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STATIC ANALYSIS OF COMBINATION BOILER

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ABSTRACT
Now-a-days combination boilers are most widely used equipment for boiling water. The existing design has direct connection between outer cylinder and inner coil that are connected by welding. The critical region of failure is found at the weld portion by static analysis. Combination boiler under static loading conditions must be assured for its structural integrity during design stage. In the present study a static analysis of combination boiler is carried out in both Normal operating and Maximum operating pressure conditions

KEYWORDS: Combination Boiler; Static analysis; Ansys; Hypermesh

INTRODUCTION
Combination boilers are type of boilers in which gas is used for both maximum efficiency domestic heating purpose. Majority of people in UK use these types of boilers in houses as it requires small area. They are durable, reliable, convenient, easier to install, simple to use and it can run economically producing a continuous stream of boiling water, whenever it is needed. Installing a combination boiler might be a onetime hassle but other boiler needs to be serviced every now and then, especially if there are strange noises or temperature fluctuations[1].

Proven technology is used for manufacturing these kinds of boilers, making them reliable and durable. They result in smooth operation for switching on and off with less wear and tear of components. Combination boilers are generally available in 24 to 40 kW output[2].

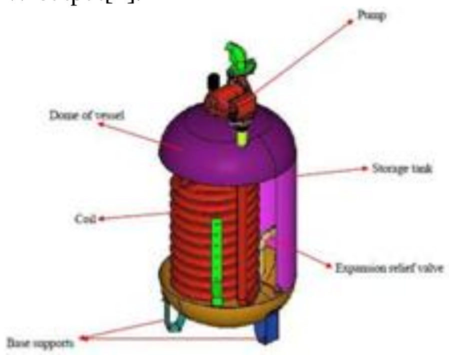

Fig 1: Combination boiler

The present work involves creation of 3D model of combination boiler considering the desired dimensions. Structural characteristics of combination boiler for the loading conditions are analyzed. Static Pressure analysis of the fitting, weld, and surrounding sheet metal to predict material failure due to Normal operating pressure and Maximum operating pressure is carried out in without reinforcement case. Combination boiler consists of six parts namely, pump, coil, storage tank, expansion relief valve, base supports and dome vessel as shown in Fig 1.

FINITE ELEMENT MODELLING, MATERIALS AND ANALYSIS
Modelling of combination boiler is created by CATIA, and its analysis has been carried out by ANSYS 15 applying boundary conditions to the imported model and results are obtained by post processor[3].

The assembly consists of 6 parts as Fig 2(a) shows inner section view of combination boiler and Fig 2(b) shows assembled view of DHW tank and pump assembly.

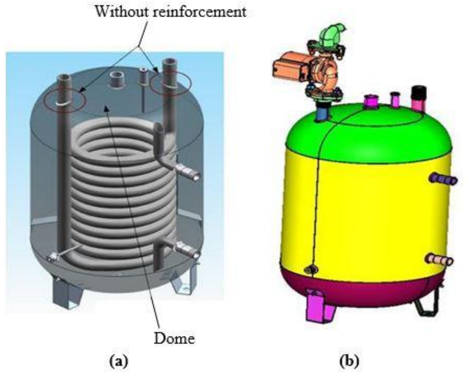

Fig 2. (a) Inner section view (b) Assembled view of combination boiler.

The outer cylinder(Tank) is assigned with 316L Stainless Steel while coil and connecting between pump fitting and coil region is assigned with 304 Stainless Steel grades of materials and all welds are 316L Si weld filler using MIG welding shown in Fig 3.

The FE modelling of combination boilers is carried out in HYPERMESH. In this model total number of nodes are 60186 with 127722 elements. The meshed model is shown in Fig 4. For the desired meshed model in structural analysis, static analysis which has been carried out with their element type as Solid 185 and shells 63 having element size of 6mm.

