Thermal Analysis of Closed Feed Water Heaters in Nuclear Power Plants

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Abstract:Wet steam extraction from turbine is included into thermal analysis of closed-feed water heaters (piped into heater). This model may be used to nuclear power plant diagnostics if steam passing through steam turbine is moist. Current calculations for feed water heaters assume that mass flows and/or enthalpy rates of steam bled from turbine are fixed values for establishing stage moisture removal efficacy. Using our approach, various problems may be detected, even if erroneous data were previously recorded in control room. There's no need for an on-site inspection, which is a big plus for BWR power plants where feedwater heaters are located in regions with significant radiation doses, such as reactor cores.

Keywords: Closed feed water heater, Nuclear Powerplant, FEM, ANSYS

I. INTRODUCTION

A steam turbine is a mechanical device that transforms rotating motion created by pressurised steam into thermal energy. Sir Charles Parsons designed current sign in 1884.

• Turbine in which steam strikes cutting edges and makes them turn.

• An arrangement of calculated and formed cutting edges orchestrated on a rotor through which steam is passed to produce rotational vitality. Today, ordinarily utilized as a part of power stations

• A gadget for changing over vitality of high-pressure steam (delivered in a boiler) into mechanical power which can then be utilized to produce power.

• Equipment unit flown through by steam, used to change over the vitality of the steam into rotational vitality.

A machine for producing mechanical power in rotating movement from the vitality of steam at temperature and pressure over that of an accessible sink. By a wide margin the most broadly utilized and most powerful turbines are those determined by steam. Until the 1960s basically all steam utilized as a part of turbine cycles was brought up in boilers consuming fossil fills (coal, oil, and gas) or, in minor amounts, certain waste items. Nonetheless, present day turbine innovation incorporates atomic steam plants and also creation of steam supplies from different sources.
The representation demonstrates a little, basic mechanical-drive turbine of a couple horsepower. It delineates the basic parts for all steam turbines paying little respect to rating or intricacy:
(1) A packaging, or shell, generally partitioned at the level focus line, with the parts darted together for simplicity of get together and dismantling; it contains the stationary edge framework;
(2) A rotor conveying the moving pails (sharp edges or vanes) either on wheels or drums, with bearing diaries on the closures of the rotor;
(3) An arrangement of heading connected to the packaging to bolster the pole;
(4) A senator and valve framework for managing the speed and power of the turbine by controlling the steam stream, and an oil framework for oil of the direction and, on everything except the littlest machines, for working the control valves by a transfer framework associated with the representative;
(5) A coupling to interface with the determined machine;
(6) pipe associations with the steam supply at the delta and to a fumes framework at the outlet of the packaging or shell.

Steam turbines are perfect prime movers for driving machines requiring rotational mechanical information power. They can convey consistent or variable speed and are prepared to do close speed control. Drive applications incorporate centrifugal pumps, compressors, send propellers, and, most critical, electric generators.

Fig 1: Steam Turbines Basics

Closed Feed water Heaters

m is separated from water in a closed buttress water radiator, and heat is transferred from steam to water without mixing. Radiator's tubes carry heated water, and resulting steam condenses on radiator's shell's outside. Condensation heat is transferred to water supply through tubes dividers, which in turn heats water supply. It's at this stage that condensate enters next lower-pressure warmer. This reduces amount of steam needed by warmer to some extent. No vapours are allowed to pass through trap. It's possible to catch some of dribble from most low-pressure warmer and transfer it to condenser, but this would be a waste of cooling water vigour. Trickle pump feeds dribble directly into sustain water stream to avoid this waste. Regardless of number of heaters, a closed-radiator system needs just one pump to provide necessary water flow. It is more costly to use closed radiators, and they may not be able to maintain same level of water temperature as open ones. Most steam power plants prefer to use closed radiators, although at least one open warmer is used to help de-aerate water. De-aerator is name given to open warmer in such a system.A bolster water warmer is a heat exchanger that uses steam condensate from a steam turbine to preheat boiler nourish water. Due to tubes and channels encasing tube side liquid, condensate does not mix with condensate as it happens with exposed nourish water warmers, as is case with these radiators. As convection and condensation rather than burning processes are used to exchange heat inside vessel, they are unfired.

In order to heat boiler feedwater, a feedwater warmer uses a heat exchanger to collect steam emitted by a steam turbine and use it to heat the water. When steam from turbine is separated or seeped, it is blended with feedwater from pump in an open feedwater warmer. In a closed feedwater radiator, drained steam is sent to feedwater without any mixing taking place. As a regenerative technique, extraction of steam from turbine is described. P ower plant's thermodynamic cycle would be incomplete without feedwater heaters. There are a plethora of feedwater warming stages that occur on a regular basis. Feedwater heaters allow temperature of working liquid to be gradually increased. Thermodynamic efficiency of a turbine cycle is enhanced as a result of this reduction in the irreversibility of warm exchange. This reduces operating costs and prevents boilers from being subjected to high temperatures. A mount of warm energy needed to warm feedwater decreases in direct proportion to magnitude of extraction arrangements. R educed rate of vitality loss to ground as a consequence of feedwater radiators removal of energy is a positive side effect.

