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Design and Analysis of Bent Tube Lugs

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Abstract: In wealthy power stations lugs are hand me down on bent-tubes to transfer considerable loads from the boiler to the cutoff point structure. These lugs are of carbon hearten or alloy hearten material, The diameter of these lugs separate from 6mm to 20mm.The made a pig of carried so from 100kg to 20MT.The diamond in the rough of these lugs are done as by American community of technical engineers-boiler and charge vesselcode-section1(power boiler). The raw material involves checking the stresses in the lugs, welds and tube. These lugs are in a job at valuable temperature and are brave creep. As the cycle predate available for the boiler raw material and heart is shrinkage in the late years, standardization of boiler components are absorbed on priority. As a symbol of this, we are attempting to correlate the bent-tube vow lug, by the agency of a personal digital assistant program

Keywords: Design and analysis of bent tube lug

I. Introduction

Pressure Vessel

Pressure vessel are leak proof containers, it have the form of spheres cylinders, ellipsoids or some composites of these such composites are illustrated in the vessel shapes . in practice ,vessels are usually composed of complete pressure containing shell together with large rings and fastening devices for connecting and securing mating parts .as the name implies ,their main purpose is to contain a media under pressure and temperature .

However in doing so, they are subjected to action of steady and dynamics support loading, piping reactions, and thermal shocks which require an over all knowledge of the stress imposed by these conditions on various vessel shapes and appropriate design means to ensure safe and long life.

The principal loads to be considered in the design of pressure vessels are:

- design loads,
- dead loads,
- wind loads,
- earth quake loads,
- temperature loads,
- piping loads,
- impact loads.

The forces applied to a vessel or its structure attachments are referred to as loads. Many different combinations of the above loads are possible; we have to select the most probable combination of simultaneous loads for an economical and safe design.

Generally failures of pressure vessels can be traced to one of the following areas:

Material: improper selection for the service environment: defects, such as inclusions or laminations; inadequate control.

Design: incorrect design conditions; carelessly prepared engineering computations and specifications; over simplified design computations in the absence of available correct analytical solutions; inadequate shop testing.

Fabrication: improper or insufficient fabrication procedure; inadequate inspection; careless handling of special materials such as stainless steels.

Service: change of service conditions to more severe ones without adequate
Provisions; inexperienced maintenance personnel; inspection inadequate for corrosion.

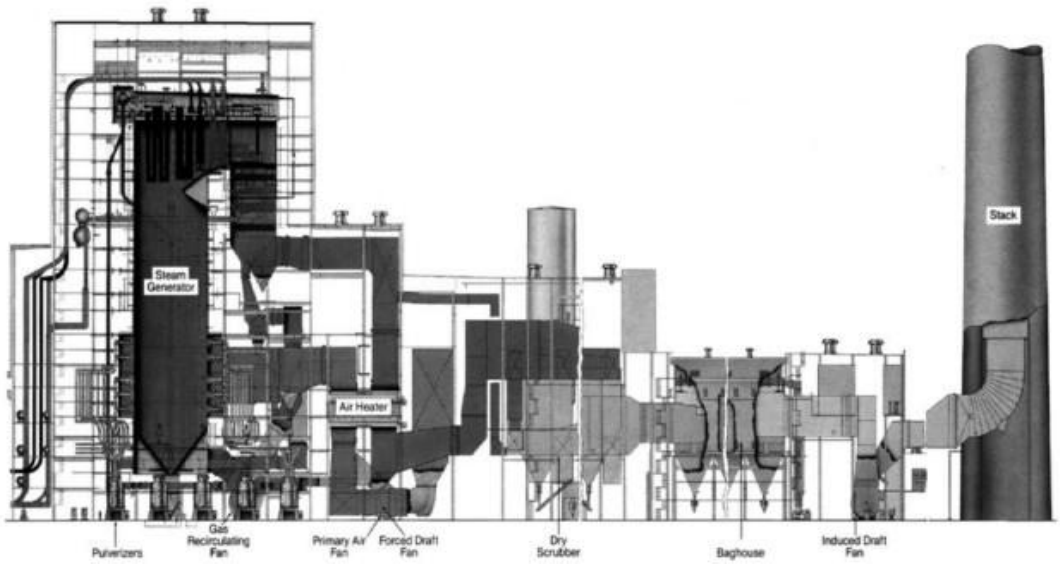
High Pressure Boiler

A boiler which generates steam at pressure greater than 80bar , a temperature of about 500°c ,producing steam more than 250tons per hour called high pressure boiler . by using high pressure boiler ,low grade fuels can burned easily .high pressure boilers are water tube boiler ,super critical boiler and uses pulverized coal firing.

