

Modeling and Simulation of Steam Generator by using CFD Analysis

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ABSTRACT: This paper reports the steam generator produces the steam for rotating the turbine and the boilers are many types but in this paper we are using the water tube boiler that is lateral drum convention generator to produce high rate of steam with the help flue gases water is converted into steam. The performance of steam power plant mainly depends on the operating pressure and temperature. With higher operating pressure and temperature we can get the higher efficiency, but that is up to certain limit, which depends on the steam generator layout and structure. In this paper we have designed the steam generator test rig in CAD software called Cero elements, this model is imported to FloEFD, computational fluid dynamics software which is in a part of CERO elements and the test was done according to literature.

KEYWORDS: steam generator test rig in CAD software, computational fluid dynamics software.

I. INTRODUCTION

This paper presents a summary of research into the design and analysis of Steam generator. The Steam generators are often called as boilers. It forms an essential part of any power plant. A steam generator is a form of low water-content boiler, similar to a flash steam boiler. The usual construction is as a spiral coil of water-tube, arranged as a single, or mono tube, coil. Circulation is once-through and pumped under pressure, as a forced-circulation boiler. The narrow-tube construction, without any large-diameter drums or tanks, means that they are safe from the effects of explosion, even if worked at high pressures. The pump flow rate is adjustable, according to the quantity of steam required at that time.

Literature reports several attempts to design a steam generator. It is used to observe the variation of pressure, temperature and density. The purpose of this paper is to use open-source CFD software to simulate pressure loss and heat transfer in a heat exchanger and validate the simulation with an actual experimental results from the literature. Different solvers and turbulence models are used to try to determine the most accurate CFD method for predicting pressure loss and heat transfer in this type of compact fin-and-tube heat exchanger. CFD analyses carried out in the various industries are used in R&D and manufacture of aircraft, combustion engines, as well as many other industrial products.

Computational Fluid Dynamics (CFD) provides a qualitative (and sometimes even quantitative) prediction of fluid flows by means of Mathematical modelling (partial differential equations) Numerical methods (discretization and solution techniques) Software tools (solvers, pre- and post processing utilities) FLUENT is a computational fluid dynamics (CFD) software package to simulate fluid flow problems. There is a variety of commercial CFD software available such as Fluent, Ansys CFX, ACE, as well as a wide range of suitable hardware and associated costs, depending on the complexity of the mesh and size of the calculations FLUENT exports CFD's data to third-party post-processors and visualization tools such as Insights, Field view and Tech Plot as well as to VRML formats.. POLYFLOW (And FIDAP) are also used in a wide range of fields, with emphasis on the materials processing industries.

Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provides the user with input-tools for the purpose of

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streamlining design processes; drafting, documentation, and manufacturing processes.. Cero is a scalable, interoperable suite of product design software that delivers fast time to value. It helps teams create, analyse, view and leverage product designs downstream utilizing 2D CAD, 3D CAD, parametric & direct modelling.

II. LITERATURE REVIEW

Literature reports extensive experimental and simulation studies on process design and analysis of steam generator. Experimental research work is focused on obtaining process parameters to achieve the steam generator performance by using various simulation process such as Computer-aided design (CAD), Cero, FLUENT and CFD. In CFD simulations of single phase flow mixing in a steam generator (SG) during a station blackout severe accident, one is faced with the problem of representing the thousands of SG U-tubes. A. Dehbi and H. Badreddine [1] proposed CFD prediction of mixing in a steam generator mock-up: Comparison between full geometry and porous medium approaches. Investigate the adequacy of this approach by performing a series of simulations. Xinyu Wei et.al [2] developed Primary fluid optimization in once-through steam generator. Bi-channel flow brings difficulties in optimizing the flow distribution ratio of the primary water (FDRP), and affects the heat transfer and flow characteristics the theoretical analysis and analytical results show that our proposed method can be used in engineering practice for optimizing the primary flow. Falah Alobaid et.al [3] developed Fast start-up analyses for Benson heat recovery steam generator. An entire simulation model is developed to investigate the influence of fast gas turbine start-up (within 20 min) on the dynamic behaviour of a Benson heat recovery steam generator. Xinyu Wei et.al [4] developed Inner tube optimization of double-tube once-through steam generator. Sanaz Naemi et.al [5] carried out Optimum design of dual pressure heat recovery steam generator using non-dimensional parameters based on thermodynamic and thermo economic approaches. Emmanuelle Martelli et.al [6] proposed Numerical optimization of steam cycles and steam generators designs for coal to FT plants. Dipak k. sarkar [7] developed gas turbine and heat recovery steam generator. Antonio Rovira et.al [8] proposed a model to predict the behaviour at part load operation of once-through heat recovery steam generators working with water at supercritical pressure. Lei Chen et.al [9] proposed Multi-objective optimal design of vertical natural circulation steam generator.

