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Combustion Chamber of Boiler to Generate Tornado Effect

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ABSTRACT

Introducing modern boiler concepts in the design of thermal power stations is nowadays becoming mandatory, not only from an economic point of view of new investments, but also as a significant and pro-active step towards the reduction of greenhouse gases & dust emissions by the enhancement of efficiency.The current work introduces a model design of combustion chamber of boiler which works on the principle of tornado effect most of which is formed from a thunderstorm. Tornado is violent, rotating column of air extending from a thunderstorm to the ground. For creating tornado, warm moist air and cool dry air is required. When these two air masses meet, they create instability in the environment. A change in wind direction and increase in wind speed and increasing height creates a horizontal spinning effect in the lower atmosphere. In the similar way, a flame is created in the combustion chamber. The flame is rotated with the help of primary motor and as the air is given to the chamber mixing of hot air and cold air occurs and due to the rotation, the flame moves upwards like a tornado. The main objective of the paper is to propose a design a novel combustion chamber of a boiler utilizing tornado-like vortex flow.

Keywords : Tornado, Combustion Chamber, Thunderstorm

I. INTRODUCTION

Increase in energy consumption has led human beings to discover many kinds of energy conversion technologies. One of the promising and highly applicable technology is conventional industrial style boiler. Over the course of history, boilers have improved with changing metal working technology, fuel availability, and increase in combustion and heat transfer technology. The challenge that all boiler manufacturers face is in utilizing their experience and current technology to produce boilers that have an advantage for the different processes to which they will be applied.

The main objective of this paper is to describe the to design advanced utility boiler reflecting the usage of tornado effect in industrial style boiler. At the heart of any boiler design is overall boiler efficiency. A good boiler design must consider several parameters and, at the same time, maintain a good overall efficiency.
The model basically consists of four sections, burner, combustion chamber, saturator/ superheater, and chimney (exhaust). In our proposed work, the combustion system consists of low NOx Burners, Over Burner Air (OBA) and Over Fire Air (OFA). In addition, a tangential firing technique has been developed using circular burners with air staging. By inclusion of OFA this system supports in-furnace air staging resulting in further reduced NOx formation.

AIR STAGING:

Air Staging is a key feature in burner design. It builds upon a principle of sequential combustion which basically means applying enough air in each stratum

to make the combustion stable, but not enough to allow nitrogen to be oxidized to NO or NO2. The main parameters governing NOx formation is local gas temperature and composition which are kept under control through Air Staging.

In our boiler design the combustion air is controlled to form a stratified mixing of fuel and air. The result is stretched flames and combustion zones where simultaneous high temperature and high Air Fuel Ratio (AFR) are avoided. The required air staging and swirl of tornado thus generated depends on many factors such as load, fuel composition and burner level. The purpose of the tornado is to control and ensure a homogeneous and optimal air-fuel mixture in the stratum. It also serves to control the penetration of the flame into the furnace. A high swirl leads to a short flame and an internal recirculation zone.

II. LITERATURE SURVEY

M. A. Waheed et al. [1], The laboratory steam boiler designed was projected from the conceptual physical geometry of fire-tube boiler which elucidated the primary units making up a boiler. Thermodynamics, heat transfer and strength of materials analysis subjected to temperature and pressure variations were conducted in the theoretical framework of the laboratory fire-tube steam boiler. Dimensions of major and secondary parts were estimated from computations from the theoretical framework and 3D modelling process for the steam boiler was then carried out to present various working drawings of the steam boiler for possible construction. Conclusively, a simple laboratory fire tube steam boiler is herein presented for fabrication, testing and further improvement. Production of a simple steam boiler of this sort will enable the availability of portable and affordable steam boilers for steam generation processes, especially in school laboratories.

F.J. Gutiérrez et al. [2], A complete dynamic model of a full-scale fire-tube boiler has been developed based on the mass, energy, and momentum balances together with constitutional equations. Two parts are distinguished in fire-tube boilers: the fire/gas side and the water/ steam side. A first nonlinear physical model has been presented and after reduced to shorten the computational time, but providing reasonable results. The boiler start-up has been also considered. Thus, it may allow to simulate the process as well as to design a multivariable controller. Simulation is useful both for training and assisting in on-line decisions. A case study has been simulated using an 800 HP fire-tube boiler and dynamic performances predicted by the model are in good qualitative agreement with data taken from the literature. The proposed modelling may be used as an effective way of undertaking a comparison between the fire-tube boiler performances when running with different fuels, especially when considering the firing of a new fuel in given equipment.