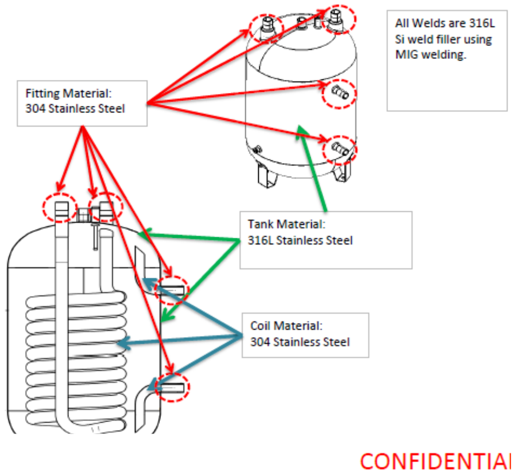

Fig 3: Materials used in Combination Boiler

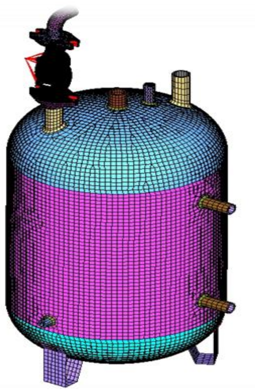

Fig 4: Finite element meshing of combination boiler.

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Boundary and loading conditions for structural analysis:

The boundary conditions were defined as per physical phenomenon of the problem defined. The combination boiler model is constrained as shown in Fig 5. The side nodes are constrained along x, y ,rx, ry, rz. The bottom surface of saddle is fully constrained in all 6 degrees of freedom [4].

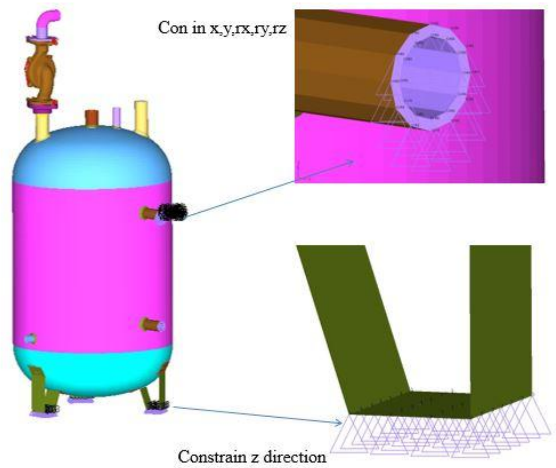

Fig 5: Boundary conditions for combination boiler.

Loading and boundary condition for static pressure analysis on normal operating pressure

The analysis is carried out by applying ambient temperature and normal operating pressure load of 12 psi to the coil and for domestic hot water (DHW) tank normal operating pressure load of 55 psi is applied.

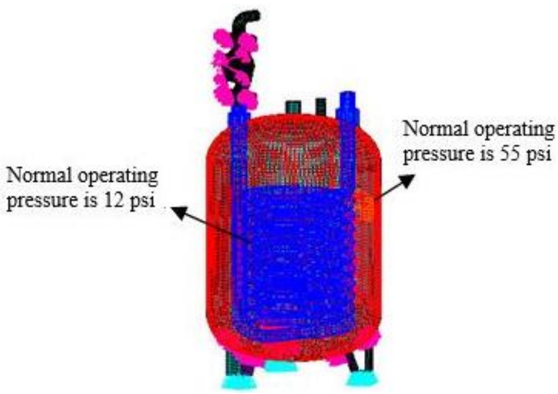

Fig 6: Meshed model with boundary and loading conditions for normal pressure

Static Pressure analysis of the fitting, weld, and surrounding sheet metal to predict material failure due to Normal operating pressure loads applied to the coil and DHW tank for without Reinforcement is shown in Fig 6.

Loading & boundary condition for static pressure analysis on maximum operating pressure

The analysis is carried out by applying the ambient temperature and Pressure load of 30 psi to the coil and for DHW tank maximum operating pressure load of 145 psi is applied.

Static Pressure analysis of the fitting, weld, and surrounding sheet metal to predict material failure due to maximum operating Pressure loads applied to the coil and DHW tank for without Reinforcement is shown in Fig 7.

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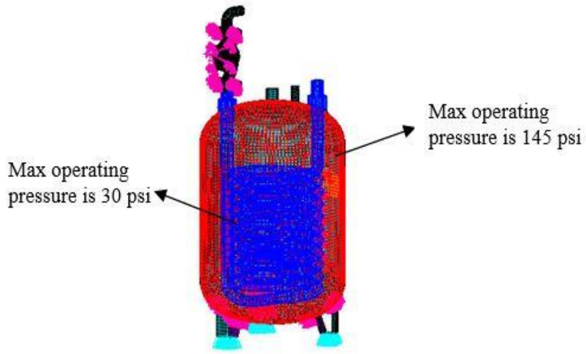

Fig 7: Meshed model with boundary & loading conditions for Max pressure

There are two different materials used in the combination boiler. The properties are shown in the Table 1.