Feedwater heaters rely mostly on waste heat from plant to lower amount of heat needed for plant. In addition, it reduces boiler's size while increasing overall plant efficiency. Standard shell and tube heaters have a slew of parallel tubes nestled within a shell. One liquid flows through a series of tubes, while another, of varying temperatures, flows over shell but remains outside of tubes in order to exchange heat via tube dividers. Separators of tube prevent two liquids from mixing.Because of this design, countless are utilized to expand the warmth exchange range and exchange warm proficiently. In a word, it is a proficient approach to utilize squander warm to save vitality.

From a proficiency point of view, the essential methods for enhancing the operation of such warmth exchangers is to keep up their operational adequacy. The proficiency of the steam control plant can be additionally expanded by expanding the surface territory of feed water warmer tube. In any case, the expenses related with either expanding the warmth exchange surfaces of existing radiators, or including extra warmers for proficiency purposes just is restrictive because of the little incremental diminishments in warm rate that would be acquired.

In the present work, the low pressure closed feed water heater comprising condensing section is modeled and simulated for analysis of feed water heater. A thorough search of the current literature revealed that there were no previous studies on optimizing the feed water heater efficiency by increasing the inlet temperature. Indigenous finite element analysis (FEA) has been carried out for optimizing the operating parameters of the feed water heater tubes in steam power plants and the results are discussed.

II. LITERATURE REVIEW

Vishwanath .H.,et al study's One of most confusing classes of weight containers is steam generator. It has a plethora of extras because of time period's strict steam quality requirements. One of primary functions of a mechanical steam generator is to create steam at required weight temperature and quantity for process businesses such as sugar, paper, jute, and substance endeavours, which is referred to as medium weight (MP) or low weight (LP). Steam from super absorption is used in food sector to produce LP and MP steam. One of steam generator's adornments is disassembled in current piece, Air Preheater. Increasing overall productivity of fossil fuel-fired power plants is an important goal for air preheaters. Recuperative primary air preheater with in-line tube plan of action, a mix of liquid progression evaluation by speculative esteem was proposed in this study. Model allows for transfer of heat from vent gas to air preheater, as well as transfer of heat from preheater tubing to surrounding environment. A CFD (Computational Fluid Dynamics) study of recuperative air preheater at Mysore Paper Mills (MPM) Bhadravathi, India, has been completed. An increase in boiler efficiency of 2.7%

This analysis takes into consideration the heat exchange, temperature variation, speed of both pipe gas and air, and heat flux. Confusion is preventing pipe gas from flowing freely, and as a result, HX tubes are emitting an unprecedented amount of heat. We may then deduce that providing riddles will increase rate of warmth exchange. When optimal weight drop on air side of plant is seen, it shows installation of a medium-sized air blower, which consumes less energy, overall plant competence improves. Temperature of vital air would rise by roughly 60°C if suggested design was included into present facility. At that time, boiler's efficiency would increase by 2.7 percent, so reducing amount of coal it needs to produce heat.

K.Sivakumar,et.alconcentrate's Bagasse is often used as a fuel in sugar plants, supplemental air is given to allow bagasse to be consumed. Air is provided by a restricted draught fan and supplementary air is provided by a sail air fan. L imited draught fan sucks essential air into airpreheater and into furnace. In an airpreheater, exhaust gases from economizer are also utilised to warm outside air before it is sent to furnace. Aeration of moist air produces corrosion in airpreheater's metal tubes when it enters system. M ain goal of this project is to prevent cold end of airpreheater from corroding and to raise temperature of supplied air to furnace. Air temperature is raised above dew point temperature (65°C) in order to prevent rusting. Computational fluid dynamics is used to analyse wind stream from FD fan to furnace.

Analyzing air duct, it becomes clear that an inclined position is superior than a straight curve in terms of performance. Steam preheaters raise supply air temperature by 20 degrees Celsius while increasing combustion temperature by 1 percent and increasing efficiency by 3 percent.

Saravanan. S, et.alstudy's a thermal power plant is one that uses steam as its primary source of electricity. A steam turbine turns an electrical generator by turning heated water into steam. After turbine, steam is condensed and reused in a condenser at that point. Thermal efficiency ranges between 45% and 47%. As it enters turbine, steam is collected and used to heat surrounding space. Feed water heaters employ extracted steam as a source of heat. A cascade mechanism connects heaters. For high and low pressure heaters, cascading is different. In this way, high pressure heater drips are transferred to deaerator for further processing. There's an issue with this one. Deaerators lose a lot of heat because of this, which reduces turbine's efficiency. High-pressure heater waste heat may be transferred to low-pressure heaters by cascading, allowing for maximum use of waste heat. Turbine system will run more efficiently as a result of this. By studying pressure reduction desuperheating station near boiler, efficiency may be improved. More work turbine can accomplish, more efficient it will be, and regenerative mechanism will assist raise temperature of water being fed into turbine. Even a 0.5 percent gain in thermodynamic power cycles is significant.