N. Samaras et al. [3], Simulation and optimization results of a 300 MW lignite-fired power plant were presented. To reduce the computational time needed the creation of the modules in gPROMS FO (Foreign Objects) for the calculations of thermodynamic and heat transfer properties of the fluids was important. Use of the FOs, reduced the number of variables to 10,906 from 375,630, the number of equations from 333,983 to 10,667 and the number of the parameters of the model. After satisfactory simulating the complete plant we optimized its operation to improve the efficiency while maintaining the same electrical power production. The results showed an absolute improvement of 0.55% of the overall thermal efficiency which is important for plants of that size since the resulting benefits were lower fuel consumption. (2.06% reduction which means 11.5 t/h less lignite), and lower flue gas emissions (2.06%reduction which means 4.8 t/h less CO2). That reduction results to lower penalty fees for

environmental pollution This work could lead to the creation of a decision tool for the control room of the unit where the model, using real time data, will allow the engineer in charge to make instant.

P. Kumar et al. [4], Pressure vessels are always works under certain pressure and temperature along with contain sometime lethal substances which are hazardous for both human and environment. Considering this, safety implications and hazards arising from the operation of pressure vessels, there is an obvious need to standardize engineering and fabrication practices. To assure minimum safety standards, several design codes have prepared and developed. Design of pressure vessel can be finished quickly by applying numerous calculations in software. The drawing process was simpler associated to the software. This study only investigated a part of parameters design. There are other parameters that are not considered such as thermal loads, wind loads, seismic load, transportation load, erection load and fabrication methods etc. however this insufficiency can be overcome by mastering software. Mechanical design of pressure vessel had been done using graphical based software. Drawing process was very easy and input can be entered in the same screen. The result fully complied with standard code and had been employed on practical design of pressure vessel.

P. Negi et al. [5], Boiler provides the major source in industries to burn fuel to generate process steam and electric power. It is the main device of power plant to generate steam by efficiently burning available fuels used to generation of power. There are mainly two types of boiler, water tube boiler and fire tube boiler. Water tube boiler are those types in which water flows inside the boiler tube and flue gases flows outside to heat up the water to generate steam. Most industrial purpose uses water tube boiler as it is more efficient than fire tube boiler. Today the main concern is to increase the efficiency of water tube boiler by enhancing the heat transfer rate in the boiler tube. Due to economic and environment demand, engineers must continuously focus on improving the efficiency of the boiler and reducing emission. wide variety of engineering situations, including heat exchangers for viscous liquids in chemical process and food industry. In real condition the boiler water tube is plane walled, due to this the flow inside the tube is laminar. Many studies have focused on turbulent flow, the laminar range is of interest in a review of corrugated geometry of boiler tubes, heat transfer studies for different geometries and other various designs are carried out. The researcher's designs going to the integration between the geometry and flow through the tube to reduce heat loss and system costs

J. Ganan et al. [6], In general, thermal power installations emit various polluting matter to the atmosphere that contribute to the greenhouse effect and the deterioration of the environment. The main pollutants emitted to the atmosphere in this equipment are Carbon monoxide (CO), Hydrocarbon (HC), Nitrogen Oxides (NOx), Carbon dioxide (CO2) and Sulphur Oxide (SO2). Due to the high contamination of these gases, environmental agencies impose some maximum emission levels. The emission of pollutants has its origin in the resulting gases of the combustion process. Three fundamental elements can be found in this process: fuel, comburent and activation energy. In this study the evaluation of the optimum operation conditions for two three-stage peritubular boilers, connected in parallel and using gasoil C is developed. This trade-off defines a maximum of the efficiency in the range of the boiler, in view of Eq. (2) the increase in the losses for sensible heat in the exhaust fumes have minor influence on the boiler efficiency than the decrease of the losses for unburned gases in the exhaust fumes. The efficiency of the boiler is obtained as a function of the losses qA and qi, by using the TESTO model 300 M-I analyser whose probe was placed at the exit of the boiler.

R.G. Hocker et.al [7]: - Dye penetrant indications on the heat-affected zone of 2014-T6 aluminium weldments have caused many rejections of production assemblies. An investigation of this problem has revealed that a large majority of these indicated defects were superficial in that they were less than 0.007 in. deep. Tests were conducted to determine the cause and nature of the surface defects. Procedures were developed to eliminate or minimize the occurrence of dye penetrant indications, and to discriminate between real weld defects and superficial surface defects. Also, procedures were developed for repairing weldments containing dye penetrant indications.

