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ANALYSIS OF THE LONGITUDINAL BUTT JOINT- A REVIEW STUDY

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ABSTRACT
Manufacturing& production engineering is mostly concerned with heavy machinery which is a must for mass production. One such component is a boiler which is used in power plants for steam production. For steam production Water is boiled inside boiler assembly with the help of combustion of fuel in furnace. The water in liquid state is made to pass through pipes which come in contact with of heat being generated in the furnace. This heat increases the temperature of water above its boiling point and ultimately the water is converted into steam. This steam is stored inside boiler shell which is developed with the help of lap joints & butt joints. Boiler shell comprises a longitudinal joint which is a double strap double riveted butt joint.

KEYWORDS: Steam Production, Boiler, Boiler Shell, Boiler joint, Longitudinal Joint.

1. INTRODUCTION
A mechanical joint is a phase of a device that's used to connect one or extra mechanical component to every other. Mechanical joints may be temporary or everlasting; maximum sorts are designed to be disassembled. Most mechanical joints are designed to permit relative movement of these mechanical components of the device in a single degree of freedom, and restriction motion in one or more others. Mechanical joints are lots inexpensive and are usually sold equipped assembled. A mechanical joint may be of following two types-

- Butt Joint
- Lap joint

A. Butt Joint
A butt joint is a technique wherein two portions of fabric are joined with the aid of certainly placing their ends together with none special shaping. The name 'butt joint' comes from the way the fabric is joined together. The butt joint is the best joint to make since it simply includes reducing the steel to the suitable period and butting them collectively. It is also the weakest due to the fact except some form of reinforcement is used (see below) it relies upon glue on my own to hold it together. Because the orientation of the metallic normally gives most effective one gives up to long grain gluing surface, the ensuing joint is inherently weak. Butt joints are widespread in automobile processes, due to their relative ease of training.

B. Rivets
A rivet is a permanent mechanical fastener. Before being hooked up, a rivet includes a smooth cylindrical shaft with a head on one stop. The quit opposite to the head is referred to as the tail. On installation, the rivet is positioned in a punched or drilled hollow, and the tail is dissatisfied, or bucked (i.e., deformed), so that it expands to about 1.5 instances the authentic shaft diameter, keeping the rivet in place. In different words, pounding creates a new "head" on the other give up by way of smashing the "tail" material flatter, ensuing in a rivet this is kind of a dumbbell form. To distinguish between the 2 ends of the rivet, the unique head is known as the factory head and the deformed stop is known as the shop head or greenback-tail.

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C. Composite materials

Composite material (additionally known as a composition fabric or shortened to composite that is the commonplace name) is a material made from two or more constituent substances with considerably considered one of kind physical or chemical residences that, even as mixed, produce a material with characteristics precise from the individual components. The character components remain separate and wonderful in the finished form, differentiating composites from combinations and strong solutions. The new fabric may be favored for plenty motives. Common examples encompass substances which is probably stronger, lighter, or much less expensive while in comparison to traditional materials.

D. Failure Theory

Failure principle is the technological know-how of predicting the situations under which strong substances fail beneath the action of external masses. The failure of a fabric is usually classified into brittle failure (fracture) or ductile failure (yield). Depending at the conditions (like temperature, kingdom of stress, loading charge) maximum materials can fail in a brittle or ductile manner or each. However, for most sensible conditions, a cloth may be categorized as both brittle and ductile. Though failure idea has been in development for over 200 years, its degree of acceptability is yet to reach that of continuum mechanics.

E. Von-mises Yield Criterion

The von Mises yield criterion (also known as the most distortion power criterion) shows that yielding of a ductile material starts whilst the second deviatoric strain invariant reaches a crucial fee. It is part of plasticity idea that applies quality to ductile substances, inclusive of a few metals. Prior to yield, material reaction may be assumed to be of a nonlinear elastic, viscoelastic, or linear elastic behavior.