By increasing the number the coils in the heaters the heat is recovered, so there is no additional supply of the heat By changing the flow of PRDS the efficiency of turbine is increased to 3%. So the complete thermal productivity of plant is increased. By this we came to know clearly that if the cascading system between the heaters is perfectly done, the efficiency of the turbine and the heater can be increased.And the waste heat is utilized properly in the heaters. And analyzing the PRDS flow at the turbine inlet will give better flow rate of steam and this will helps to increasecomplete thermal efficiency of plant.

Khub Chand Kushwaha, BhupendraKoshtistudy's m any utilities operate together in a power plant to satisfy ever-increasing demand for electricity in an efficient manner. Steam power plants experience several off-design circumstances. Because to low demand on power plant and lack of specific components, this may arise. O perational characteristics of design are altered as a result of these circumstances. This study explains how feed water heaters may operate outside of their intended parameters, resulting in a decrease in performance and efficacy. In addition, performance of feed water heater is examined in this research.

Mass flow rate of steam is inversely related to mass flow rate of feed water in fractional regions of de-superheating and condensing zone. In case of drain cooling, polar opposite is true. Distributions, however, seem to be unaffected by fluctuations in steam temperature. All off-design circumstances have a negligible effect on feed water's exit temperature. As mass flow rate of supply water or steam rises, so does heat transfer rate.

Ch.vijayakumar, Dhananjayakumar concentrate's Any country's progress is influenced by its capital's energy usage. Increasingly more people are becoming interested in control period on a large scale. Because of country's energy constraint, each power plant must be operated at its highest possible productivity level due to their major commitment to control creation. One of regenerative framework's feed water radiators, which helps plant's overall thermal efficiency. In today's world, each characteristic that directly or indirectly affects performance of a warmer has been researched. For example, bay temperature, saturation temperature, terminal tap distinction, depletion cool approach, and temperature rise are all regarded components. There are two HP radiators in Unit 1 VTPS that provide information for testing and calculations

On basis of techno-economic inquiry, number of radiators for most part used in 210 MW units ranges from 6 to 7, and therefore effectiveness increases by 5% to 6% roughly. Present power plant's heaters need to be operated and maintained at a higher level so that design and calculation values don't deviate significantly. In addition, it has been shown that heaters operate at 75-80% efficiency when operated and maintained in this manner.

III. OBJECTIVE

Shut feedwater heaters with wet steam being evacuated from steam turbine are analysed using a model . U sage of this model in nuclear power plant diagnostics is critical when fluid flowing over team turbine is wet steam.

- Modeling of closed feed water heater using UG software
- Static linear analysis of closed feed water heater using Ansys workbench
- Static bi linear analysis of closed water heater
- Static thermal analysis of closed water heater
- Life estimation of of closed water heater

IV. METHODOLOGY

- **Geometric Modeling:**Many of methods and ideas used here may be used to sets of any finite dimension, although forms explored here are mostly two- or three-dimensional.

- **Finite element Model:**After being imported and meshed in FE programme ANSYS, three-dimensional model built using CATIA or UG is then known as a Finite Element Model.

- **Suitable Boundary Conditions (sensitivity analysis):**Ansys is used to do sensitivity analysis on meshed model, which is subjected to specified boundary constraints.

Design Of Steam Preheater

Nothing more than a heat exchanger, steam preheater is. In this project, steam preheater is used to transmit steam's high temperature to surrounding air and raise temperature of surrounding air. Sugar mill has 400°C, 42 kg/cm2 pressure steam available. Turbine turns with help of this steam, which is then used to generate electricity. With a temperature of 200°C, pressure of 1.5 kg/cm2, steam exits turbine. For boiling house, part of this superheated steam will be used to heat atm air in steam preheater. Following aspect is generally always taken into account when designing a heat exchanger for a specific application. For corrosion prevention, air temperature is raised beyond dew point temperature.

A. STEAM REQUIREMENT

Steam inlet temp = 200°C
Steam pressure = 1.5kgf/cm^2
Mass flow rate = 0.833 kg/s
Specific heat capacity Cp = 4.4895 kJ/kg-K

B. AIR REQUIREMENT

Air inlet temp = 40°C
Mass flow rate = 15.11 kg/s
Volume of air = 13.4 m^3/s
Specific heat capacity Cp = 1.005 kJ/kg-K
Table I shows comparison between air and steam mass flow rate

C.AREA OF STEAM PREHEATER

Height of exchanger = 2150mm
Width of exchanger = 1390 mm
Diameter of tubes = 21.3 mm
Breath of exchanger = 1005 mm
Length of exchanger = 1.255 mm
Number of tubes = 168
To reach dew point, steam preheater uses 3 tonnes of steam mass per hour.