Water tube boiler

A water-tube boiler is a type of boiler in which water circulates in tubes heated externally by the fire. Water-tube boilers are used for high-pressure boilers. Fuel is burned inside the furnace, creating hot gas which heats up water in the steam-generating tubes. In smaller boilers, additional generating tubes are separate in the furnace, while larger utility boilers rely on the water-filled tubes that make up the walls of the furnace to generate steam.

The heated water then rises into the steam drum. Here, saturated steam is drawn off the top of the drum. In some services, the steam will reenter the furnace in through a super heater in order to become superheated. Superheated steam is used in driving turbines. Since water droplets can severely damage turbine blades, steam is superheated to 730°F (390°C) or higher in order to ensure that there is no water entrained in the steam.



water tube boiler

Cool water at the bottom of the steam drum returns to the feed water drum via large-bore 'down comer tubes', where it helps pre-heat the feed water supply. to increase the economy of the boiler, the exhaust gasses are also used to pre-heat the air blown into the furnace and warm the feed water supply. Such water-tube boilers in thermal power station are also called steam generating units.

Super critical boilers

The increasing the fuel costs with decreasing fuel quality have constantly persuaded power engineers to search for more economical methods of power generation. the most recent method to produce economical thermal power is by the use of super critical steam cycle.

Between the working range of 125bar and 510° c to 300bar and 600°c ,a number of steam generation units are designed which are basically characterized as sub –critical and super critical . usually a sub-critical boiler consists of three distinct section as per –heater (economizer),evaporator and super heater is required .the constructural layouts of both types of boilers are otherwise practically identical.

With the recent experience gained in design and construction of super critical boilers, it has become a rule to use super critical boiler above 300mw capacity units.

Although, thermodynamically higher steam temperature and pressure are always desirable but the trend is altered due to availability of material and difficulties experienced in the turbine and condenser operations due to large volume.

Economizer:

Economizers are mechanical devices intended to reduce energy consumption and to perform a preheating a fluid. In simple terms, an economizer is a heat exchanger.

In boilers, economizers are act as a heat exchange devices that heat fluids, usually water. . They are a device fitted to a boiler which saves energy by using the exhaust gases from the boiler to preheat the cold water used to fill the feed water.

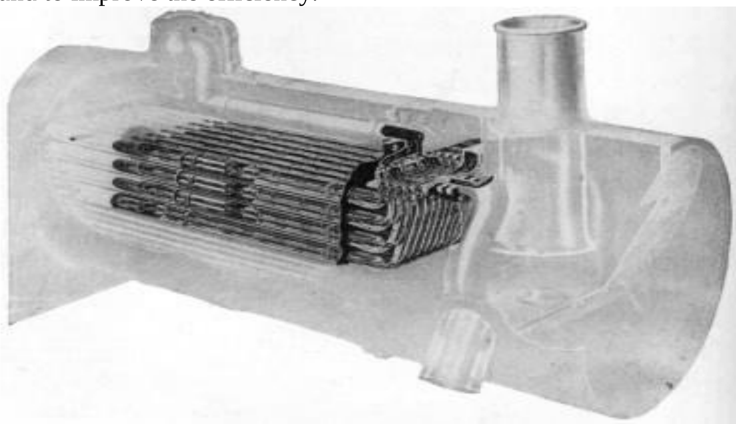
Modern-day boilers, such as those in coal-fired power stations, are still fitted with economizers which are descendants of Green's original design. they are often referred to as feed water heaters and heat the condensate from turbines before it is pumped to the boilers.

The economizer also prevents flooding of the boiler with liquid water that is too cold to be boiled given the flow rates and design of the boiler.

A common application of economizers in steam power plants is to capture the waste heat from boiler stack gases (flue gas) and transfer it to the boiler feed water . This raises the temperature of the boiler feed water. thus lowering the needed energy input, in turn reducing the firing rates to accomplish the rated boiler output.

Super Heater

The steam produced in the boiler is in the state of saturated condition . the moisture in the steam will effect the turbine blades and cause corrosion. To avoid this, the super heater is used. It is used to increase the temperature of steam and to improve the efficiency.



super heater

The super heater is composed of four basic stages,

- Pendant spaced section
- Platen section
- Rear horizontal section
- Steam cooled wall &roof section

The platen section is located directly above the furnace in front of the furnace arch. it absorbs heat mainly by radiation.