Falah Alobaid et.al [10] presented Numerical and experimental study of a heat recovery steam generator during start-up procedure. Jianli Hao et.al [11] presented Scaling modeling analysis of flow instability in U-tubes of steam generator under natural circulation. Joshua Tanner Olson et.al [12] presented Tube and shell side coupled thermal analysis of an HTGR helical tube once through steam generator using porous media method. Hongcui Feng et.al [13] reported Thermodynamic performance analysis and algorithm model of multi-pressure heat recovery steam generators (HRSG) based on heat exchangers layout. Xinyu Wei et.al [14] has developed Study on the Structure Optimization and the Operation Scheme Design of a Double-Tube Once-Through Steam Generator. D. Markusn et.al [15] presented a numerical investigation of combined wave-current loads on tidal stream generators. Ryszard Bartnik [16] developed Selection of the Structure of the Heat Recovery Steam Generator for the Repowered Power Unit. Itsik Mantin [17] presented Predicting and Distinguishing Attacks on RC4 Key stream Generator. D.A. Karrasa and V. Zorkadisb [18] reported on neural network techniques in the secure management of communication systems through improving and quality assessing pseudorandom stream generators.

III. MODELING OF STREAM GENERATOR

Modeling is the scientific way to study quality of performance of the objective. Input Data of Steam Generator are Outer chamber dimensions: 5mm Thickness, Tube dimensions: inner diameter 20mm, thickness 2.5mm, Fluid chamber: Diameter 100mm, thickness 5mm, length 500mm Analysis input data are Fluids used: air, water, Material of solid: stainless steel, Inlet mass flow of water 0.001kg/s, at atmospheric conditions, Fire (air) mass flow rate: 5kg/s. PTC Cero Parametric provides the broadest range of powerful yet flexible 3D CAD capabilities to accelerate the product development process. By automating tasks such as creating engineering drawings, we are able to avoid errors and save significant time. The software also lets us perform analysis, create renderings and animations, and optimize productivity across a full range of other mechanical design tasks, including a check for how well our design conforms to best practices. PTC Cero Parametric enables us to design higher-quality products faster and allows us to communicate more efficiently with manufacturing, suppliers

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This paper uses CFD for analysis of flow and heat transfer (not for analysis of chemical reactions). Some examples of application areas are: aerodynamic lift and drag (i.e. airplanes or windmill wings), power plant combustion, chemical processes, heating/ventilation, and even biomedical engineering (simulating blood flow through arteries and veins). Simulations of quantitative prediction of flow phenomena using CFD software at a limited number of points and time instants, for a limited range of problems and operating conditions, with high resolution in space and time, for virtually any problem and realistic operating conditions, Error sources: modeling, discrete- tin, iteration, implementation It provides the flexibility to change design parameters without the expense of hardware changes. It therefore costs less than laboratory or field experiments, allowing engineers to try more alternative designs than would be feasible otherwise. It has a faster turnaround time than experiments

