Study Strength of Blind Riveted Lap Joint Structure under Tensile Shear Force

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***Abstract*—In joint of sheets, blind rivet assembly is considered one of the most important and suitable ways to achieve a big amount of shear stresses in the structure without failure, blind rivets describe a hollow body contain a mandrel or stem, and when the rivet is set, mandrel pull and the body are deformed to clamp and hold the materials of the plates together securely. Blind rivets are easy to install, versatile, and unlike many fasteners, the failure of lap joints is most likely to occur as a result of shear failure of the rivets itself or bearing failure (crushing) of the plate, or tensile failure of the plates of structure, alone or in combination depending on the makeup of the joints. This investigation is concerned to study the influence of hole diameter, length of the rivet, the thickness of joint and using washer on the secondary head side of the generated shear stress, the mechanical behavior, particularly, ultimate tensile strength were investigated using a universal testing machine. The result shows that the maximum tensile force to increase when the hole diameter increase, changing the length of rivet influence on the strength of the structure the maximum tensile force increases with an increase the length of rivet, Furthermore, maximum shear force increase with decreasing the thickness of sheets and using the washer produces same results as increasing the maximum shear force before failure of the structure.**

***Index Terms*— blind rivet, single lap joint, tensile test and shears force**

I. INTRODUCTION

In manufacturing word one of the most important aspects is how to choose the method of assembly parts, assembly means that many parts put together to perform a specific function and increase manufacturing process efficiency, assembly methods of joining parts are extremely important in the engineering of a quality design, so it is necessary to have a thorough understanding of the performance of joints and fasteners under all conditions of use and design. The field of assembly is very large and there are a large number of different assembly methods, in sustainable manufacturing, joining process has a big role and consider a key for enabling technology. General assembly (fastening) parts may be classified into two groups, First permanents fastening and temporary or detachable fastening, second temporary or detachable fastening. In permanent fasting structure, the parts cannot be disassembled without destroying the connecting parts, such as welding and riveted joints, while the temporary or detachable fastening are those fastening types which can be disassembly structured without destroying the connecting parts [1]. Improvements of traditional processes for monolithic structures and material properties as well as extended use of additive manufacturing processes lead to decrease joining parts and the number of joints in a product [2].

Blind rivets consider as permanent fastening, riveted joints similar to the welded and adhesive joints. Blind riveted joints have been used in many applications including automotive applications, airplane structure manufacturing furniture applications, building, and construction and appliance application. Blind rivets are most commonly used in steel, stainless steel, aluminum and copper, one of the biggest benefits of blind rivets is combining different materials in the structure, this kind of joining technology allows to effectively joining materials with a significant difference in mechanical properties, for example, soft with tough materials [3]. For minimum corrosion and maximum strength of the structure, the rivets should be made of materials that match the materials of the pieces to be joined. Generally riveted joint, in larger quantities joints, sometimes cheaper than the other options, but it requires higher skill levels and more access to both sides of the joint structure [4]. Blind rivet materials usually made soft and ductile materials such as aluminum.

Blind rivets are mainly used in applications where there is no access to the rear side of the joint. The industry factory offers a wide variety of general-purpose rivets with standard size and shape, depending on the design of the rivet shank shape [5].

Blind rivets consider alternative solution to assembly parts instead of threaded fastener in many cases, to avoid the disadvantages related to through drilling fasteners [6]

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The blind rivets have a two-piece construction; one is called the rivet body, or a hat and another piece are called a mandrel as shown in Fig. 1.

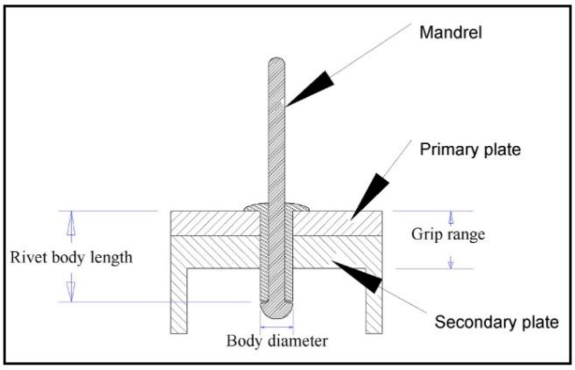

Figure 1. Assembly with two plates with blind rivet.