The pendant section is located behind the screen tubes. the pre dominant mode of heat transfer is convection.

The horizontal section of the super heater is located in the rear vertical gas path above the economizer. this is the primary super heater of the convective &counter flow type.

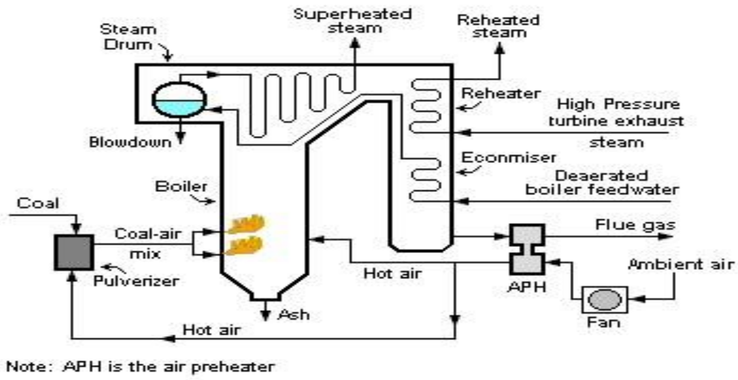
The steam cooled wall section form the side ,front and rear walls and roof of the vertical gas path.

Most boilers heat water until it boils, and then the steam is used at saturation temperature . super heated steam boilers boil the water and then further heat the steam in a super heater.

This provides steam at much higher temperature, but can decrease the overall thermal efficiency of the steam generating plant due to the fact that the higher steam temperature requires a higher flue gas exhaust temperature.

There may also be practical limitations in using "wet" steam, as causing condensation droplets will damage turbine blades. Superheated steam presents unique safety concerns because, if there is a leak in the steam piping, steam at such high pressure/temperature can cause serious, instantaneous harm to anyone entering its flow. Since the escaping steam will initially be completely superheated vapor, it is not easy to see the leak, although the intense heat and sound from such a leak clearly indicates its presence. So whether by convection or radiation the extreme heat in the boiler furnace/flue gas path will also heat the super heater steam piping and the steam within as well. It is important to note that while the temperature of the steam in the super heater is raised, the pressure of the steam is not the turbine or moving pistons offer a "continuously expanding space" and the pressure remains the same as that of the boiler. The process of superheating steam is most importantly designed to remove all droplets entrained in the steam to prevent damage to the turbine blading and associated piping.

Air Preheater



Air pre heater

An air preheater or air heater is a general term to describe any device designed to heat air before another process .The purpose of the air pre heater is to recover the heat from the boiler flue gas which increases the thermal efficiency of the boiler by reducing the useful heat lost in the flue gas. As a consequence, the flue gases are also sent to the flue gas stack or chimney at a lower temperature, allowing simplified design of the ducting and the flue gas stack. It also allows control over the temperature of gases leaving the stack to meet emissions regulations.

Bent Tube Lug

In any large power stations , lugs are used on bent- tubes to transfer huge loads from the boiler to the ceiling structure . These lugs are of carbon steel or alloy steel material .the thickness of these lugs vary from 6mm to 20mm .

The load carried is from 100kg to 20 metric tone .the design of these lugs are done as per American society of mechanical engineering (ASME) – boiler and pressure vessel code- section 11power boiler[3.14] the design involves checking the stresses in the lugs, welds and tubes.

These lugs are operating at high temperature and are subjected to creep. As the cycle time available for the boiler design &construction is reducing in the recent years, standardization of boiler components are taken up on priority.

As a part of this ,we are attends are taken up on priority . and we are attempting to standardize the bent – tube support lug in FEA using ANSYS.

Bent tube lug load calculations:

The following chapter depicts the manuals calculation of maximum stress occurring on the lug for the proposed configurations of bent tube lug and finite element analysis same to get clear in picture of stress distribution pattern along the lug using ANSYS .the analysis results are checked with the manual calculation to find out the level of accuracy in the computer aided analysis.