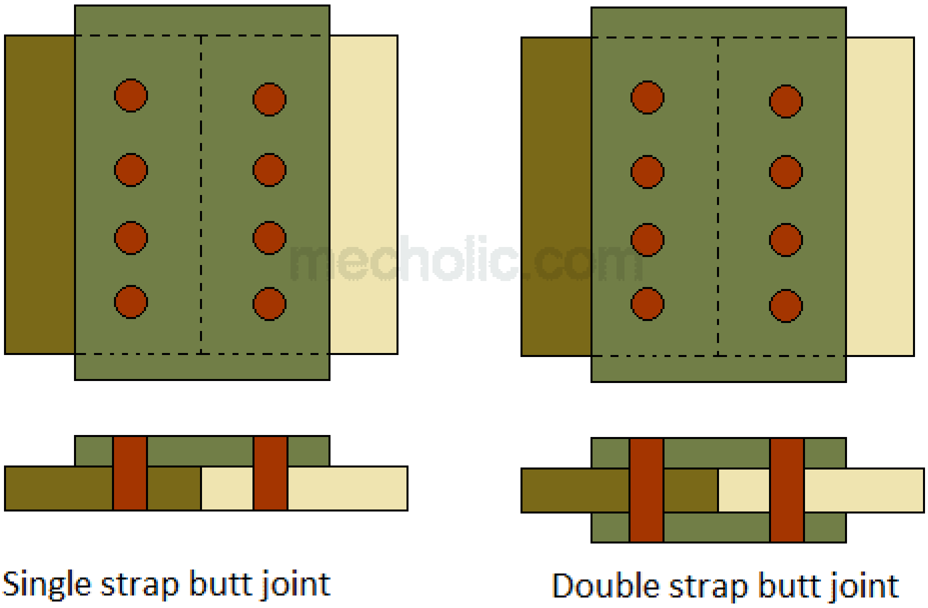

Fig. 1 Different types of butt joints

2. LITERATURE REVIEW

C-P Fung & J Smart [1] analysed snap & countersunk type single lap joint experimentally, numerically & with the help of ABAQUS software for fatigue failure. They tested 11 specimens experimentally & numerically & created two-dimensional analytical model using software. The material used for fatigue test (in order to provide experimental data) was selected as aircraft quality aluminium alloy BS 2L70 & 2 mm thick strips of this material were joined together with the help of either 2, 5/32 inch snap head rivet (BS SP80) or countersunk head rivets (BS SP71).

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M.N. Buradkar et al. [2] considered an arc welded lap joint for their project. They conducted experimental as well as Photoelastic analysis on a specimen to evaluate the breaking strength with varying the gap between the plates of joint. Their research indicates that the results obtained by experimental & FE analysis studies were seen in accordance with each other. For further verifying the results, Photoelastic study was also conducted & value of shear stress was determined. This study shows that the shear stress decreases when the gap distance is increased.

Chavan Vikrant Vijaykumar et al. [3] conducted a tensile strength analysis on a simple lap joint under varying conditions. Process parameters included joint geometry, type of loading, welding geometry, welding defects, environmental factors, specimen preparation, overlap length, gap size etc. For the purpose both experimental & FE Analysis were performed & the results were determined. Other 5 specimens of gap sizes of 0.2, 0.4, 0.6, 0.8 & 1 mm were tested & again the results found were regular. The results show that increasing gap size results in decreasing tensile strength. Optimum results were found at overlap length of 25 mm & at gap size.

Ceyhun Kose et al. [4] examined the Effect of post weld heat treatment & heat input on the microstructure & mechanical properties of plasma arc welded AISI 410S ferrite stainless steel. For the purpose AISI 410S ferrite stainless steel strips were welded together using plasma arc welding process. Study showed that increasing heat input results in decreasing tensile strength & hardness of welded joints whereas grain coarsening & ductility were increased. Tensile test also caused ductile fracture modes in all specimens.

Hariharan E et al. [5] conducted a comprehensive test on bonded single lap joints, riveted single lap joints & hybrid single lap joints at two different layers made up of composite materials. Material used for the purpose was E-glass fibre (Unidirectional) & epoxy resins. They found that maximum stress occurred at the corner sections of the joint & load &displacement data were in close agreement with each other. Minimum stress occurred at layer number 3 & increasing the layers resulted in reduction of stress. Their study also indicated to use hybrid single lap joints in order to get maximum strength.

