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Development of a Rivet Extractor

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Abstract: A manual rivet extractor was designed and fabricated to facilitate removal of blind rivets of sizes 4.0mm x 19mm and 4.8mm x 19mm from joints, machines and other structured assemblies without causing damages to joined components. The extractor parts were made up of mild steel. It had two head screw of 5mm and 4mm beak. It is a manually operated device that was readily be fabricated in simple workshop. Safety load of each head screw of 5mm and 4mm beak were calculated to be 120.69KN and 94.54KN respectively. The torques on them were 452.58Nm and 283.62Nm respectively. It is a robust and handy device that when operated carefully is expected to be useful for operator for a while.

Keywords: Extractor; rivet; beak; joint; torque

1. Introduction

The crude method of disassembling riveted joint by the use of pinches cause damage to the parent material. Effort is now made to design a friendly use and handy device that extracts (disassembles) riveted joint without causing damage to the parent materials. This device is also extended to use in pressing out link pins from cycle and motorcycle chains. The component of the rivet extractor are; the handle, the round screw head, the body, the pin and the support (L-attachment). The handle been attached with the round screw head which when turned round proceeds through the body to a bore on the L-support at the riveted joint head for withdrawal of the rivet.

Blind rivets are designed for use where only one side of the joint is accessible. They are primarily for structural joints of both light and heavy gauge materials, and for this purpose are usually made of mild steel. For application where lightness and resistance to corrosion is important pure aluminum alloys, titanium, copper, brass and morel may be used. There are also structural blind rivet, which are designed to take shear and tensile loads, [1]. These blind rivets are of different sizes, namely; 3.8mm x 19mm with hole size of 3.9mm, 4.0mm x 19mm with hole size of 4.1mm, 4.8mm x 19mm with hole size of 4.9mm sizes respectively. Blind rivets have grip range from 13.5mm to 15.5mm.

The function of a rivet in a joint is to make a connection that has strength and tightness. The strength is necessary in order to contribute to strength and to prevent leakage as in a boiler or in a ship hull, [2]. Ref. [3] design a tool that was design mainly for the Finish nails, Staples, Brads, Pin-nail, Screws, Cleats and Brackets, Rusty or damaged fasteners, Pneumatic fasteners, Headed nails, Ring shank and screw nails, Hardwood floor fasteners, and Structural fasteners. The entire tool is drop forged of the same steel used in the jaws of bolt-cutters. In addition, all 22 teeth are induction hardened to the same Rockwell hardness equal to a high grade of wire cutter. China

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chain extractor were produce in the year 2010 mainly for the extraction of blind rivet removing/pressing out of chain links for repair application. There are different varieties of the chain rivet extractor. The chain rivet extractor was made from aluminum alloy. And this gives the device a good resistance to corrosion, because of the presence of aluminum in the material [4]. In using the extractor, the materials to be disassemble is placed in between the L-support and the body of the rivet extractor and the round screw head is driven into the hole of the rivet by a clockwise turning of the handle, until the round screw head gets a firm grip inside the hole of rivet joint head. Thereby, as the body is being lifted up anticlockwise, the round screw head is pulled out slowly along with the rivet.

2. Theoretical analysis

2.1. Rivet materials

According to [5] rivets for mechanical and structural applications are normally made from ductile (low carbon) steel or wrought iron. For applications where weight, corrosion, or material constraints apply, rivets can be made from copper (+alloys), aluminium (+alloys), etc. The properties of a material enable the material to withstand chemical reactions or to react with other chemicals. This depends on the atomic structure of the material and also the carbon content. Such reaction includes burning, rusting or corrosion [6].

2.2. 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 yields stress (0.2% proof stress) YR0.2 as follows:- hand driven rivets tensile stress (40%YR0.2), shear (36.6%YR0.2), bearing (80%YR0.2) Machinery's handbook includes some values for steel rivets. These are typical values for ductile steel: tensile (76MPa), shear (61MPa) and bearing (131MPa), [5].