The loads of lug depends upon

- steel weight of the economizer
- water weight of the economizer
- steel
- weight of the super heater
- water weight of the super heater

The stress of lug depends upon

- due to tensile load
- due to compressive load
- due to internal pressure

Material Properties

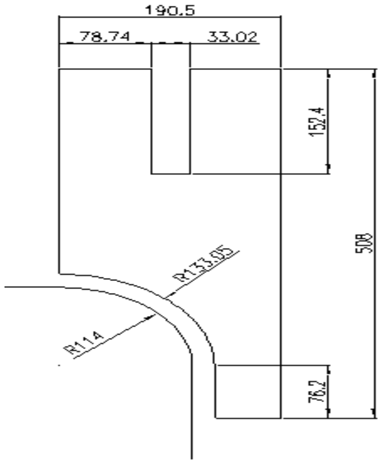
2.2.1 ALLOY STEEL CODE : SA 213 T22

Carbon (C) :	0.05 – 0.15
Manganese (Mn) :	0.30 – 0.60
Phosphorus (P) :	0.025
Sulphur (S) :	0.025
Silicon (Si) :	0.5 - Max
Chromium (Cr) :	1.9 – 2.60
Molybdenum (Mo) :	0.87 – 1.13

Welding Specifications

Welding Rod Material :	Alloy Steel Rod
Welding Rod (Type) :	E 9018 B3

2.4 Design of Bent Tube Lug



Bent tube lug

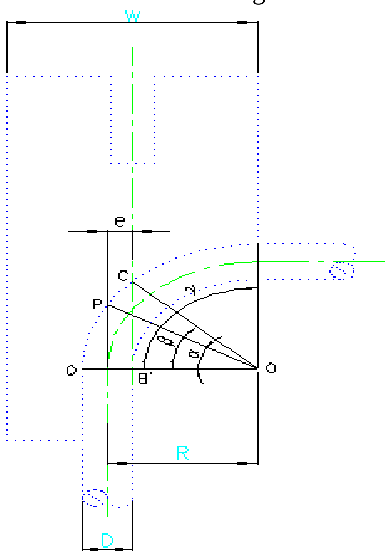


Figure 2.4.2 Bent tube angle details

Ansys

The ansys is a computer program for finite element analysis and design . this program is used to find out how a design (e.g machine components) works under operating conditions .in fact ,it is also used to find out the proper design provided the operating conditions are known. ANSYS program was introduced

By Dr.john Swanson and Swanson analysis system, inc (SASI) IN 1970. ANSYS program is a general purpose program meaning that we can use it for almost any type of finite element analysis virtually in any industry.

General purpose also refers to the fact that the program can be used in all disciplines of engineering – mechanical, electrical, electromagnetic, electronic ,thermal ,fluid ,bio medical .

This is also used as an educational tool in universities and other academic institutions . the ANSYS can be run on many types of computer –PC's , work stations ,minicomputers, super mini ,main frames, etc. several operating systems are supported as a multitude of graphical devices.

Program Organization

The ANSYS program is organized into two basic levels:

- Begin level
- Routine level

The beginning level acts as a gateway into and out of the ANSYS program. when we first enter the program we will be the begin level as indicated by the BEGIN rompt.

At the processor level, several processors (routine)are available , each serving a specific purpose as given table 2.5.1.types of processors

	Function	
PREP7	General pre processing to build the model (geometry materials, coupling,and constraint equation, etc	/PREP
SOLUTION	Loading and solving to apply loads and obtaining the finite element solution	/SOLU
POST1	General post processing –to review results over the entire models	/POST1
POST26	Time history post processing –to review results over the entire model over time	/POST26
OPT	Design optimization	/OPT

Program Organization

Ansys Data Base

This is one of the largest databases that stores all input data and results data in an organized fashion. The main advantages of having such a data base is that any specific data can be listed, displayed ,modified or deleted quickly and easily ,regardless of which processor we are working .

This gives us the advantages of accusing the model and load portions of the data base from anywhere in the program.

Finite Element Analysis Software

- PROBLEM
- PREPROCESSOR
- POSTPROCESSOR

Analysis and Design Optimization

Preprocessor

- Reads control parameter
- Reads or generates nodal co ordinate's boundary solution.
- Reads or generates element data connectivity, element loads.
- Reads material constants –constitutive matrix coefficients.
- Loading conditions.

Processor

- Calculates control parameter for storage scheme for equations.
- Generates elements matrices stiffness matrix and nodal load vector.
- Assembles element equations.
- Boundry conditions.
- Performs solution procedures.

Postprocessor

- Prints or plots deflected shape
- Prints or plots contours of displacements
- Calculates strains or stress
- Prints or plots contour of stresses displays stress bands

Post Processing

Post processing is that phase of analysis in which we review the results. It is probably the most important step where we try to understand how the applied loads affect our design and how good the finite element mesh is and so on . two post processors are available to review our results.