N.B. Yahia et.al. [8]: - Radiography is a method of evaluation and non-destructive control. Given the relevance of radiographic inspection of many different areas of industries, there has been numerous research projects aimed at automating the analysis and the interpretation of welding discontinuities. In this work, the automatic control and inspection of welding defects is made by edge detection method of radiographic images, based essentially on the use of a Multilayer Perceptron (MPC). This paper describes an origin method to detect welding defects existing in the weld radiography based in the use of the artificial neural networks, aim the classification and the increase of the successful recognition default percentage. Therefore, this work is done in four steps: the first step consists in the preparation of the database to be used later in the second step for training MPC. The next step is done in two main parts; the first part is devoted to the detection of contours, then the second section consists in the elimination of additional contours. Finally, it concludes with on real cases study.

III. PROPOSED WORK

The design of the boiler is divided into 3 sub sections: fuel hopper design, combustion chamber design and the tornado/cyclone design. The combustion chamber of the boiler is designed by taking the standardized combustion process with excess air of 20%. When the fuel and air enter the combustion chamber, it burns due to high velocity and temperature and then temperature increase rapidly in the combustor. Air contributes to a controlled expansion in the tornado section of the burner where it reacts with the unburned fuel from the centre reaction to complete the combustion process.

The study of combustion chamber design and entry of air into combustion chamber is shown in Figure. 1. It shows a slotted chamber with angle of 40-50 degree. It depicts combustion chamber attached to flame and fuel injection system. To obtain flame, the air enters the combustion chamber tangentially at 40-50-degree angle. Due to the centrifugal force the fuel injector moves upwards axially and anticlockwise.

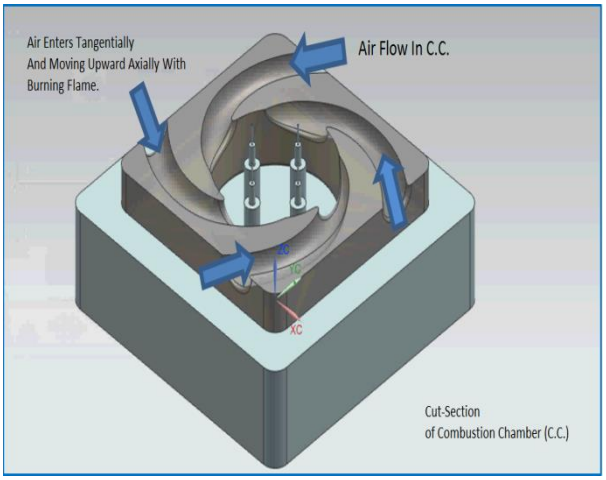

Figure 1. Cut Section of Combustion Chamber

Flame tornado is produced because of upward mobility of air. The gyration of tornado is basically dependent on earth rotation direction. Earth rotation is anti-clockwise direction so all tornado/cyclones on earth tornado/cyclones on earth are moving in anti-clockwise direction. Figure 2 demonstrates one of such flame tornado.

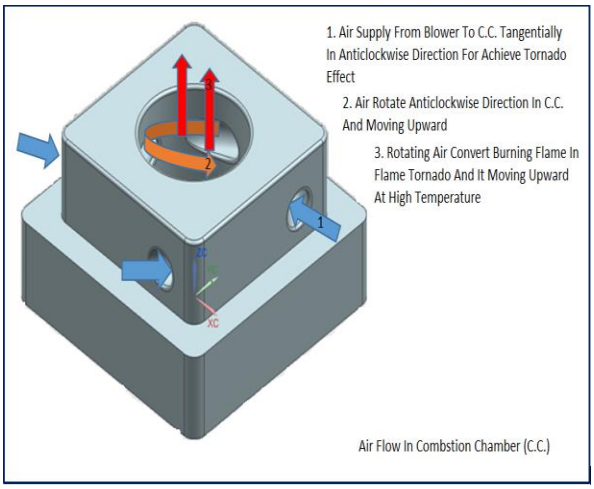

Figure 2. Air Flow in Combustion Chamber

IV CONCLUSION

Tornado effect have will be a valuable process in the design of boilers for many special applications. The advantages of this type of combustion chamber that it allows the user to include larger steam storage and steam height resulting in higher steam quality and rapid load swing handling ability. Also, it allows the designer to have a lower overall pressure drop with a boiler efficiency that is still over 81%. Hence, the objective of designing a combustion chamber of boiler by utilizing tornado effect in the of bed combustion chamber has been successfully establishes the objective.

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