3. Design analysis (design calculation)

3.1. Tensile strength of a blind rivet

According to Ajax fasteners rivet handbook, the tensile strength of aluminum shell of a blind rivet is around 1500KN-1600KN.

3.2. Tensile strength of aluminum shell of blind rivet by calculation

Using the formula[6];

$$\sigma_{uts} = \frac{F}{A} \tag{1}$$

Where, $\sigma_{uts} =$ ultimate tensile stress in N/m^2.
F = tensile strength in N.
A = area in m^2.

Thus, $\sigma_{utsAl} = \frac{F_{Al}}{A_{Al}}$

Implies, $F_{Al} = \sigma_{utsAl} \times A_{Al}$ (2)

Where, F_{Al} = tensile strength of aluminum (in N).

σ_{utsAl} = ultimate stress of aluminum (in N/m^2).

A_{Al} = area of aluminum shell (m^2).

$A_{Al} = \pi r^2 + \pi r^2 + 2\pi rh$

$A_{Al} = 2\pi r(r + h)$ (3)

3.2.1. For aluminum rivet shell of size 4.8mm x 19mm

Known: $\sigma_{utsAl} = 310MPa = 310N/mm^2$ (University of Liver pool).

Diameter of the rivet shell, D = 4.8mm,

Radius of the rivet shell, r = $\frac{4.8}{2} = 2.4mm,$

Height of the rivet shell, h = 19mm.

From equation (3),

$A_{Al} = 2 \times \frac{22}{7} \times 2.4(2.4 + 19)$

$A_{Al} = 322.83mm^2$.

From equation (2),

$F_{Al} = 310 \times 322.83$

$F_{Al} = 100{,}078.63N = 100.08KN.$ (Tensile strength of aluminum shell of size 4.8mm x 19mm).

3.2.2. For aluminum rivet shell of size 4mm x 19mm

Known: height of rivet shell, h = 19mm,

Diameter of the rivet shell, D = 4mm,

Radius of the rivet shell, $r = \frac{D}{2} = \frac{4}{2} = 2mm.$

From equation (3);

$A_{Al} = 2 \times \frac{22}{7} \times 2(2 + 19)$

$A_{Al} = 264mm^2$

From equation (2);

$F_{Al} = 310 \times 264 = 81{,}840N$

Thus, $F_{Al} = 81.84KN.$ (Tensile strength of aluminum shell of size 4mm x 19mm).

3.3. Tensile stress of mild steel

To calculate the tensile strength of the effective area of head screw made of mild steel;

Using the formula, $\sigma_{utsms} = \frac{F_{ms}}{A_{ms}}$

Implies that, $F_{ms} = \sigma_{utsms} \times A_{ms}$ (4)

Where: $F_{ms} =$ tensile strength of mild steel (N),

$\sigma_{utsms} =$ ultimate stress of mild steel (N/m^2),

And $A_{ms} =$ effective area of the head screw or beak (m^2).

But, $A_{ms} =$ area of cylinder $+$ surface area of cone.

Area of cylinder $= 2\pi r(r + h_e)$

Surface area of cone= πrs
Thus, $A_{ms} = 2\pi r(r + h_e) + \pi rs$ (5)
Where: r = radius of the beak (in mm),
h_e= height of the effective area of the beak (in mm),
S = length of the slant side of the cone (in mm).

3.3.1. For beak ofsize 5mm diameter

From equation (5), we have;
$A_{ms} = 2 \times \frac{22}{7} \times 2.5(2.5 + 19) + \frac{22}{7} \times 2.5 \times 5$
Where, $\pi = \frac{22}{7}$,
$r = 2.5mm$,
$s = 5mm$,
And, $h_e = 19mm$.
Thus, $A_{ms} = 337.86 + 39.29\ mm^2$
From equation (4), we have;
$F_{ms} = 480 \times 377.15\ N$
Where, $\sigma_{utsms} = 480\ GPa = 480\ MN/m2 = 480N/mm^2$ (strength of mat. R. H. Ryder).
$F_{ms} = 181{,}029.92\ N = 181.03\ KN$.
Using factors of safety, n = 1.5.
The safety load will be; $F_{ms} = \frac{181.03}{1.5} = 120.69KN$.