1 Tube

Tubes allows the passage of fluid from Inlet Chamber to Outlet chamber

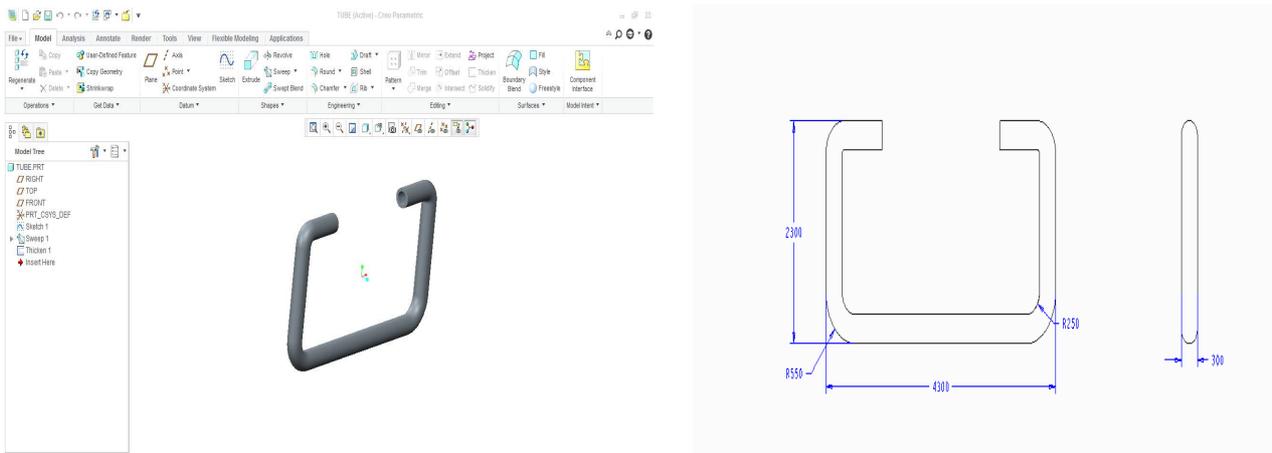


Fig.1 Tubes

2 Chamber

Heating chamber provides the necessary amount of Heat to make the liquid to steam. The heating chamber is also called here as furnace in which the fuel is burned to generate sufficient amount of heat.

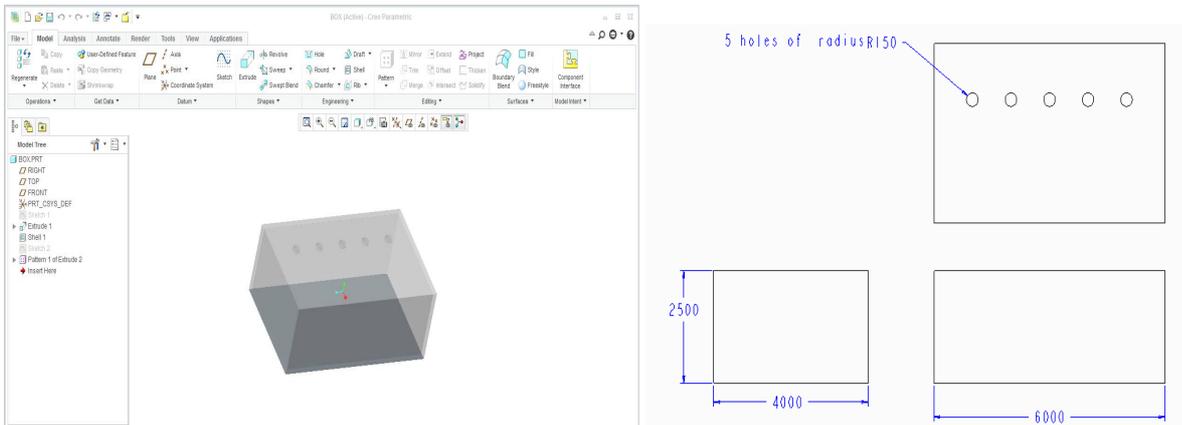


Fig.2 Chamber

3 Water Supply Chamber

Water supply chamber consists of two chambers. One is Inlet chamber and the other one is outlet chamber. Both the chambers are placed side by side; to facilitate the easy flow of liquid converted as a steam, from inlet chamber to outlet chamber.

