Analysis of Rivets Using Finite Element Analysis

[1,]Arumulla. Suresh, [2,]Tippa Bhimasankara Rao

[1]pg Student, Department Of Mechanical Engineering, Nimra Institute Of Science And Technology

[2] Hod, Department Of Mechanical Engineering, Nimra Institute Of Science And Technology, Vijayawada, Ap, India

Abstract:

A rivet is a cylindrical body called a shank with a head. A hot rivet is inserted into a whole passing through two clamped plates to be attached and the heads supported whilst a head is formed on the other end of the shank using a hammer or a special shaped tool. The plates are thus permanently attached. Cold rivets can be used for smaller sizes the - forming processes being dependent on the ductility of the rivet material. When a hot rivet cools it contracts imposing a compressive (clamping) stress on the plates. The rivet itself is then in tension the tensile stress is approximately equal to the yield stress of the rivet material. Design of joints is as important as that of machine components because a weak joint may spoil the utility of a carefully designed machine part. Here in this project we are modeling the rivet using proe and analysing the rivet forces by Ansys which will give results by using finite element analysis.

Keywords: *ANSYS, Cold rivet, Hot rivet, Pro-E.*

I. INTRODUCTION

Rivets are considered to be permanent fasteners. Riveted joints are therefore similar to welded and adhesive joints. When considering the strength of riveted joints similar calculations are used as for bolted joints. Rivets have been used in many large scale applications including shipbuilding, boilers, pressure vessels, bridges and buildings etc. In recent years there has been a progressive move from riveted joints to welded, bonded and even bolted joints A riveted joint, in larger quantities is sometimes cheaper than the other options but it requires higher skill levels and more access to both sides of the joint There are strict standards and codes for riveted joints used for structural/pressure vessels engineering but the standards are less rigorous for using riveted joints in general mechanical engineering Mechanical joints are broadly classified into two categories viz., non-permanent joints and permanent joints. Non-permanent joints can be assembled and dissembled without damaging the components. Examples of such joints are threaded fasteners (like screw-joints), keys and couplings etc.

Permanent joints cannot be dissembled without damaging the components. These joints can be of two kinds depending upon the nature of force that holds the two parts. The force can be of mechanical origin, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by applying mechanical force. The components can also be joined by molecular force, for example, welded joints, brazed joints, joints with adhesives etc.

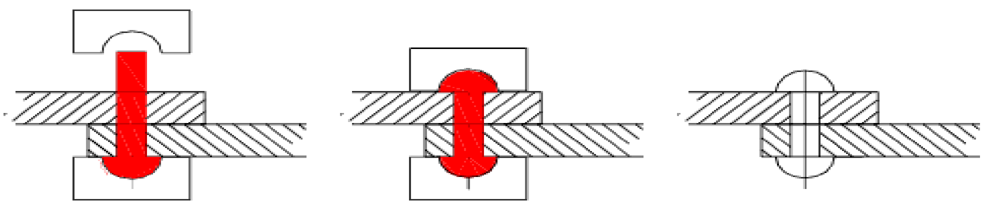

Fig.1.0 rivets

II. RIVET

A Rivet is a short cylindrical rod having a head and a tapered tail. The main body of the rivet is called shank (see figure 1.1). According to Indian standard specifications rivet heads are of various types. Rivets heads for general purposes are specified by Indian standards IS: 2155-1982 (below 12 mm diameter) and IS: 1929-1982 (from 12 mm to 48 mm diameter). Rivet heads used for boiler works are specified by IS: 1928-1978.

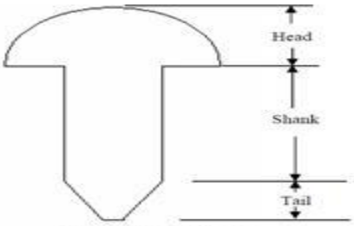

Fig.1.1 Rivet Terminology

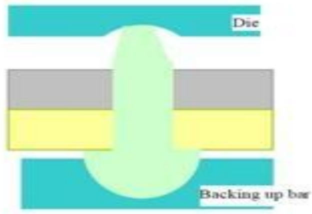

Figure 1.2: Riveting operation

Riveting is an operation whereby two plates are joined with the help of a rivet. Adequate mechanical force is applied to make the joint strong and leak proof. Smooth holes are drilled (or punched and reamed) in two plates to be joined and the rivet is inserted. Holding, then, the head by means of a backing up bar as shown in fig 1.2, necessary force is applied at the tail end with a die until the tail deforms plastically to the required shape.