POST1, the general post processor and POST26, the time history post processor .the former allows users to review the results over the entire model at specific load steps and sub steps. the later allowing reviewing the variations of a particular results item at specific points in the model with respect to time , or to some other result item.

2.5.5. A Typical Finite Element Program

Input Data

1.problem title	
2.structure data	Control function ,no of nodes, material group, element load
3.nodal data	Coordinates ,degree of freedom
4.material property data	For each group properties to be given
5.element data	Connectivity properties ,material group, element load
6.nodal load	Along the degree of freedom
7.load combination	Element and nodal load multipliers

Output

1.nodal displacement	
2.stress resultants	Selected points

Definition of the Problem

To determine the stress distribution in hanger tube lug and designing as per ASME guideline.

Dimensional details:
Tube out side diameter : 38.1 mm
Tube thickness : 8 mm
Lug thickness : 10 mm
Lug height : 508 mm

Material Data:

young's modulus "E"=18000 Pa
Design pressure= 2.851 kg/mm²
Design temperature = 521.1°c
Lug material= SA 213 T22
Lug material composition = carbon, silicon.
Lug allowable stress = 6.5261 kg/mm^2
Load per tube = 8551.35kg
Poisson's ratio 'v'= 0.3

Elements Used

- The element used for structural analysis is PLANE 82
- dimensions 2-d
- shape or characteristics: quadrilateral, eight nodes
- degree of freedom; displacement (at line4,5,6)

Material: PLANE82

- PLANE82
- 2-D 8-Node Structural Solid

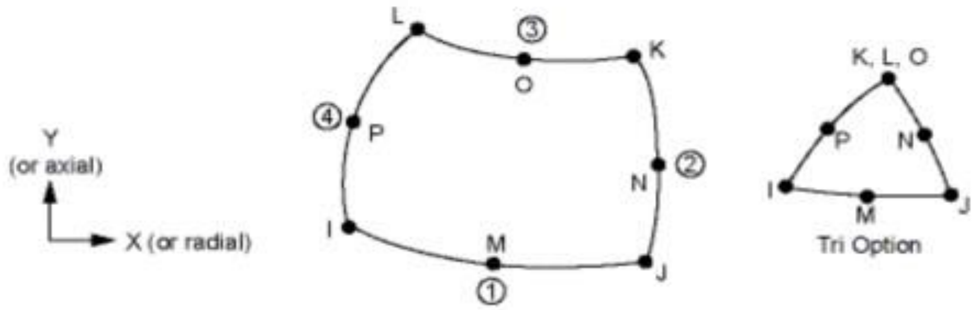
A. PLANE82 Element Description

PLANE82 is a higher order version of the 2-D, four-node element (PLANE42). It provides more accurate results for mixed (quadrilateral-triangular) automatic meshes and can tolerate irregular shapes without as much loss of accuracy. The 8-node elements have compatible displacement shapes and are well suited to model curved boundaries.

The 8-node element is defined by eight nodes having two degrees of freedom at each node: translations in the nodal x and y directions. The element may be used as a plane element or as an axisymmetric element.

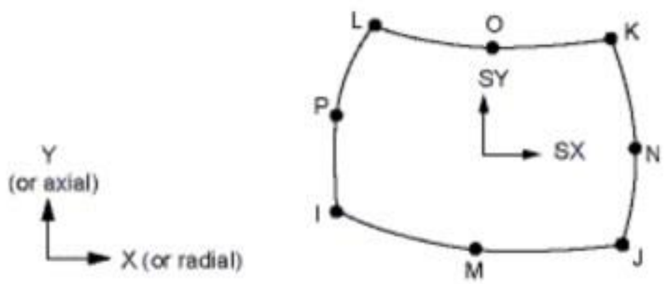
The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. Various printout options are also available. See PLANE82 in the ANSYS, Inc. Theory Reference for more details about this element. See PLANE83 for a description of an axisymmetric element which accepts nonaxisymmetric loading.

PLANE82 Geometry :



PLANE82 Geometry

PLANE82 Stress Output:



PLANE82 Stress Output

The Element Output Definitions table uses the following notation:

Design Variables:

Design variables are independent quantities that are varied in order to achieve the optimum design .upper and lower limits are specified to serve as a constrained on the design variables . these limits defined the range of variation for the DV . in this problem ,thickness of the lug and tube diameter, and thickness of the tube are obvious constrained for the design's variables.