Boiler proficiency

Current operating pressure of steam in sugar mills is 42 kg/cm3 at 420ºC. If we raise pressure of steam, then power output grows mean while efficiency of boiler is rises. the existing water tube boiler has capacity of generating 64 tones of steam/hr. if we enhance steam output by modifying design, then also enhance boiler performance rise. In many of sugar mills bagasse is utilized as a principal fuel. Bagasse in India nearly have moisture content of approximately 50 percent (i.e) if we take 1 kilogram of bagasse then it has 0.5 kg of water in it. If we lower moisture content in bagasse by just boosting boiler efficiency. U sage of heat recovery device such as air preheater,economizer,superheateretc.will also boost boiler efficiency. In airpreheater air to boiler is heated by flue gas. So performance of boiler rises with employment of the air preheater. E fficiency of boiler is based upon efficiency of combustion and heat transport inside boiler. Boiler efficiency is determined via heat loss technique as
Boiler efficiency = 100 -- various losses

B.VARIOUS LOSSES

Dry flue gas loss = 5.27%
Fuel moisture = 14.47%
Hydrogen moisture loss = 8.33%
Air moisture loss = 0.27%
Unburnt carbon loss = 2.00%
Ash sensible heat loss = 0.01%
Radiation & convection loss = 0.55%
Total losses = 30.90%
Present boiler efficiency = 100 – total various loss
= 100 – 30.90
Boiler efficiency = 69.10%
After raising combustion temperature of air duct, boiler's efficiency improved.

1.Dry flue gas loss

$$= 100 \times [C\% + S\% - C \text{ in ash}] \times 30.6\ (T1 - T2) / 12\ (CO2 + CO)$$

Where
T1 is temperature of flue gases before air preheater
T2 is temperature of flue gases after air preheater
Dry flue gas loss = 1.94%

2. Hydrogen moisture loss

$$= 9 \times h\ \{1.2(T1 - 25) + 2.442 + 2.99(25 - T2)\}$$
= 15.10%

3. Fuel moisture loss

$$= \{1.2(T1 - 25) + 2.442 + 2.99(25 - T2)\}$$
= 9.43%

4. Moisture loss in air

= weight of flue gas x moisture in air x 2 (T1- T2)
= 1.02%

5. Heat loss in fly ash = 0.983%

6. Ash sensible heat loss = 0.01%

7. Radiation & convection loss = 0.55%

Total losses = 27.03%

Boiler proficiency = 100 – 27.03
= 72.97%

Boilers efficiency rises as temperature of combustion chamber rises.

TABLE I. PROCESS DESIGN DATA

Sr. No.	Parameters	Unit	Value
1	Tube side fluid flow rate	kg/sec	26.66
4	Shell side fluid flow rate	kg/sec	3.12
3	Tube side fluid inlet temperature	°C	115
4	Tube side fluid outlet temperature	°C	187
5	Shell side fluid inlet temperature	°C	343
6	Shell side fluid outlet temperature	°C	125
7	Tube side fluid inlet pressure	bar	16.7
8	Shell side fluid inlet pressure	bar	117.6
9	Tube side fluid inlet velocity	m/sec	1.6

TABLE II. GEOMETRIC DESIGN DATA

Sr. No.	Parameters	Unit	Value
1	Shell material	SA 516 GR 70	
2	Tube material	SA 556 GR A2	
3	Tube outside diameter	m	0.0158
4	Tube wall thickness	m	0.0016
5	Tube inside diameter	m	0.0126
6	Tube pitch	m	0.021
7	Tube layout	Triangular (60°)	

CATIA – MODELING

The CAD/CAM incorporated frameworks encountered a huge advancement as of late, making a nearby association between the two contiguous territories: productive design side – CAD, technological design side - CAM. CAD builds models of provided questions and generates handling, assembly data necessary by CAM unit in order to construct a virtual model.

While CAD-created model will be accurate in terms of geometry, customer must keep in mind that model must be similar to CAM handling on machine tools throughout its construction. In response to a geometric example on designer's drawing board, PC aided manufacturing was developed. PC-supported assembly begins with transfer of desired geometric model to PC using an application. This process may be achieved in a variety of ways, but perfect set-up hinges on a few key aspects. There are a variety of uses for a geometric model, including creating work drawings and subassemblies, checking or improving form using a restricted component figure software, and so on. For example, we may find out that all of numerous 3D geometric parameterized models offered by various companies (AutoCAD Inventor, SolidWorks, SolidEdge, CATIA, ProENGINEER, etc.) are based on 3D geometric parameterized models. Those that make use of geometric model might either be standalone applications or part of a larger framework.

CATIA V5 R19 is exhibited as an arrangement of workplaces (Workbenches) that can be enacted in succession to accomplish an arrangement of assignments. Along these lines we could abstain from working with a solitary interface excessively complex for most client errands. The PC-supported programming of CNC machine devices development programmefocuses on creation of piece-program starting with arrangement of operations to be done on test, using electronic PC framework for this change. Since advent of PC-assisted programming, numerous programming languages used on different PC platforms have seen advancements. Basically, they are an organization of geometric definitions that may cover level geometry (2D) and midway, space geometry (3D), as well as a second set of movement requests with which MUCN portable subassemblies can be developed. Genuine processing takes place in this section, which creates a dataset in a certain midway form. There are specific projects known as postprocessor or simulators that take data from halfway structures produced by processor itself and process it to create phrases as indicated by syntactic specificities of numerical control hardware, which are required to use these information to create programmes. An overview of a particular model may be used to create a tree structure that contains learning, or it can be more broad, such as computations or master frameworks. R eport's left tree structure allows you to choose work plan that will be used to create profile. As a result, chosen arrangement will be emphasised in a different colour scheme.