Wei Lu et al. [6] examined tensile properties of lap joint through an extended analysis of tensile properties of the same. They selected lap length, Specimen thickness & specimen width as the process parameters & evaluated their effects on load & stress distribution of the joint. They also found that Specimen width had very less effect on tensile strength but mattered significant when talking about its effect on maximum tensile strength. To validate the experimental results, they also conducted simulation of the analysis on ANSYS software.

JI-Ung Choi et al. [7] examined the lap shear strength of welded specimens of alloy 718 with EBW (Electron Beam Welding) and LBW (Laser Beam Welding) and Brazing. Primary objective of the study was to investigate the optimum welding method for overlap welding of this alloy for blow forming. The material used was alloy 718 with grain size of approximately 7 microns. They conducted tensile shear test of the welded lap joints which showed that the failure occurred at base metal, weld metal or portion adjacent to the weld joint. They conclude that LBW method of welding is showing better results than EBW with strain more than 9%.

S. Venkateswarlu et al. [8] examined the behaviour of bonded single lap joint, riveted lap joint & hybrid lap joint using two different composite materials under tensile loading. CFRP material was used to erect the 3D model of lap joint using PRO-E & then the analysis was performed on ANSYS workbench. Adhesive layer employed between the plates was of 0.4 mm thickness. Element type selected for the analysis was hexagonal. They conducted the shear tress analysis on all three type of joints & the results showed that shear stress for hybrid single lap joints was less than other type of joints. They also concluded that carbon reinforced plastics had maximum strength as compared to other materials. It was found that hybrid type of single lap joint was more useful than the other two when talking about aerospace applications.

CH V K N S N Moorthy et al. [9] examined the tensile strength & shear stress distribution for bonded type single lap joints under different design conditions. Fracture characteristics of the joint were also investigated through a structural analysis in ANSYS (15.0) workbench. Material used for the purpose was carbon fibre T-700. Meshing employed was ***"SOLID45"***. They used adhesively bonded joint configuration for the study &

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found that overlap length was the primary element affecting all other parameters like adhesive strength, adhesive properties and adhered properties & joining procedure. They concluded that for an optimal overlap length, joint strength was maximum with minimum applied adhesive which maximizes the load bearing capacity of the joint.

P. Lazzarin et al. [10] examined notch stress intensity factors (N-SIFs) & fatigue strength of aluminium & steel welded lap joints under different design conditions. Thickness of the plates used varied from 3 to 24 mm. Here fatigue total life has been correlated to Mode I N SIFs i.e. ΔK_1^N. Fatigue properties of steel welded joints were compared with aluminium welded lap joints. The mean value of ΔK_1^N was found to be in a ratio of 2.0 & scatter band size practically coincides.

Peng Liu et al. [11] examined the fracture behaviour of an electron beam welding (EBW) joint of T2 copper & 45 steel. A full-strength joint was obtained with highest tensile strength of 270 MPa. A macroscopic tensile fracture test conducted on this specimen resulted in necking phenomenon & obvious features like dimples & spherical structures which were seen through scanning electron microscopy (SEM). Results of SPT & numerical simulation of this joint were compared with each other which show that fracture would occur first at copper side because of toughness difference.

Marta Kaluza et al. [12] examined the behaviour of methacrylate adhesive joined single lap joint under tensile conditions. Laboratory tests were conducted on a double lap specimen of high strength domex-700 steel. Appropriate lengths were found to be between 300 & 400 mm. This test resulted in two kinds of behaviour of the specimen, Quasi-brittle which occurred at an anchorage length of 200 mm & ductile behaviour which occurred at 300 & 400 mm of anchorage length. They also used an optical measurement method which provided a detailed strain distribution on the specimen surface.

Kocabas et al. [13] studied the response distributions & fracture mechanisms of an adhesively bonded single lap joint under different design conditions. For the purpose a single lap joint with a mild steel adherend S255 was tested. The adhesive was made up of a two-component structural epoxy ductile (Veropal super HE-20) & brittle (Carboresin). This study shows that overlap length and design conditions play an important role in design stage of bonded structures up to a certain limit. After this limit overlap length loses its importance and now the primarily affecting parameter is adherend yielding.

