning PID controllers in industries. Linear programming has been used for tuning of PID controller parameters using a primal-dual interior point method which has been suggested by Edimar J. Oliveira et. al (2014). In this method P and I are combined terms and D term is separate as in parallel PID architecture. It gives minimum oscillation with stable operation to the output signal.
Possibility of using different control loops was explored by Karppanen (2000). Control loops in a CFBC boiler were made to control the process parameters like main steam pressure, steam temperature, drum pressure, furnace temperature, furnace pressure, Drum level and SO$_2$ control. The results implied that the fuzzy logic control is better than PID control for bio fuel and fuel feed compensation has been provided for fluctuations in the fuel feed.

The study of various control process in the boiler has been well described. One of the major issues that exist in the drum is the inverse phenomena or the non-minimum phase behaviour that exists in the drum called the Swell and Shrink Phenomenon. In-order to reduce the overshoot or to avoid the trip of the boiler, various control strategies have been followed by many of the authors. Some of the works where the drum pressure, level of the drum is controlled are elaborated here.

Mihai Iacob (2008) developed a three element cascade control versus single element control to reduce the non-minimum phase of swell and shrink effect and improve the response of the system. Third order model developed by Gordon Pellegrinetti and Joseph Bentsman (1996) showed closer correlation with the inputs whereas the first, second and higher order terms of water level are not coherent with the input.

An internal controller model was proposed by Barbara Molloy (1997) in the case of drum water level control. The fuzzified linear and nonlinear controllers predict the non-minimum phase effect of drum and react accordingly, whereas the PI controller cannot predict the same which could result in drum- 'dry-out'.
A non-linear model based on the physical parameters of a drum boiler and its associated components was studied by K.J.Astrom and R.D.Bell (2000). Association of swell and shrink phenomena with respect to the level of the drum has been well described by the authors. Further, the placements of poles and zeros and their contribution towards stability have been determined.

Min Xu et al. (2005) presented a cascade generalized predictive controller which consists of two loops namely, the inner loop with adaptive control and an outer loop with Generalized Predictive Control (GPC). The results shown implies that generalized predictive controller performed well when compared to the cascade PID controller since the oscillations are more in the case of cascade PID when subjected to more fluctuation in the main steam flow.

Based on the boiler drum dynamics, a linear state space model has been explained analytically. A comparison is made between linear and non-linear systems and the accuracy of the linear model has been evaluated by Mrunalini et al. (2006). Keeping the mass flow rate of feedwater, steam and fuel flow as inputs and pressure, level, steam-mass fraction as state variables the dynamics of the drum boiler has been manifested.

Conventional three element controller is made use of in the drum level control while the one suggested by Enrique Arriaga de valle and Assad(2006) is a modified fuzzy logic based three element controller where the error and the rate of change in error are given as inputs to fuzzy controller which in-turn actuates the PI controller. Similarly for the steam pressure control there exists a modified steam pressure controller which makes use of pressure error and rate of change in pressure error, level error and rate of
change in drum level error. There is a reduction in fuel flow while the load is increased from 10 to 100%.

Lavanya Krishnaswamy and S.Renganathan (2008) made an attempt to model the circulation system using neural network architecture. For the evaluation of the plant performance, a parallel architecture has been adopted with a cascaded feed-forward neural network having one hidden layer and a learning rate of 0.1, momentum parameter of 0.01. A step change of $\pm 5\%$ and $\pm 10\%$ change in feed water flow, heat transfer to rise and change in steam flow was given and the performance of the same has been determined.

Calculating the time constant using the storage capacity which expressed by an index called the accumulation value has been illustrated by S.Dharmalingam et al. (2009 and 2011). The determination of time constant and storage capacity helps in minimizing the steam pressure fluctuations. The design of a controller is purely based on the time constant of the system. Passivity based inventory control of drum boiler has been developed by Chengtao Wen, Ivan Lee, B. Erik Ydstie (2009) which ensures closed loop stability and good control performance. It ensures asymptotic stability of the system. Single loop generalized predictive control has been used by James Ridley Muir (1995) and is used for combustor temperature control and multivariable control of combustor for the removal of heat and combustor temperature control.