Modeling of hook

It's quite difficult to depict snare with any precision since there are still t o clarify any puzzling geometry, it is always necessary to arouse a few doubts. These presumptions are formed, taking into account difficulties involved in hypothetical count and relevance of parameters that are considered and those that are ignored. When putting on a show, it's easy to ignore details that don't matter as much or have a little impact on overall evaluation. Continually, hypotheses are generated based on what makes a good display and how precise it has to be.

ANSYS – MESHING AND ANALYSIS

MESHING

The components utilized for the meshing of the full and ventilated plate are tetrahedral three-dimensional components with nodes (iso-parametric). In this reproduction, the meshing was refined in the contact zone (circle cushion). This is critical in light of the fact that in this zone, the temperature differs altogether. Without a doubt, in this firmly disfigured zone, the Thermo mechanical inclinations are high. This is the reason a precise record of the contact conditions include the utilization of a refined work. Three cross sections have been tried naturally utilizing a choice called meeting in ANSYS Workbench Multi material science.

The objective of meshing in Workbench is to give strong, simple to utilize meshing apparatuses that will improve the work era prepare. It is necessary to break down model used into a small number of discrete parts, known as restricted components. A scientific net or "work" is needed to do a restricted component analysis since model is partitioned into numerous discrete sections.A limited component work display produced. The components utilized for the work of the model are tetrahedral three-dimensional components with 8 nodes.

Components are linked together at a restricted number of points called Nodes in structure, which is examined using a technique known as limited component analysis. These elements and nodes are then linked to stacking limit criteria. Mesh is name given to a collection of these parts. Only most time-consuming parts of a restricted component analysis are examined in depth. Creating nodes and components using a preprocessor gives user more flexibility over size and quantity of components. Different geometric substances may be used to map or generate various kinds of components. Component qualities that should be validated before doing a restricted component analysis for networks, contortion records, like, may be checked on components formed by various preprocessor-programmed component era capabilities. For most part, preprocessor's programmed work creation capabilities are used instead of just describing nodes. Assignments or deciphering of current nodes can be used to easily characterise nodes if necessary for any reason. Nodes can be plotted, erased, or sought as an additional option as well.

ANALYSIS-FINITE ELEMENT ANALYSIS (FEA)

Introduction to finite element method*:*

For a wide range of construction issues, restricted component method is a useful tool. Intricate shapes and geometries of any kind may be handled by method, regardless of material or stacking circumstances. With today's perplexing building frameworks or outlines where closed form arrangements of monitoring equilibrium circumstances are normally not accessible, broad remark about restricted component technique fits in with analysis prerequiste. As a result, creators may execute parametric plan ponders, taking into account several plan situations (such as distinct forms, materials, and loads), and then compare results to choose best outline. When avionics industry needed a method for worrying about baffling airframe structures, they developed this technology. It is derived from framework analysis approach, which was used as part of flying machine strategy. Both analysts and experts have become more familiar with concept. Limited component approach is based on premise that a body or structure may be broken down into smaller, more manageable parts known as "limited components." It is thus regarded that initial body, or structure, is a collection of these components linked together at a few points known as nodes or nodal focus.

THE PROCEDURAL STEPS IN FEM

- Modeling
- Account of Continuum
- Collection of appropriate interpolation model
- Origin of element stiffness matrix
- Collection of element equations to gain equilibrium equations
- Enforcing boundary condition
- Result of system equation to find nodal values of displacement
- Computation of element strains and stresses

Process for solving a static structural issue may be summarised in this way:

Step-1:- Modeling

Modeling is process of creating an object's geometry from a mathematical description that can be read by a computer. As CPU as well as input devices are used to execute different software instructions, this mathematical model serves to show a picture of item created and controlled.

Step 2:- **Explanation of continuum (Structure).**

The first step in finite component approach is to divide structure of arranging location into sub-components or divisions.

Step 3:- **Choice of proper interpolation model**

We expect a suitable component arrangement, within a component, to accurately predict uprooting (field variable) layout of a mind-boggling structure under any predefined load circumstances. A greed-upon structure must be fundamental and must meet specific convergence requirements.

Step 4:- **Derivation of element stiffness matrix**

A suitable Variation guideline or equilibrium circumstances may be used to deduce component's stiffness matrix [K(e)) and load vector [P(e)].

Step 5:- **Collectionof element equations to getequilibrium equations**.

Individual component stiffness networks and load vectors must be assembled in an acceptable manner to calculate overall equilibrium state of structure, which is made up of a few finite components..

$[K]\varphi = P$

Where [K] is called amassed stiffness matrix,

Φ is known as vector of nodal displacement

P is vector or nodal drive for total structure.

Step-6:Applyingboundary conditions

Because of this, it is impossible to solve these equations without substituting boundary conditions. When a body or structure has a border or impact, displacement may be described in geometry boundary conditions.