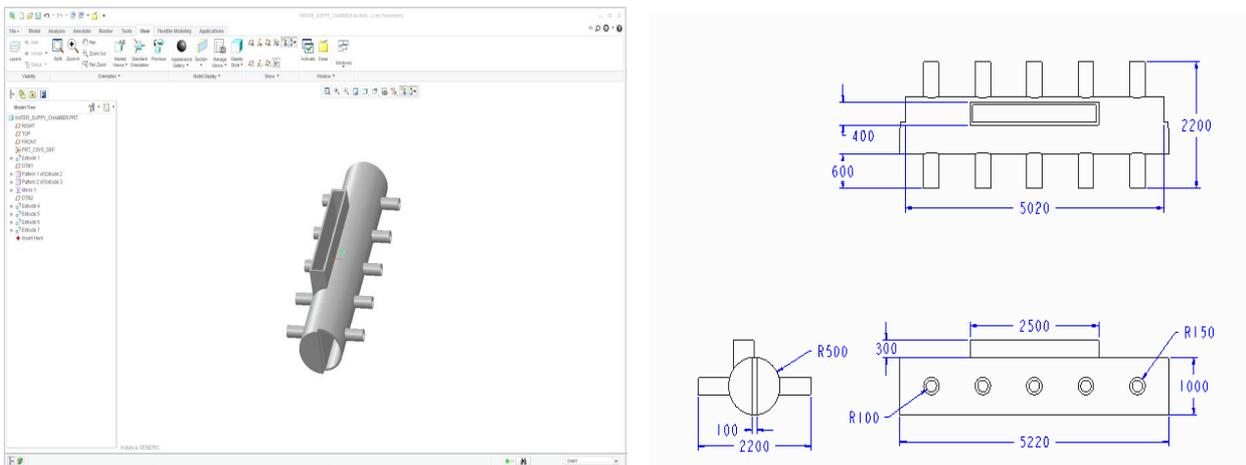


Fig.3 Water Supply Chamber

4 Assembly of Steam Generator Equipment

The below Image represent t, the complete test rig of Steam generator equipment. Cold water enters through Inlet Chamber at ambient pressure. Then It enters to the boiling chamber horizontally at the centre of the chamber. Water is boiled and steam is generated within the chamber. This steam will move upward to the chamber due to density variation and passes out through the pipes located on the upper surface of the chamber. The steam then passes through the outlet chamber, which is from there fed to the end use

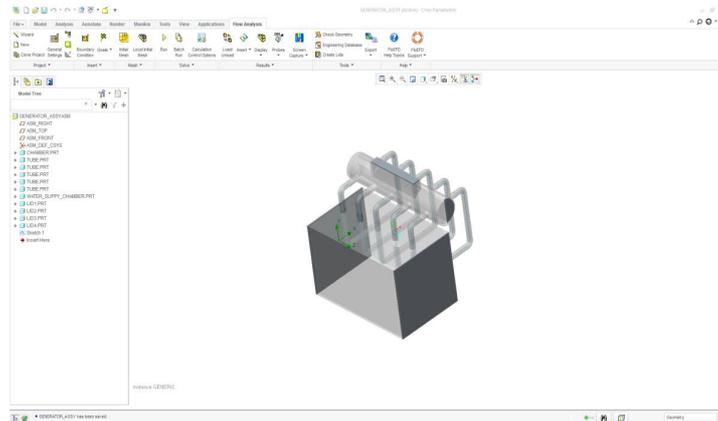


Fig.4 Assembly of Steam Generator Equipment

IV. RESULTS AND DISCUSSIONS

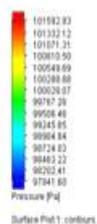
Various high-performance alloys and super alloys have been used for steam generator tubing, including type 316 stainless steel, Alloy 400, Alloy 600MA (mill annealed), Alloy 600TT (thermally treated), Alloy 690TT, and Alloy 800Mod

1 Input Data of Steam Generator

Outer chamber dimensions: 5mm thickness, Tube dimensions: inner diameter 20mm, thickness 2.5mm, Fluid chamber: Diameter 100mm, thickness 5mm, length 500mm. Analysis input data are Fluids used: air, water, Material of solid: stainless steel, Inlet mass flow of water 0.001kg/s, at atmospheric conditions, Fire (air) mass flow rate: 5kg/s. Boundary Conditions are Out Side Temperature: 26 °C, Out Side pressure: Ambient Pressure (1 Bar), Heat Input 500 °C

2 Pressures

Below figure shows the pressure variation within the steam generator. Pressure scale is indicated in the figure to show the value of the pressure within the steam generator



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A Graph at the centreline of each pipe is drawn to trace out the pressure variation from the inlet to outlet. This graph shows maximum pressure when the fluid is passing through the heating chamber region indicating the gain in energy

3 Temperatures

The figure indicates the temperature distribution in the steam generator. The input temperature is 500°C and Inlet water temperature is 41.2 °C. This colour graph represents temperature at every point in the chamber. As represented the green colour area indicated the temperature range between 200 to 300 °C, which is above boiling point. The water entering is converted to steam with the built test setup

The above graph represents the temperature variation of fluid inside the steam generator. The graph is drawn by the values traced along the centreline of the pipe. The graph show that the temperature is changing along the line and it is more near the exit of the heating chamber acquiring maximum energy. The maximum temperature attained within the steam is 244.3 °C.