Jonathan P.-H. Belnoue et al. [14] proposed a new kind of methodology for finite element analysis of adhesively bonded joints. Previously cohesive & adhesive failures were not used to being treated separately but they considered both of these separately. Initially this method provided accurate prediction of failure process of adhesive joints under complex multi-axial loading. They prepared a smeared crack model to predict cohesive failure. They also validated the model through several kinds of fracture test.

Jonathan P.-H. Belnoue et al. [15] moved further with their study already discussed in previous paragraph & this work presents an in-depth investigation into interaction among plasticity, cohesive failure & adhesive failure with application structural joints. A quasi-static finite element analysis of double lap joints was performed with various thicknesses & different levels of hydrostatic pressure being the primary process parameters. The numerical analysis resulted in the exact prediction of driving mechanisms & failure process. This work also exactly predicted the fatigue failure of the specimen.

R.D.S.G. Campilhoa et al. [16] compared the failure mechanisms of single lap joints using three different types of adhesives which possess several advantageous properties as compared with conventional joints. For the purpose they compared three different joints employed with three different types of adhesives namely- Araldite AV138, Araldite 2015 and Sikaforce 7888. Performance of all the three type of joints was examined with varying overlap lengths. To validate the results, they also conducted a numerical simulation analysis on ANSYS workbench based on cohesive zone models (CZM). This study reveals that CZM method is highly accurate except for ductile adhesives.

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Murat Yavuz Solmaz et al. [17] evaluated the effects of different taper angles & varying overlap lengths on the failure & fracture mechanisms of single lap joints. For the purpose they used Neoxil CE92 N8 adhesive & carbon fibre reinforced fibre (CFRP) adherend. They conducted lap shear tests on the single lap joint (SLJ) specimens & their study indicated that increasing the taper angle & overlap length increases the joint strength up to a certain limit. This test was performed for six different taper angles & two different overlap lengths. Numerical simulation analysis was also performed in ANSYS software to validate the experimental results. The results showed a peel effect at every overlap length for every specimen that was tested. Optimum results were obtained at 15° taper angle.

Debora C moreira et al. [18] studied about the results of flexible adhesives on the performance of bonded single lap joints at various overlap lengths. Also, aluminium adherend was used to make the specimen. In order to estimate horizontal & vertical displacement fields, digital image correlation method was employed at overlap region. It was found that vertical displacements were associated to small deflections. Adhesive thickness was not equal at horizontal co-ordinates. This study revealed that the shear strain decreased at the edge of overlap.

P.D. Yadav et al. [19] evaluated the performance of hybrid type of single lap joint under different design conditions. The experimental analysis was done using STAR tensile testing machine. Parameters on which the study was based were base metal, adhesive & number of bolts. Their study indicates that if we use base metal as aluminium & composite (FRP) then ultimate tensile strength increases up to 97%, if we use adhesive as H3151 and E120HP then ultimate tensile strength (UTS) of the joint increases by 1.79%, number of bolts has little effects on UTS, The strength of hybrid type of single lap joint is more than simple bolted joints.

Du Chen et al. [20] analysed an adhesively bonded single lap joint. The testing method was based on a two-dimensional elasticity theory in conjunction with the variation principle of complementary energy. To illustrate this theory three different types of adhesive layers (flexible, medium & inflexible) were provided and comparisons were made with other known solutions to the same problem. Special attention was given to stress distribution. It was seen that the difference occurred only near the joint. For a relatively inflexible adhesive layer, the stress values increased which shows that this kind layer is not favourable. For an adhesive layer falling between above two categories, the values of stress calculated showed irregular relation with other two results hence it was concluded that this type of layer is also not preferable.

3. CONCLUSIONS

Looking at the literature review, I conclude that

- Low carbon steel is the material being conventionally used for the development of longitudinal joint of a boiler shell.
- Using this material increases the overall weight of the boiler shell.
- In order to lower this weight different kinds of other materials are being tried & tested by the researchers.
- There is a scope in improving the overall performance of the boiler joints.

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