State Variables:

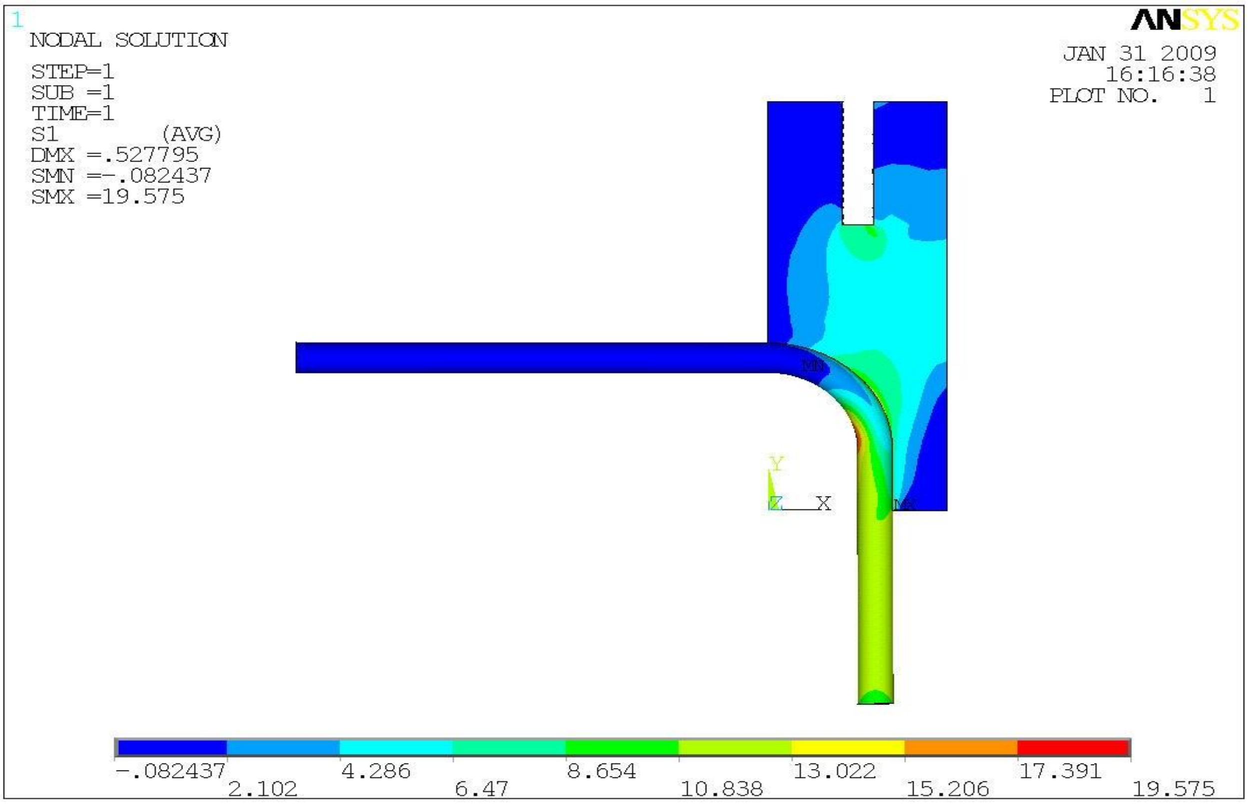
State variables are the quantities that constrained the design .they are also knows as dependent variables and are typically response quantities that are the function of the variables .a state variables may we a maximum and minimum limit . or it may we a maximum and minimum limit or it may be single sided , having only one limit.