Table 1: Material Properties

Sl. No.	Material	Young's Modulus (Gpa)	Poisson's Ratio	Yield Strength (Mpa)	Density (kg/m^3)
1	316L Stainless Steel	193	0.3	280	8000
2	304 Stainless Steel	193	0.3	280	8000

RESULTS AND DISCUSSION

Static analysis on normal operating pressure

The analysis is carried out to identify the maximum stress of the component, when it is subjected to the given loading conditions (12 psi and 55 psi) and boundary conditions. Static analysis for without reinforcement shows the resultant contour plots of von-mises stresses in Fig 8. The maximum von-mises stress for Normal operating pressure is 115.644 Mpa.

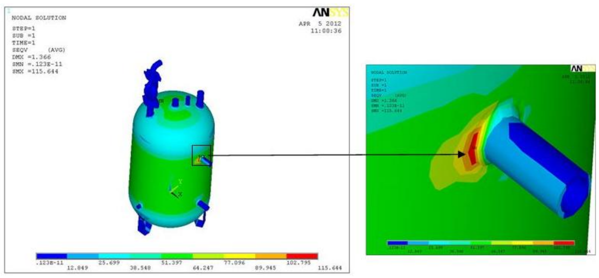

Fig 8: Von-mises stress for Combination Boiler at normal operating pressure.

Static analysis on maximum operating pressure

The above analysis is carried out to identify the maximum stress of the component, when it is subjected to given loading conditions (30 psi and 145 psi) and boundary conditions. Static analysis for without reinforcement, the resultant contour plots of von-mises stresses, are shown in Fig 9. The maximum von-mises stress for Maximum operating pressure is 278.225 Mpa.

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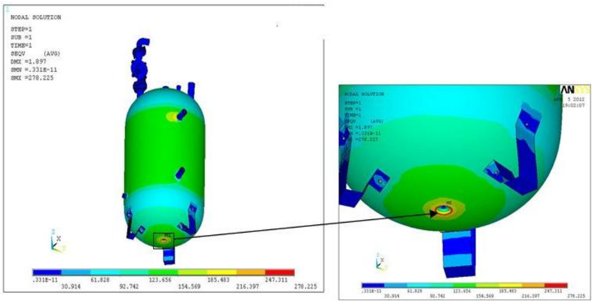

Fig 9: Von-mises stress for Combination Boiler in maximum operating pressure.

In case of normal operating pressure, the analysis is carried out to identify the maximum Von-mises stress that occurs at welded portion of DHW tank and pressure relief valve (Fig. 8). In this region 115MPa of Von-mises stress was observed. As the operating pressure is applied is low to the DHW tank and coil, the FOS obtained was more compared to maximum operating condition.

In case of maximum operating pressure, the analysis is carried out to identify the maximum Von-mises stress that occurs at bottom portion of DHW tank (Fig. 9). In this region the Von-mises stress observed was 278 MPa. In this case higher operating pressure is applied to the DHW tank and coil resulting in a lower FOS. Similar results were observed by several researchers [5, 6].

Table 2: Result summary

Sl No	Cases	Material	Yield strenght (Mpa)	Von-mises stress (Mpa)	FOS
1	Normal operating pressure	Steel	280	115	2.43
2	Max. operating pressure	Steel	280	115	1.00

CONCLUSIONS

Finite element Analysis for pressure loading is carried out for the two cases for the modeled equipment. Modeling of combination boiler is created by CATIA, and its analysis has been carried out by ANSYS 15 by applying the boundary and pressure loads conditions on DHW tank and coil. Static analysis is carried out to evaluate von-mises stresses of the required component. For normal operating pressure, the component experiences less stress and FOS is more, while at maximum operating pressure the stress level is increased and FOS reduces. The weld portion is found to be weaker section as per the static analysis. Von-mises stresses are within the allowable range and therefore the design is safe.

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