There are two types of blind riveted joints, the lap-joint, and the butt-joint. In the lap-joint, the plates (two or more) overlap each other and are held together by one or more rows of blind rivets. While in the butt-joint, the plates (two or more) being joined in the same plane and are joined using a cover plate (one side or both sides), which is riveted to both plates by single or more rows of blind rivets. In the joints of pieces the strength of the structure is an important requirement of the designer, thus the choice of an optimized parameter such as hole size, grip range, joint thickness the main purpose.

In all installation of blind rivets in structures, the inspection for the assessment consider important, especially when factor of safety for structure has big priority, such as aircraft in order to reduce operation cost and maintenance.

This research aims to investigate the effect of parameters hole diameter, joint thickness, rivet body length and using the washer in the secondary head on the resulting of structural strength, to achieve such research objective shear test for lap joint studied.

II. Experimental Procedure

A. *Description of Blind Rivet and Tested Specimen Geometry*

Experiments involved fabricating single-lap riveted joints of two mild steel constructional steel sheets, a plain lap consider joint between two pieces of metal in which the pieces overlap without any change in the form of sheets. Holes made in the center of overlap sheets and riveted with aluminum alloy blind rivets, because of low coast, riveting provides neatness and strength as well as lighter weight, aluminum rivets used widely. The used rivets had same diameter of the body cylinder part (4.8 mm), and the blind rivets were driven by using hand pliers rivet tool. Lap joint prepared from the sheet with materials mild steel, described by the following dimensions (90 mm long and 30 mm width) with thickness as shown in Fig. 2.

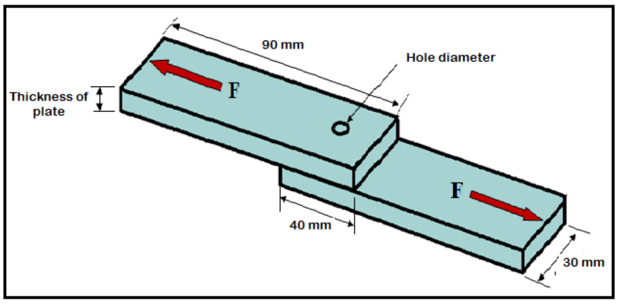

Figure 2. Specimen geometry.

B. *Methodology*

The mechanism of fracture during shear tests on the maximum load-bearing capacity of lap joints was experimentally analyzed by study force-displacement curves constructed during the shear test for 30 samples; good surface edges of specimens were obtained by chamfering the drilled hole edges in order to prevent structural defects as possible. The investigation was planned to determine the influence of several variable such as hole diameter, rivet body length, and using the washer, for determining the maximum strength of blind rivet to kind of test conducted the static shear test.

For all joints, the two ends of joint fixed by bolts on the testing machine and the static shear tests (lap joints) and tensile tests were performed with the force-displacement curves recorded via a TQ SM 1000 Universal material testing machine at room temperature. Fig. (3) shows the bearing stress between the plate and rivet.

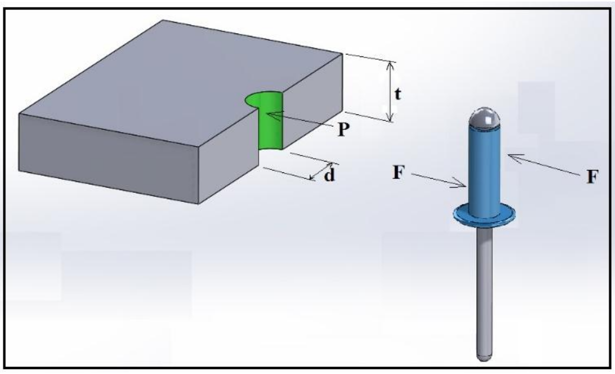

Figure 3. Bearing stress between plate and rivet.