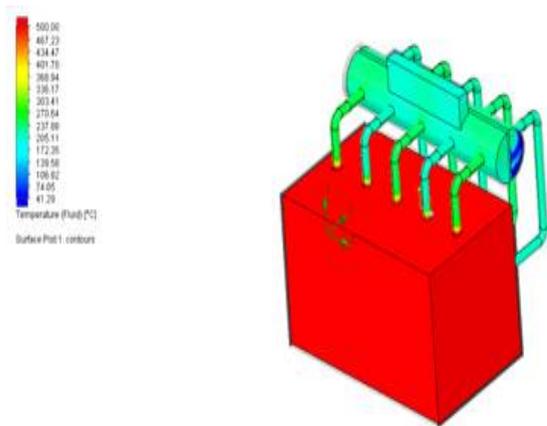


Fig.7 Temperature variation of the fluid in the test rig.

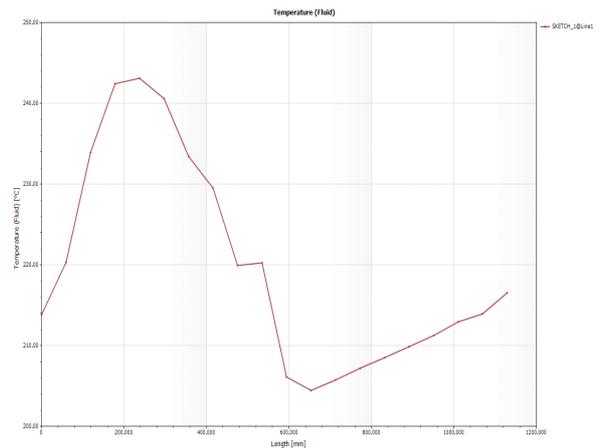


Fig.8 Temperature variation of fluid along the centreline

4 Densities

The Density of the fluid changes with respect to temperature. As it acquires heat the density will drop. The blow colour graph shows the highest density region at the inlet chamber. While passing through the pipe line due to temperature variation the density had changed and the reached a point of 810.3kg /m3.

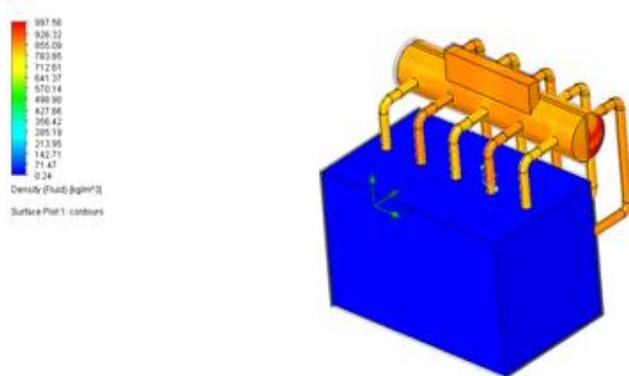


Fig .9 Density variation of the fluid in the test rig

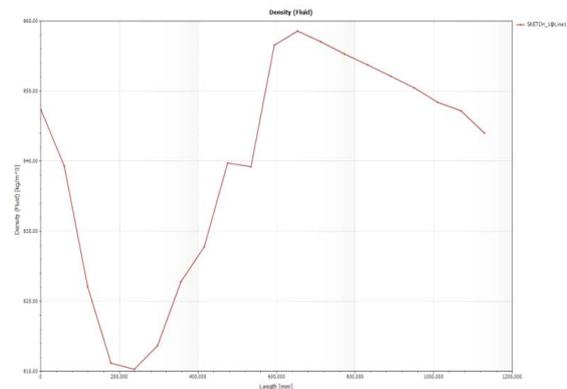


Fig.10 Density variation of the fluid in the test rig

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The variation in the temperature is shown in the colour plot is represented in a graphical for shown below when the water enters in to system the density 847.2 kg/ m³ and it is converted into steam and leaving the system density is 810.3kg/m³.

VI. CONCLUSION

The performance of steam power plant mainly depends on the operating pressure and temperature. With higher operating pressure and temperature we can get the higher efficiency. But that is up to certain limit, which depends on the steam generator layout and structure in this paper we have designed the steam generator test rig in CAD software called Cero elements. This model is imported to FloEFD, computational fluid dynamics software which is in a part of CERO elements and the test was done giving the following conditions. Heat input=500°C, Inlet water temperature=41.2°C, Inlet pressure=1 bar, Flue gas temperature=500°C, Water of viscosity=0.0091 poise. From the results it is observed that the outlet temperature is 244.3°C which is within the limits And the pressure drop in the system is 0.21 bar which are in good agreement with literature

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