3.3.2. For beak of size 4mm diameter

From equation (5), we have;
$A_{ms} = 2 \times \frac{22}{7} \times 2(2 + 19) + \frac{22}{7} \times 2 \times 5$
Where, $\pi = \frac{22}{7}$,
$r = 2mm$,
$s = 5mm$,
And, $h_e = 19mm$.
$A_{ms} = 264 + 31.43\ mm^2$
$A_{ms} = 295.43\ mm^2$(effective area of the beak).
From equation (4), we have;
$F_{ms} = 480 \times 295.43\ N$
$F_{ms} = 141{,}805.71N = 141.81KN$.
Using factors of safety, n = 1.5.
The safety load will be; $F_{ms} = \frac{141.81}{1.5} = 94.54KN$.
Using the equation; Torque = Force × Radius
$T = F \times r$ (6)
Where, T = Torque in Nm,
F = Tensile strength of material in N,
r = Radius of material in m.

3.4.1. Torque for head Screw with Beak of Diameter 5mm

Known, $F = 181.03 \times 10^3 N$,
$r = 2.5mm = 2.5 \times 10^{-3} m$.
From equation (6),we have;
$T = 181.03 \times 10^3 \times 2.5 \times 10^{-3} Nm$
Thus, Torque,$T = 452.58 Nm$.

3.4.2. Torque for head screw with beak of diameter 4mm

Known, $F = 141.81 \times 10^3 N$,
$r = 2mm = 2 \times 10^{-3} m$.
From equation (6),we have;
$T = 141.81 \times 10^3 \times 2 \times 10^{-3} Nm$
Thus, Torque, $T = 283.62 Nm$.

4. Materials and methods

4.1. Production of each parts of the rivet extractor

The each part of rivet extractor was produced as follows.

4.1.1. Production of the body

These are the steps taken in producing the body:

1. First of all, from the parent metal bar of size 400mm length by 50mm width by 25mmheight long bar was marked out with steel rule and scriber to size 240mm length which was cut out with hacksaw on the bench vice.
2. The material was squared to the required rectangular shape of 240mm length by 40mm width by 25mm height on a milling machine.
3. Try square was used to ensure accuracy of the squared edges on the marking out table.
4. Marking out of the two slots of 20mm x 10mm along the length of the bar was carried out on the work bench and this was taken to the vice and the slot was cut out with hacksaw. The slot was filed to achieve accurate and smooth surface.
5. Along the length, starting from 100mm to the end, 10mm was measure inward along the width and marked, starting from the edge along the width, for the four edges. After then, the body was taken to the bench vice and was chamfered.
6. Inside the slot, along height and width, the center of the 10mm diameter hole was located and the pilot hole was made by the use of center punch and hammer. Also, the center of the 22.5mm diameter hole was marked out along the length and width on the body.
7. The drilling of the threaded hole and slots hole were carried out with drilling machine of drilling bit of 22.5mm and 10mm respectively.
8. The internal thread, smooth threading, was made by using tap wrench of size 24mm x 22.5mm.
9. The component was clean up with emery cloth.

4.1.2. Production of the L-Support

These are the steps taken in producing the L-support:

1. From the parent metal bar of size 160mm length by 50mm width by 25mm height,the marking out of size of the metal to 130mm length was done on the marking out table and the metal was cut out on the bench vice with the use of hacksaw.
2. The metal was squared to rectangular shape on the milling machine to 130mm length by 40mm width by 20mm height.
3. Try square was used to ensure accuracy of the squared edges on the marking out table.
4. With the use of a ruler and a scriber the 130mm bar was measured along the length on a workbench to 40mm length and was taken to the bench vice for cutting with the use of hacksaw.
5. One side of the metal bar, 40mm length by 40mm width, was center punched and a hole of 8mm in diameter was drilled with a drilling machine with a drilling bit of size 8mm.
6. The second side of the metal bar, of size 90mm length by 40mm width, was marked out and cut at the edges to create an align joint to the body slot of size 20mm length by 20mm width by 25mm height. This was done on a bench vice with the use of hacksaw and finish with a file.
7. At the slot side, the center of the hole as located with ruler and scriber. The center was center punched and drilled with a drilling bit of size 10mm in diameter.
8. The second side of the bar was stand vertically at right angle on the work-bench and the first side of the bar, size 40mm x 40mm, was brought horizontally to the second side and arc welded together with the use of solder.
9. After which grinder and hand file was used to produce the edge or remove the excessive solder from the joint.

   Finally, emery cloth was used for the surface finishing.

4.1.3. Production of the Pin

These are the steps taken in producing the pin:

1. From a parent cylindrical bar of 700mm length by 35mm in diameter, after fixing it properly on the shuck of a lathe machine, the metal rod was turn on a lathe machine to 40mm length by 10mm diameter after been marked out by venire caliper and scriber.
2. The accuracy of the length and the diameter was ensured with venirecaliper before the pin was finally cut off with the use of hacksaw from the parent metal.
3. Finally, emery cloth was used for the surface finishing.

4.1.4. Production of the Handle

These are the steps taken in producing the handle:

1. From the remaining rod of length 660mm, the rod wasread just and tighten properly on the shuck.
2. The rod was marked out at 200mm length using venire caliper and scriber.
3. The marked out portion was turned to 16mm diameter.
4. The machine surface was cut-off using hacksaw.
5. Emery cloth was used for the surface finishing.

4.1.5. Production of the Screws

These are the steps taken in producing the screws:
For head screw of beak 5mm diameter,

1. From the remaining cylindrical bar on the shuck, the rod was readjusted and retighten to get the required length of the first head screw (190mm length).
2. With the aid of venire caliper and scriber the length of 60mm was marked out.
3. The marked out length was machine on the center lathe machine to 5mm diameter.
4. Measured incrementally from 60mm inward (toward the shuck), 90mm was marked out with use of venire caliper and scriber.
5. The 90mm length was machine to 24mm diameter.
6. The external threading was also carried out on the lathe machine to a debt of 1.5mm.
7. 40mm was further marked out and machine to 32mm diameter.
8. Hacksaw was used to cut off the already machined component.
9. Hold with a vice, the handle hole of 16mm was drilled on the headed portion of the screw on drilling machine after been center punched.
10. Emery cloth was used for the surface finishing.

For head screw of beak 4mm diameter,
the steps are the same as above for head screw of beak 5mm diameter above, but with a difference in step iii. Thus, for head screw of beak 4mm the marked out length was machine on the center lathe machine to 5mm diameter.

A higher order shear deformation theory with thickness stretching effect was successfully developed and applied to study the buckling behavior of functionally graded plates without enforcing zero transverse shear stresses on the top and bottom surfaces of the plate. This eliminated the need of using shear correction factors. It can be concluded that for getting the more improved results for buckling the thickness stretching effect should be included in the development of the higher order theory for simply supported FG plates. Hence, the present findings will be useful benchmark for evaluating the other future plate theories and numerical methods such as the finite element and meshless methods.

5. Testing

The materials to be disassemble was placed in between the L-support and the body of the rivet extractor and the round screw head was driven into the hole of the rivet by a clockwise turning of the handle, until the round screw head gets a firm grip inside the hole of rivet joint head. As the body was being lifted up anticlockwise, the round screw head was pulled out slowly along with the rivet.