Step 7:- **Solution of system equation to find nodal values of displacement**

General equilibrium conditions must be altered to represent limit states of issue. After joining of limit conditions, thee equilibrium conditions can be communicated as,

$[K]\varphi = P$

For straight issues, vector "φ" can be fathomed effortlessly. In any case, for non-direct issues, procedure must be acquired in a grouping of steps, each progression with alteration of stiffness matrix [K] and "φ" or the load vector P.

Step 8:- Component strain and stress calculations. If necessary, component strains and stresses may be calculated from known nodal displacements using fundamental conditions of solid mechanics or auxiliary mechanics. Well-ordered generic FEM approach is illustrated in portions in aforementioned steps.

Convergence requirement:

For a seemingly intractable problem, finite component technique provides a numerical solution. It may be expected that layout should focus on structure's proper specification. When a result, as job improves, arrangement should align with correct conclusion, which would be achieved if acceptable displacement task met preceding three requirements. Component's internal displacement must remain constant. It is possible to meet this requirement by using polynomials for displacement model.The displacement work must be equipped for speaking to inflexible body displacement of the component. This is the point at which the hubs are given such displacement relating to an inflexible body movement; the component ought not understanding and subsequently prompts zero nodal strengths. Consistent terms in polynomials utilized for displacement models would more often than not guarantee this condition. The displacement work must be equipped for speaking to consistent strain states inside the component. The explanation behind the necessity can be comprehended on the off chance that we envision condition when body or structure is separated into littler and littler components. As components become smaller and smaller, strain in each one becomes more and more uniform. Polynomials' direct expressions for elasticity in one, two, and three dimensions meet requirement.Be that as it may, in consistent shape rather than steady strains.

Linear Static Analysis

It is simplest as well as most generally used type of analysis

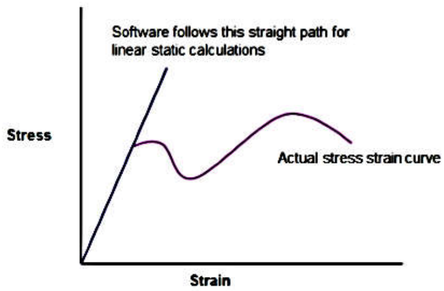

Fig2 : Linear Static Approach

Linear means straight line. $\sigma = €E$ is the condition of straight line (y = mx+c) going over origin. 'E', Inclination of bend is measured by Young's modulus, which is a constant value. After reaching yield point, material follows a nonlinear curve, while programming follows same straight path. F inal tension of junction causes segment to split into two distinct pieces, although programming-based analysis does not show any problems with this design.

Single unbroken section with red colouring at location of disappointment is shown in this image. To determine whether section is bomb or not, investigators must compare maximum stress esteem and final stress.

For static analysis, there are two requirements:

No difference of force with respect to time (Dead weight)

Equilibrium condition - ∑ Force = 0 and ∑Moments = 0.

As a result, peak linear stress and strain of dead frontal axle may be determined using this approach.

Bilinear Kinematic Hardening

Hardening:

Several yield criteria are dependent on loading history and development of plastic strain in order to be applicable to a given material. H ardening rule describes how loading affects yield criterion's change in hardness. Further loading from a condition on yield surface increases yield stress, resulting in an increase in plastic strain for a material that is plastically deforming due to hardening.

Isotropic and kinematic hardening are two of most frequent hardening rules. Modeling materials under monotonic loading and elastic unloading is possible using an isotropic kind of toughness. But this sort of hardening is generally ineffective for structures that suffer plastic deformation following reverse of a material's elastic state.

Metals undergo cyclic loading, which causes kinematic hardening. Bauschinger effect, in which compressive yield strength decreases in response to tensile yielding, may be modelled using this method.

Plastic ratcheting, accumulation of plastic strain under cyclic loading, may also be modelled using this technique.

Due to cyclic loads and a constant yielding surface cross section on frontal axle considered dead, Bilinear Kinematic Hardening technique is used for analysis.

Kinematic Hardening:

Kinematic hardening affects yield stress during plastic deformation. Plastic deformation generates a rise in tensile yield stress and a reduction in compressive yield stress under uniaxial tension. Bauschinger effect and plastic ratcheting may be modelled using this sort of hardening, which can be applied to both monotonic and cyclic loading.

The yield criterion has the form $F(\sigma') - \sigma y = 0$

Where $F(\sigma')$ is a scalar function of relative stress σ' and σy is yield stress.

Relative stress is, $\sigma' = \sigma - \alpha$

When plastic deformation occurs, yield surface's location in stress space changes, and thereby shifts backstress.

Kinematic Hardening:

In order for bilinear kinematic solidifying to be successful, bilinear tensor for backstress has to progress.

This line of stress and strain is described by client's digression modulus ET. Underlying slope of bend is material's elastic modulus, which causes plastic strain to grow and provides back stress.

In order for this diffusion modulus to be significant, it must not be less than zero or more than elastic modulus, which it is. E lastic range is always 20 for uniaxial strain followed by uniaxial pressure, since compressive yield stress decreases in magnitude as tensile yield stress increases.