Equation (1) determines the Shearing stress failure in rivets.

$$\tau = \frac{F}{\frac{\pi d^2}{4}} \tag{1}$$

where (τ) shear stress structure of the blind rivet, (F) applied force on specimen and (d) diameter of the rivet, equation (2) represent bearing stress between the plate and rivet.

$$\sigma_b = \frac{p}{d * t} \tag{2}$$

where (p) applied force on the hole surface, (d) hole diameter and (t) thickness of the plate.

III. Results and Discussion

When the blind rivet is tightening completed on the structure, an initial compressed load is placed on the rivet body that must be taken into account in determining its safe working proper strength or external load-carrying capacity.

In the shear test, the force loading of the lap joint lead to stress concentrations on the contact surface of the rivet and the hole, in this investigation the applied load increased by the failure in structure appears, all the failures appear in the rivet itself without and deformation in the specimens.

The results of shear force that can bear the structure before failure when changing the diameter in three different sheets of single holes as shown in Fig. (4), rivet holes drilled usually larger than the nominal diameter of the rivet body, with keeping the length of rivet constant(L=20 mm), the joint loadings reached close values in force-displacement curves in test, results of shear force (D=5 mm) around 1.4 KN and extension reached to 1.73 mm before failure of structure, while the maximum shear force reached 1.53 KN when the diameter of hole equal 5.5 mm with extension 1.78 mm, when the diameter equal 6 mm, maximum shear force reached 1.5 KN, the clearance between the rivet body and the hole caused the rivet to tilt in the hole during the tensile shear force effect and lead to increase the extension between the spacemen to 2.8 mm before failure.

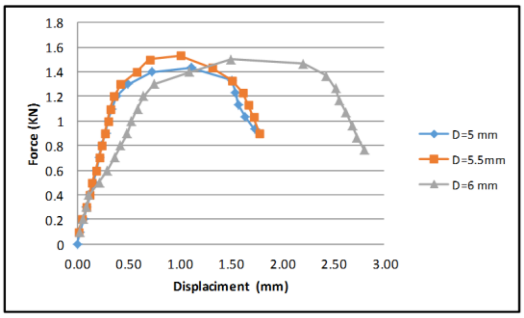

Figure 4. Change diameter of hole (D= 5 mm, 5.5 mm and 6 mm).

Fig. (5) shows the results of changing the rivet body length on the maximum shear force applied to the specimens before failure, by keeping constant diameter equal 5mm. Increasing the length of rivet body lead to increase bearing shear force of structure, this trend observed for all tested types of joint, when the length of rivet body equal 10 mm the maximum shear force reached 1 KN with extension 2.34 mm, when the length of rivet increased to 12 mm, the maximum bearing shear force increased 10%, so it reached 1.1 KN with extension equal to 1.92 mm, while in the third samples the length of rivet body equal 20 mm the maximum shear force reached 1.4 KN with increasing 40%, with extension equal 1.73 mm.

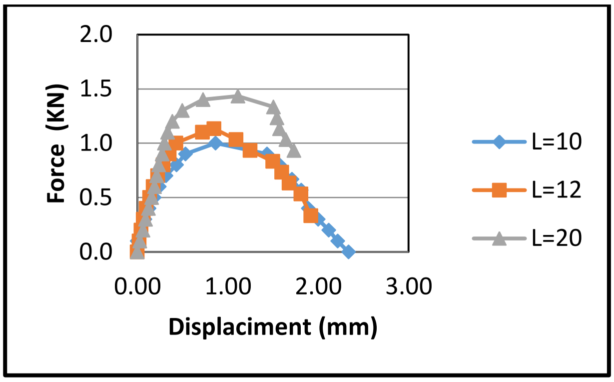

Figure 5. Change length of the rivet (L= 10 mm, 12 mm and 20 mm).