Table

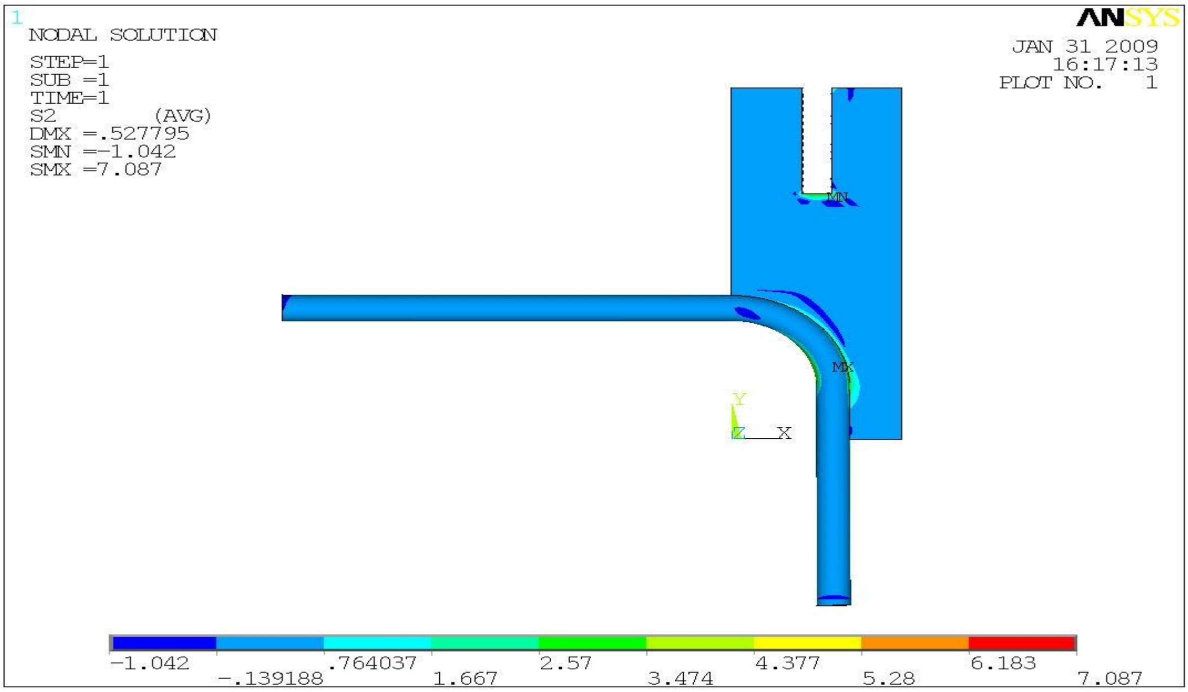
First

Sl. No.	Description	Dimensions in mm
01.	Tube out diameter	38.1
02.	Thickness	8
03.	Lug thickness	10
04.	Lug design temperature	521.1°c