For dead frontal axle model, commercial FE packages will supply yield stress, tangent modulus, and young's modulus to determine real stress and strain. You will get a mix of elastic and plastic strain from this procedure.

Neuber's Rule:

Kt is geometric mean of stress and strain focus components (K and K€) for a kaleidoscopic body with an irregular non-linear bend in stress-strain curve, according to Neuber.

This is stated as follows:

$$K_{\sigma}K_{\in} = K\tau^{2}$$

Where,

Kσ = actual stress concentration factor

K€ = actual strain concentration factor

Kt = stress concentration factor for a linear elastic material

Stress concentration factor, Kσ is ratio of notch root stress and net-section nominal stress.

$$K_{\sigma} = \frac{\sigma}{s}$$

Strain concentration factor, K€ is ratio of notch root strain, net-section nominal strain e.

$$K_{\varepsilon} = \frac{\varepsilon}{e}$$

Hence, Neuber's rule is re-written as:

$$\sigma_{\varepsilon} = K_{t}^{2}\,Se$$

This is often re-written in terms of stress and strain ranges for scenario when stress range far from notch is linear elastic:

$$\Delta\sigma\Delta\varepsilon = \frac{(\mathrm{K_t}\Delta\mathrm{S})^{2}}{\mathrm{E}}$$

The frame introduced in the above condition is generally utilized as a part of fatigue life computations utilizing the linear static method. There is a clear correlation between a material's elastic modulus and its stress and strain extents.

In this way, This rule will be used to linear static analysis results in order to obtain real stress and strain levels. It will be compared to Bilinear Kinematic Hardening method's output to see whether results are comparable. For example, a connection between two approaches will lead to discovery of a correction criterion that reduces entire design cycle for component.The graphical representation of Neuber’s rule is as per the following figure