6. Result and Discussion

Based on the testing of the machine on different combination of materials, it was clearly seen or proved that the rivet extractor device extract or remove blind rivet from joined materials efficiently and neatly compare to other crude tools, like pinches and punch and hammer, commonly used. The threaded beak and the cone shape at the tip of the beak gives this rivet extractor device more advantages over the existing one in the market. The cone shape tip of the beak enable the beak to find its way into the rivet head and push out the pin from the rivet shell with ease, while the threaded portion of the beak allowed firm grip on the wall of the rivet shell and prevent the shell

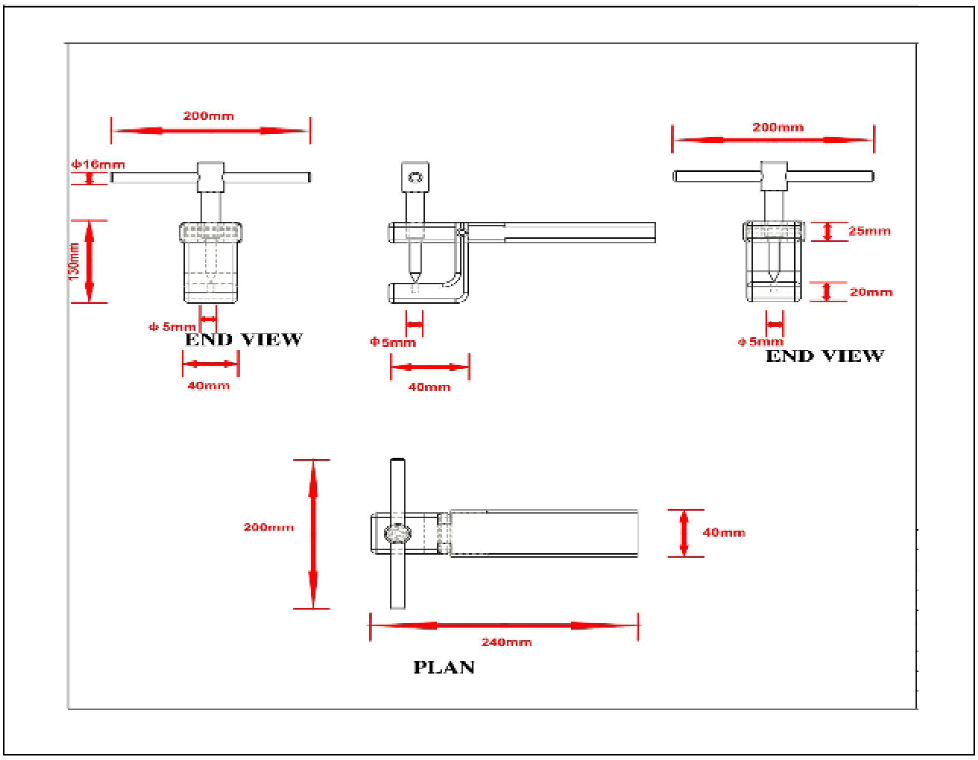

Figure 1: Orthographic Drawing of the Rivet Extractor.

from falling into the material (in case of hollow material). During testing it was observed that the extractor become less effective (efficiency become low) to remove rivet if there is any distortion or defect on the rivet or the joint. Also for aluminium rivet shell the extractor device must not be remove once it is engaged with the wall of rivet shell otherwise one will need greater force to remove the pin from the rivet shell. This happen because once the threaded beak is remove and reengage it spoil the thread created by the beak in the first engagement with the aluminum shell, and the thread that the beak make with the rivet shell is what make the remover of the pin from the shell easy. It was proved by testing to be effective, save time and energy compare to other crude equipment used. This are the advantages of this rivet extractor device in compare to other crude tools commonly used and other rivet extractors in existence after testing or experimentation.

7. Conclusion

In carrying out this project we have successfully fabricated a manual rivet extractor device. A simple device that can easily remove a rivet was designed and fabricated. The material selected for the fabrication is cost effective and available and the method used in producing this device is simple. This device simply extracted the rivet without any damage or distortion to the joint, compared to the improvising methoded applied by used of crude tools. The device also helped in the saving of time and energy, compared to when other improper equipment are used. Therefore, this device can be used in all workshops to improve upon the method of rivet extracting operation.

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