Principle Stress

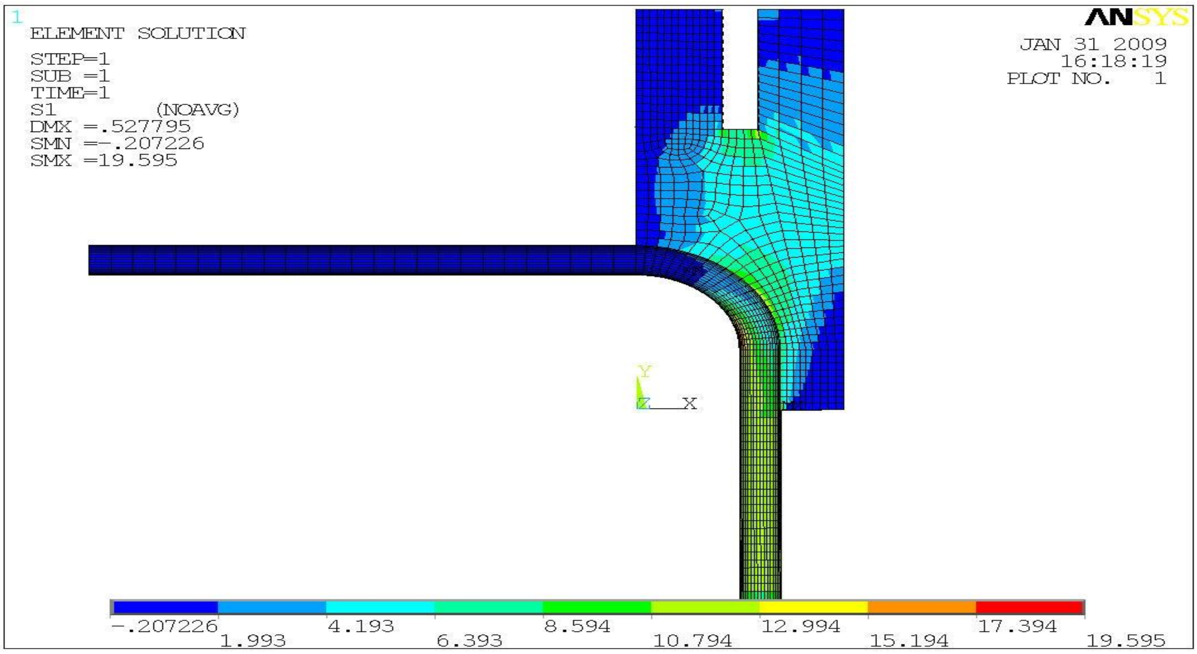


Second Principle Stress

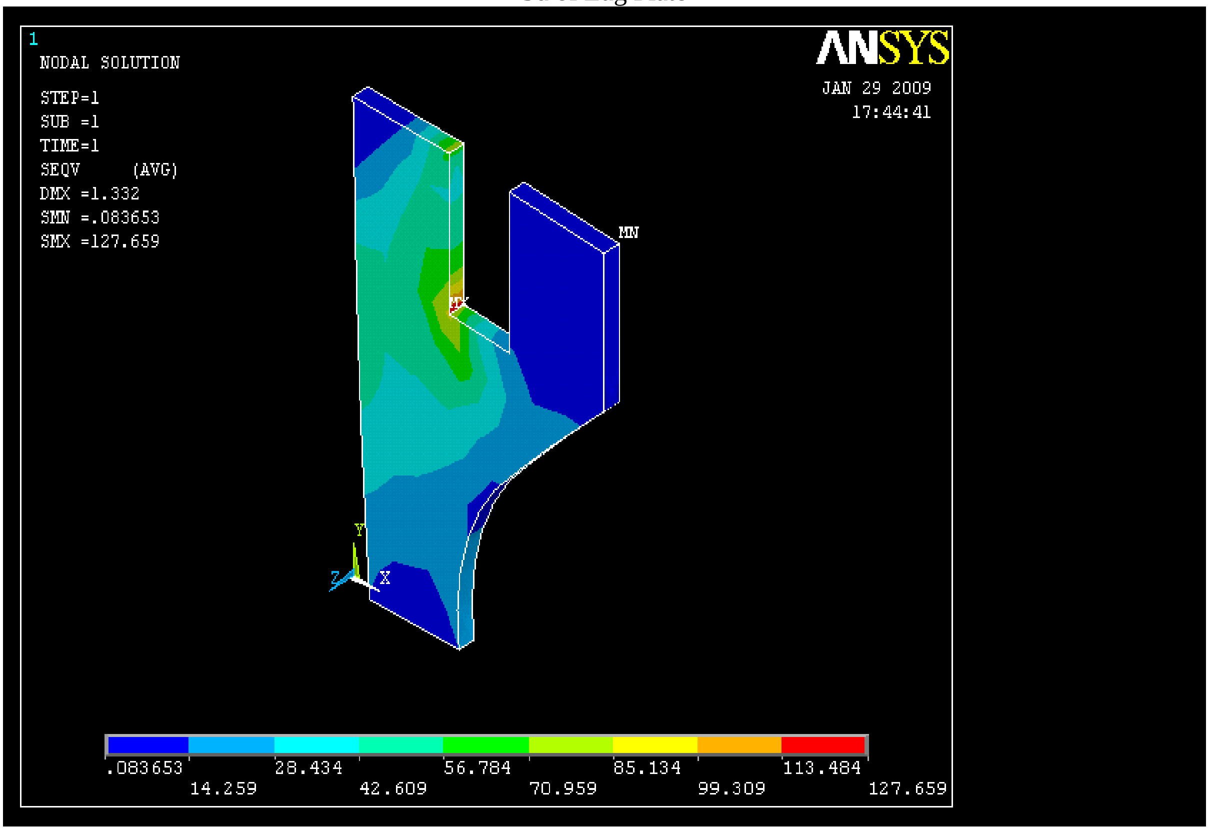


Third Principle Stress

Von Mess Stress



3d of Lug Plate



Conclusion

A brief description of steam generator internal components is presented. these components are subjected to a variety of loading significant loading includes dead weight, seismic, and pipe rupture effects.It is recognized that a proper design and analysis are important for safety of the plant. Considering the material testing , quality control during manufacturing and detailed analysis of the internals, it is reasonable to limit their primary stresses similar to class one components considering for cyclic stresses and fatigue is not necessary except for the feed water distribution system. A set of damping values based on testing and analysis are provided for seismic analysis of the internals. It can be found from the result that the effect of with the permissible limit .so as we select designed thickness of lug material. The total stress from the analysis for structural loading is around 8551.35 kg is well within the code allowable limit. It can be concluded from the analysis that in a bent tube lug it will be safer to use SA213 T55 Metals where can with stand higher stresses. Hence the proposed arrangements can be implemented for 500 MW boiler.