The thickness of the material joints influences the strength of the joint, the results for single lap joint thickness shown in Fig. (6) by keeping constant diameter equal 5 mm and the length of rivet constant and equal 10 mm. When the thickness of the plate equal 0.8 mm the maximum shear force reached 1.3 KN with extension 3.12 mm when the thickness of the plate equal 1.8 mm the maximum shear force reached 1 KN with extension 2.08 mm. The tilting of structure and deformation in plats with 0.8 mm thickness sustains higher load capacity than riveted joints of 1.8 mm thickness.

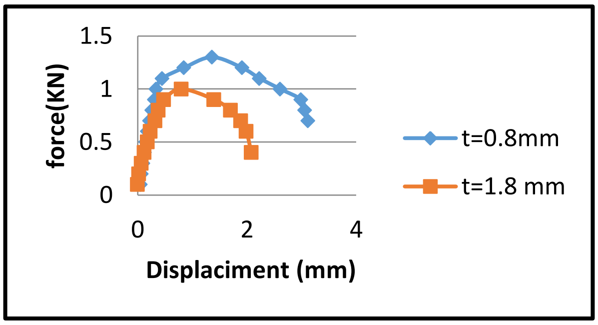

Figure 6. Change joint thicknesses (0.8 mm and 1.8 mm).

The results of using a washer on the secondary head sideshow in Fig. (7), washers generally use to increase the strength of structure by increasing the contact area between the deformed secondary head of the rivet body after assembly completed and the plate surface, which prevent the tilting of the rivet in the hole during the tensile shear force effect. The analysis of the data in Fig. (7) reveals that using washer in the secondary head at the back of the plate have a higher shear force capacity than structure tested without using the washer When the washed used the maximum shear force reached 1.6 KN with extension 1.8 mm, while without washer the maximum shear force reached 1.4 KN with extension 1.7 mm before failure.

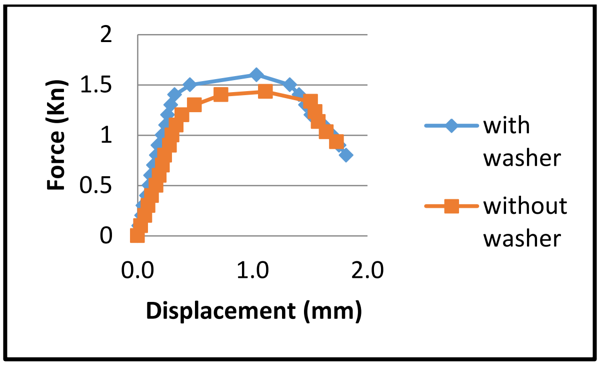

Figure 7. Effect of using a washer on the secondary head side.

IV. Conclusion

In properly design and assembly, structural member or mechanical element of blind rivet, it is necessary to restrict the shear stress in the structural parts to a level that will be safe, the stress can reduce by changing the parameters, such as hole diameter, length of rivet, thickness of structure and using the washer on the secondary head side,

This paper presents the experimental analysis of the capacity of a single joint load for blind rivets and the statistical analysis of the results. The most important conclusions are:

1) Changing the hole diameter in structure influence on the maximum load-bearing capacity of the joints, when shear forces subjected to the structure, also the displacement of joint structure increase by increasing the hole diameter.

2) The length of the rivet will change the grip range, which affects the maximum bearing shear force of the structure; increase the length of rivet lead to increase the bearing shear force.

3) When the plates of joint thickness decrease the maximum bearing of shear force increases. Because of the applied shear force, in thin plates, the deformation and tilting of the structure appear greater than thick plates

4) Using washer to increase the secondary head area of the rivet, which led to an increase the maximum load-bearing capacity of the joints.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper

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