III. RIVET MATERIAL

Rivets are manufactured for the materials conforming to IS: 1148-1982 and IS: 1149-1982 for structural work and to IS: 1990-1973 for pressure vessels. Rivets are usually made from the tough and ductile material namely low carbon steel (C15), nickel alloy steel, and wrought iron. Rivets are also made from non-ferrous material such as copper, aluminum alloys and brass for anti corrosive properties where strength is not major requirement. According to BIS, the rivet material should have tensile strength more than 350 $N/mm^2$and elongations not more than 20%.

3.1 Manufacturing of rivet

Solid rivets which is of commonly used in mechanical system are generally manufactured in large numbers starting with a wire, rod or bar of material of substantially the same diameter as the desired shank of the finished rivet. In fabrication, the rod is cut off; the end of the rod is inserted into the die defining the rivet, and then typically given an initial upset followed by a final blow to form the head and tapered region between the head and shank of the rivet.

- Selecting of rod of same dia as of rivet
- Cutting of rod
- Cold heading of rivet into dies

IV. RIVETING TECHNIQUES

There are several common methods or techniques for performing riveting operations. There is the standard hand riveting with a bucking bar or a blind rivet. Three basic alternative methods of riveting are cold riveting, hot riveting, and automated riveting. Each method is used to achieve different characteristics. In the standard riveting process and in cold or hot riveting a bucking bar is used at the bottom end of the rivet to cause it to form a head when the rivet is driven through the hole. Bucking bars are of different weights depending on the size of the rivet being used. In the cold riveting process the rivets are kept in a refrigerator until they are ready to be used. The rivet is driven while it is still cold. While it is cold the rivet remains soft and is more malleable. The rivet will cure at room temperature and become hardened. This process is necessary for rivets produced from certain aluminum alloys. The hot riveting process is done for the same reasons. The difference is the rivet will be at room temperature before its use. When the rivet is needed it will be heated and then driven while it is still hot. When it cools again it will return to its hardened state. Automated riveting processes are cheaper, but do to lengthy setup time they are usually limited to one rivet type. Automated riveting can include the hot or cold riveting methods. The most common types of riveting other than the standard methods are cold riveting, hot riveting, and automated riveting. Each of the riveting methods have advantages, whether it is strength, ease of production, or cost.

V. DESIGN STRESSES

For rivets used for structures and vessels etc the relevant design stresses are provided in the applicable codes. For rivets used in mechanical engineering, values are available in mechanical equipment standards which can be used with judgment.BS 2573 Pt 1 Rules for the design of cranes includes design stress values based on the Yield stress (0,2%proofstress) $Y_{R0.2}$ as follows Hand driven rivets tensile stress(40%$Y_{R0.2}$,.Shear (36,6%$Y_{R0.2}$),Bearing(80%$Y_{R0.2}$) Machinery's handbook includes some values for steel rivets . I have interpreted these values and include them below as rough approximate values for first estimate. These are typical values for ductile steel. Tensile (76MPa), Shear (61MPa), Bearing (131MPa)

VI. ANALYSIS OF RIVET

The material properties which are used for analysis of rivet

Table Material properties of adherents and adhesive used			
Material	Young's modulus (N/mm^2)	Poisson's ratio	Shear modulus (Gpa)
Adhesive	2.5×10^3	0.38	0.905
Steel	2.0×10^5	0.30	78.1