With an objective of improving the combustion efficiency of the system, complete study was carried out by Jalali & Hadavand (2007) for bed temperature control (i.e) $H_\infty$ control. The observation on stability of the system is found to be more in the case of $H_\infty$ control. Aboozar Hadavand (2007) designed two different types of controllers namely linear quadratic
regulator (LQR) with feedback controller and Quantitative feedback theory controller (QFT) among which LQR improved the system performance and QFT controller improved the stability of the system.

Xiao-Feng Li et al. (2011) proposed a new coordinated control which combines both fuzzy feed-forward control and the fuzzy-PID feedback control to overcome the long settling time, strong coupling, nonlinearity and inconstancy for a 300MW circulating fluidized bed unit. The controller achieves better performance within a specific range of load variations.

Sato et al. (2007) designed a feed-forward compensated self tuning PI controller for controlling the pressure of the furnace. Yu-Fei Zhang et al. (2013) design on multivariable fuzzy controller reduced the regulating time and improved the dynamic performance of the circulating fluidized bed combustion system. Bed pressure, main steam pressure and bed temperature control are taken into account for controlling. When subjected to an external disturbance, the controller adjusts itself in such a way that it eliminates the external disturbance completely and quickly.

L. Sivakumar et al. (2016) considered CHR method and ZN methods for the calculation of controller parameters in the main steam pressure control for worst load condition and significant change in the calorific value of the coal. Hence during fuel switching and load disturbances, the use of controller parameters are demonstrated. R. Rivas-Perez et al. (2014) proposed a fractional order PI (FPI) controller which yield a third order with time delay model for controlling steam pressure in the drum. The fractional PI controller performed well with wide variation of change in calorific value of the fuel.
Pal Szentannai (2011) proposed a control structure for the combustion control and it has been estimated as a function of cost called target function. The control strategy is a conventional controller. It has two control variables namely the primary and the secondary air. The process variable to be controlled has been designed as gradient estimator block. The load signal was a controller block again. The model has computational time less than that of the simulation time and more accurate than the conventional system.

MUSMAR predictive adaptive controller presented by R.N. Silva (2000) showed reduction in fluctuations of steam temperature when compared with a cascade PI controller. Han et al. (2004) described Fuzzy adaptive predictive functional control and this control has been presented for Super-heater temperature control. Liu & Chan (2006) studied the importance of reliable control of superheated steam temperature. A nonlinear neuro-fuzzy based generalized predictive controller (NFGPC) has been studied in the paper. NFGPC yields better results when compared to the cascade PI controller.

Super-heater temperature control with drum pressure, steam enthalpy, heat supplied by flue gas, steam flow rate and attemperator spray flow as inputs and steam outlet temperature as output has been modelled by S.Samyuktha and P.Kanagasabapathy (2008). Fuzzy based model with three different techniques has been used to optimize the model and the results were found to match with that of the original transfer function model.

For super heater steam temperature control, cascade controllers, fuzzy controller, state variable controller (SVC), neural networks, neuro-fuzzy controllers were employed and a comparative study has been made by the authors A. Renga Reddy et al. (2002). Based on the work suggested by them,
for process whose physics are unknown and complicated neural network based modelling and control is preferred. If the load variations are small for base load units, SVC is preferred. Generally a cascade control particularly PI-PID is preferred the most.

A neural network based model has been obtained by Jan Dimon Bendtsen and Ole Sorensen (1999) for attemperator valve and this has been used as a state observer and parameter estimator and a pole placement controller was designed and the results show that the results are better than linear observer.

An intelligent control of steam temperature and water level has been elaborated by Wei Wang et al. (2002). Hybrid intelligent controls of steam temperature have fuzzy expert systems with PID. Over-ride control has been used for primary spraying and fuzzy-PI with gain scheduling for secondary spray processing. For water level control, multi variable fuzzy controller and intelligent co-ordinator has been used. This high level supervision improves the performance of the system.

Soft computing methods are being used to control the input and output variables. Genetic algorithm is widely used for optimizing the system parameters and it has been well described by many authors like S.V.Wong (1999), H. Ishibuchi et al. (1995).