Fig 3: 3d modal of feed water heater

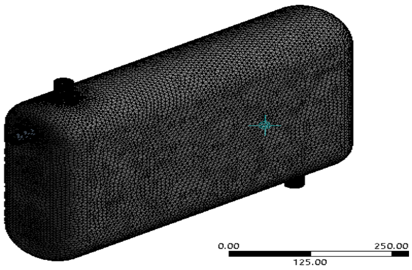

Fig 4: meshing of modal of feed water heater

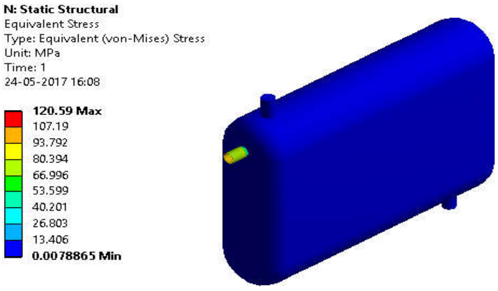

Fig 5 :max equivalent stress is 120.5 mpa in feed water heater

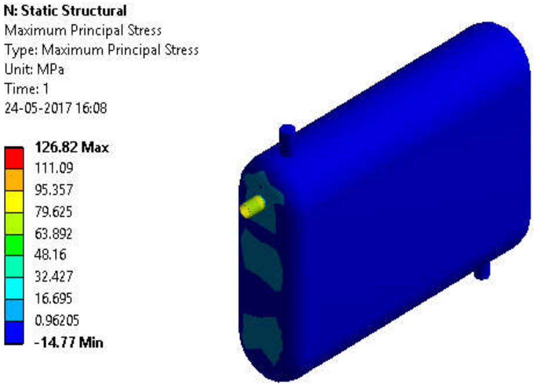

Fig 6 :max maximum principal stress is 126.82 mpa in feed water heater

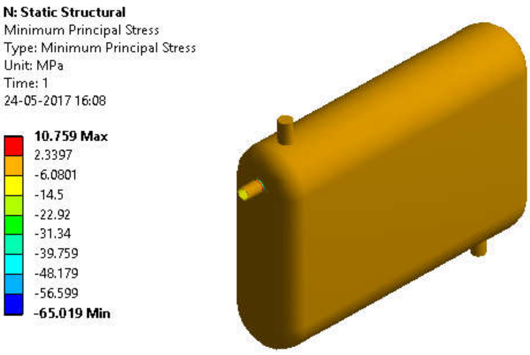

Fig 7 :Max minimum Principal stress is 10.756 mpa in feed water heater

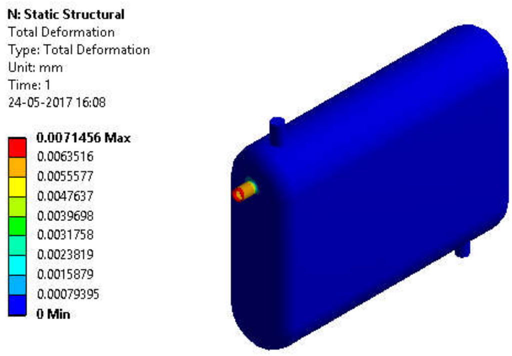

Fig 8 : max total deformation is 0.0071456 in feed water heater

Thermal analysis

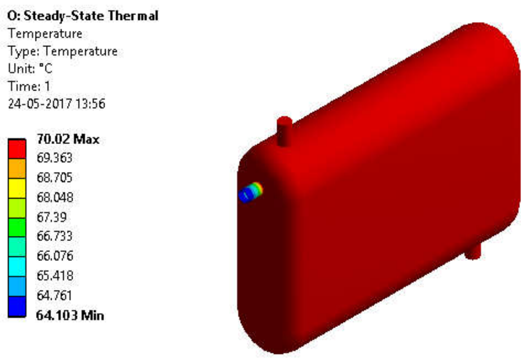

Fig 9: max temperature is 70.02 °Cin feed water heater

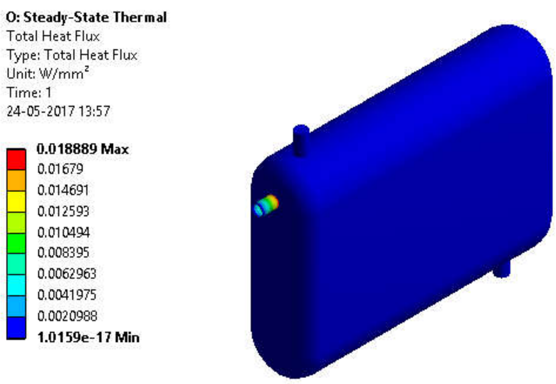

Fig 10: total heat flux is 0.0188 in feed water heater

Life estimation

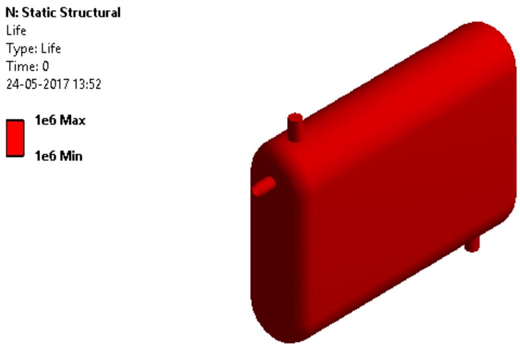

Fig 11: life estimation is 100000 cycles is feed water heater

Goodman diagram

Mean Stress can be calculated from,

$$\sigma_{mean} = \frac{\sigma_{von}}{2}$$

=330.5mpa

Where

σ_{von} = Equivalent von-Misses Stress

$$\sigma_a = \frac{\sigma_1 - \sigma_2}{2}$$

=140.965 mpa

Where

σ_1= Maximum Principal Stress

σ_2= Minimum Principal Stress

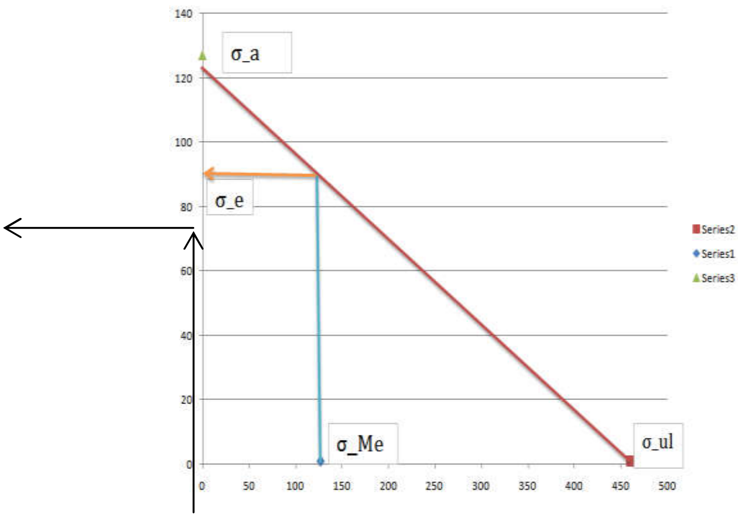

Fig 12: Goodman Diagram

Number of cycles:

$$N_f = \left\{\frac{[\sigma_{ult} - \sigma_{ult}(\frac{1}{fos} - \frac{\sigma_a}{\sigma_e})]}{\sigma_a}\right\}^{\frac{1}{0.08}}$$

Where,

N_f =Fatigue life

σ_{ult}=Ultimate stress

fos=Factor of Safety

σ_e=Endurance limit

b = Fatigue strength exponent

σ_a=Alternating stress

$$N_f = \left\{\frac{580 - 580(\frac{1}{1.4} - \frac{122}{79})]}{122}\right\}^{\frac{1}{0.08}}$$

$$N_f = 1.01 \times 10^6$$

V. CONCLUSION

An air duct with an angled position has better performance than one with a straight curve, according to research. At same time, steam preheater raises temperature of supply air by 20°C, and combustion temperature rises by 1% and efficiency increases by 3%.

1. Maximum stress, strain, and deformation of a closed-feed water heater have been determined using a linear static structural analysis. Along hook, a total deformation of 2.423 mm is observed to have a peak stress of 310.45 Mpa.
2. Fatigue life of crane hook was tested for 1000000 starting and shutdown cycles, and findings show that design has a fatigue life of over 100000 cycles.

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