Table.1.0 Material properties

6.1 Results and discussions

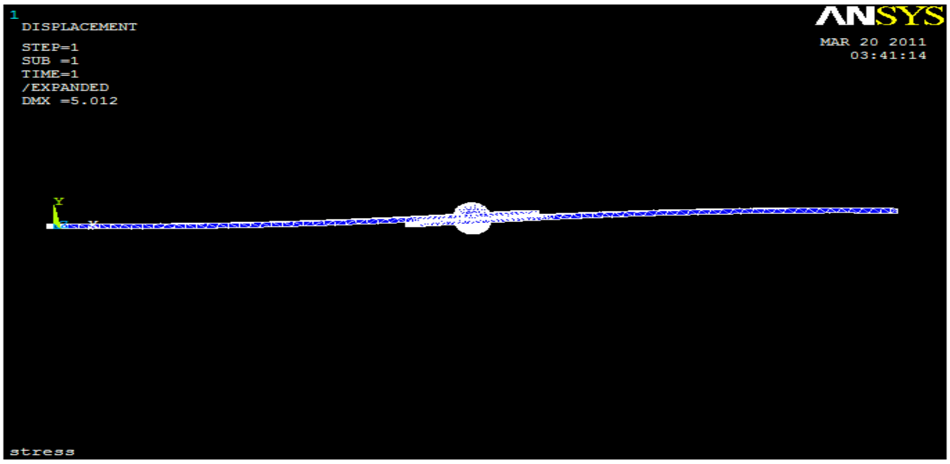

Fig.1.3 The Deformation of a single lap riveted joint without adhesive

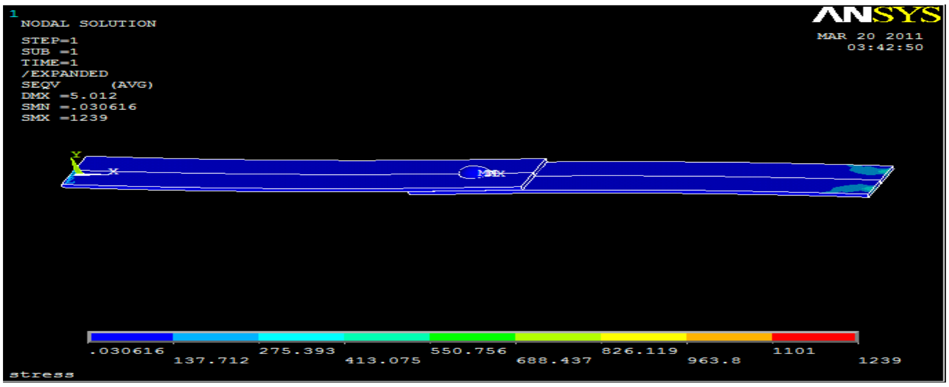

Fig.1.4 The stress distribution of a single lap riveted joint without adhesive

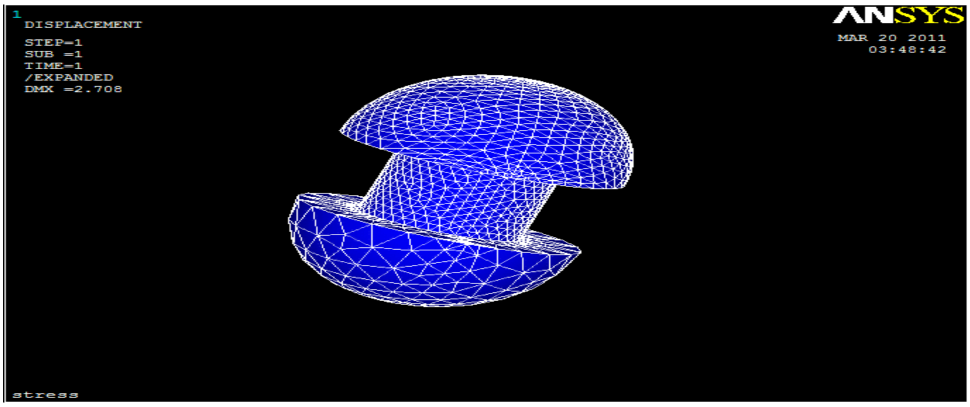

Fig.1.5 the Deformation of a rivet without adhesive

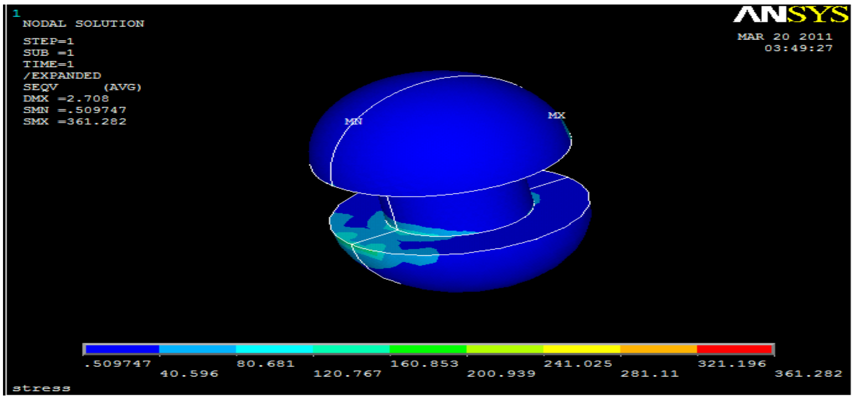

Fig.1.6 The stress distribution of a rivet without adhesive

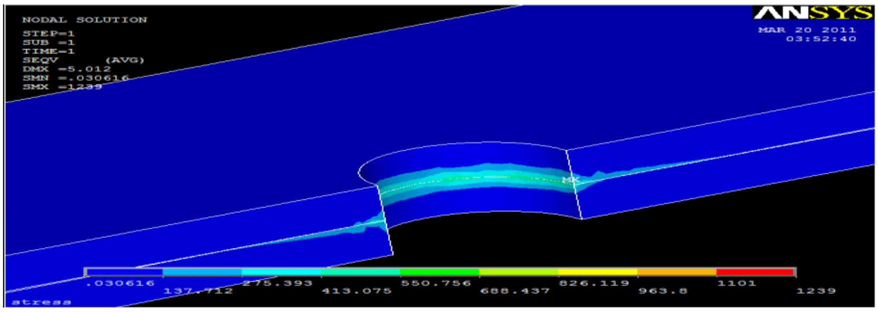

Fig.1.7 The stress distribution of a single lap riveted joint without adhesive and shows at the contact of plates and rivet.