A.Chaibakhsh et al. (2007) developed a parametric model based on the physical and thermo-dynamical laws. The model parameters are obtained and tuning and optimization of model parameters was done using Genetic algorithm. This model, when validated with the actual plant yield
very good response and accurate results. The model is effective during start-up and shut-down operations.

MPC using gain scheduling and linearization was developed by Jean Thomas (2014) and it yields stable and fast electric power load tracking, increased plant efficiency, increased components lifetime and comply safety and environmental constraints. Levine, William S (1999) proposed a Ricatti controller which provides a better solution when compared to pole placement method. It is a robust controller since it attains infinite marginal gain and offers a phase margin $\delta \geq 60^\circ$..

G.Thenmozhi et al. (2016) considered fuzzy logic for the realisation of Re-heater steam temperature control. A comparison was made between simple P, PI, PID, cascade controllers and fuzzy controller and the performance parameters were studied. Fuzzy controller showed a lower settling time and no overshoot.

Internal model control, an effective control strategy was first proposed by Morari and Zafiriou (1989). Decentralized IMC control strategy was given by Hovd et al. (1993) and 1994. IMC based PID controller for Super-heater steam pressure control was used by Zhao Kun-long and Wang Zai-ying (2015).

Linear Parameter Varying (LPV) model is often considered when it is required to operate at various working points and is described by Jiangyin Huang (2010). Under varying steam load, the boiler shows non-linearity and hence linear parameter varying model is considered which yields better accurate results when compared to the other methods. Similarly study shows
that a LPV model along with MPC controller performed well when compared with that of a linear model with MPC controller.

As developed by P. Ponnusamy, L. Sivakumar and S. V. Sankaran (1983), the low order model transfer functions of the various subsystems are obtained using system identification technique and based on these transfer functions, the control of various system and sub-systems are being done in the subsequent chapters.

As suggested by the authors, it becomes necessary to obtain a system with better performance. In order to investigate the performance of the 210W CFBC boiler, the mathematical modelling of boiler components are done. The main components of CFBC boiler unit are

1. Drum and its associated components
2. Furnace, Cyclone separator and a return leg for recirculation of particles
3. Super heaters and Re-heaters and Fluidized Bed heat exchangers

The layout of CFBC boiler is shown below. The entire CFBC boiler unit is divided into five circuits namely

1. Coal and air flow path
2. Feed water and steam flow path
3. Flue gas flow path
4. Solid particles flow path
5. Ash disposal path

The furnace is made up of water – cooled tubes. Provision for supplying Coal, primary air, secondary air, limestone and removal of ash are
provided as shown in the Figure 1.2. Limestone is fed into the furnace in order to reduce emissions. Coal in the fluidized form is carried away into the furnace through primary air and secondary at proper stochiometric ratio. Coal is burnt in the lower part of the furnace and the fine solid particles are suspended above the bed. Heat produced is transmitted to the upper part of the furnace through convection and radiation which in turn heats up the water tubes surrounded all along the furnace.

In the water circuit, water from condenser is pumped to the boiler drum and it passes through HP heaters, control valve and economizer. Water is converted into steam due to the heat absorbed from the furnace and heat exchangers like evaporator. The steam gets collected in the drum through the upriser tubes. The water in the tubes get heated up and hence a two phase mixture of water and steam is present in the upriser and down comer tubes.

The steam thus collected in the drum is superheated through low temperature super-heater (LTSH), Fluidized bed heat exchanger super-heater I (FBHE SH-I), super-heater II (FBHE SH-II) and Final super-heater (FSH). From FSH, the main steam passes through the throttle valve to High Pressure Turbine (HPT), it expands and it is reheated again in RH1 and RH2 and gets condensed through Intermediate Pressure Turbine (IPT) and Low Pressure Turbine (LPT).
Flue gases produced in the furnace pass through a series of superheaters and re-heaters. The flue gas from the furnace passes through the back pass, air pre-heaters and then to the chimney through electrostatic precipitators. The final Super-heater, Re-heater-I, LTSH and economizer are there in the back pass. From the LTSH, it passes to the air pre-heater. The flue gases are blown out by ID fan through electrostatic precipitator. The blown out flue gases pass away through the chimney.