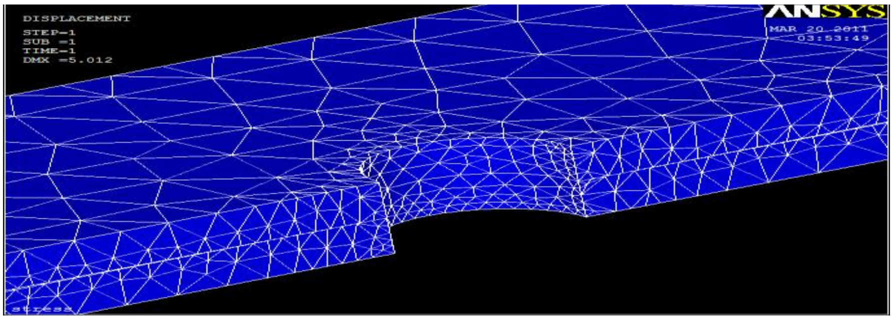

Fig.1.8 The stress distribution of a single lap riveted joint without adhesive and shows at the contact of plates and rivet with meshing elements.

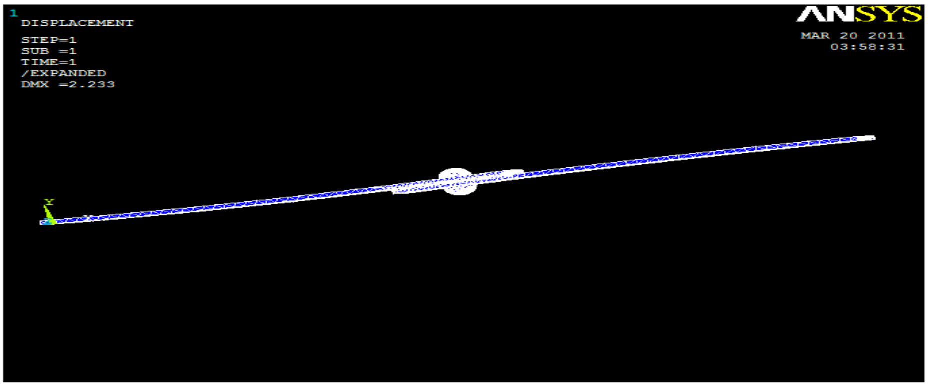

Fig.1.9 The deformation of a single lap riveted joint with adhesive b/w the plates only.

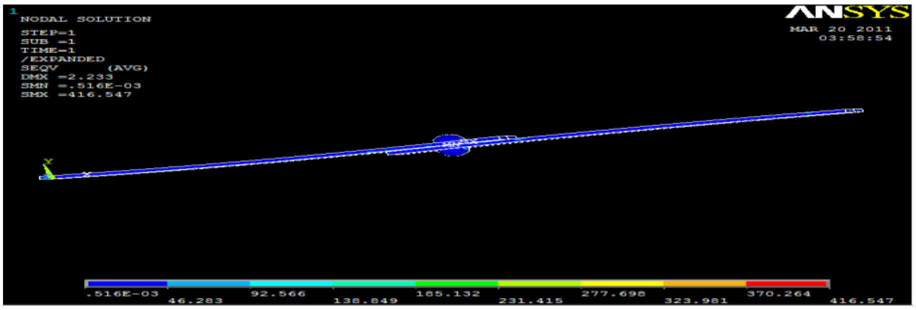

Fig.2.0The stress distribution of a single lap riveted joint with adhesive b/w the plates only.

VII. CONCLUSION

- Finite Element Method is found to be most effective tool for designing mechanical components like single lap riveted joints.
- ANSYS can be used for analysis of complex and simple models of different type without any effect on practical and economical issues.
- The results obtained from ANSYS software for the Adhesively Bonded Single lap riveted joints are compared with each other at different conditions of using adhesives at described locations leads to decreasing the stresses, uniform distribution of load gives more efficient and life to the joints.

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