Some of the solid particles which are left unburnt in the furnace are carried away by the flue gas. These solid particles are re-circulated to the furnace through two cyclone separators with loop seal arrangement, four
fluidized bed heat exchangers are available, two on each side of the cyclone separator.

Ash is collected at the bottom of the bed and it is removed through the opening provided at the bottom of the furnace.

Several authors have described different controllers for controlling the outputs of the boiler. Though literatures with simulation results show that advanced controllers improve the performance of the system, PID controllers are still used in the thermal power stations because of ease of control and various other reasons. Hence the study of the performance of PID controllers as applied to boiler components/sub-systems becomes necessary. Also a comparison of PID controller over the other controller is important while controlling the outputs. The next important factor is the stability studies. The effect of stability on the system is studied. Based on the literature survey and the system description of 210MW CFBC boiler, the following work progress is followed.

- Mathematical modeling of different systems using first principles approach
- Simulation of each system using MATLAB-SIMULINK software and obtaining their performance parameters with reduced peak overshoots without disturbing the stability of the system.
- Further the study also facilitates how the different controllers like PID, fuzzy logic, neural network controllers, linear parameter varying model etc. could be applied towards the control of CFBC boilers.
- A comparative study of the system with different controller configurations.
• Determination of a suitable controller for the specific component or the system

1.3 ORGANIZATION OF THE THESIS

The work being done and reported is given in the subsequent chapters and is briefed below. The Thesis has been compiled into five chapters. The first chapter of the thesis includes the introduction, literature survey and the description of the components involved in the research work of 210MW CFBC boiler. The mathematical modelling of systems / sub-systems like circulation system, Super-heaters, Re-heaters, Furnace and attemperators of CFBC boilers comprise the chapter two.

Chapter three discusses the design and evaluation of different control algorithms and the realization of different controllers. The application of these control algorithms to different components /systems under study is made. The realization of these controllers subjected to the different algorithms led to the determination of the performance parameters. A comparison is made between the different controllers and is elaborated in this section. Linear Parameter Varying (LPV) model for the sub systems are also discussed along with the first principle’s model. Application of controllers like P, PI, PID, P-PID, PI-PID, fuzzy, hybrid and neural controllers to different systems is made and selection of a suitable controller based on the process dynamics is presented here in chapter four. Simulation results of the above said controllers are also elaborately discussed. Further advanced controllers like neural controller algorithms are also presented here. The conclusion and the future scope of improvement of the research work has been consolidated and reported in Chapter five.
1.4 MOTIVATION, OBJECTIVE AND PROBLEM IDENTIFICATION

Performance And Diagnostic Optimization (PADO) is a major area in the power plants. In order to optimize and diagnose, mathematical modelling is done. Modelling and Simulation has been done using Matlab. During normal and abnormal situations, the plant has to be controlled and analyzed. Different control schemes to meet the required performance criteria as desired by the plant owners and operators, has to be done by Control and System Engineers. Hence a study on the different controllers has been done at the beginning of this research work and the applications of these controllers to various other components are being done.

In this thesis, a 210MW Circulating Fluidized Bed Combustion Boiler (CFBC) unit has been considered for the study. Modelling and Control of CFBC boiler has been done and an attempt is made to study the performance of system to analog PID controllers and different controllers.

Different analog controller configurations like P, PI, PID are employed in the various thermal power stations for controlling the critical process parameters. Cascade controllers, fuzzy controllers, neuro controllers and hybrid controllers (PID and fuzzy) are being employed for tuning the process parameters. These controllers are conventionally tuned at 100% load. Depending on the load parameters and the non-linearity of the process, further improvements have been made by changing gain and other parameters. Hence the necessity of modelling and control as applied to 210MW Circulating Fluidized Bed Combustion Boiler is made and simulations are done to obtain better performance of system in such a way that the stability of the system
remains unaffected. Application of these smart techniques to the control system and their response to the system is studied.

1.5 SUMMARY

This chapter gives an overview about the introduction, need and literature survey related to the design and control of CFBC boilers. Further the layout, components / sub systems involved in the research work of 210MW are elaborated.