iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: XI Month of publication: November 2021

DOI: https://doi.org/10.22214/ijraset.2021.39177

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Case Study of Strength Calculation and the Possible Repair Options for Screw Thread Damages

Chandrasekhar Narahari[1], Karthik Chilumoju[2], Kiran Kumar Singani[3], Vamshi Kiran Bathku[4], Swathi Vaidehi K[5]
[1, 2, 3, 4, 5]*Independent Researcher*

Abstract: Thread Strength and repair capability are critical to successful screw joints for any mechanical assembly. This paper explores the effect of the thread damage utilizing hand calculations, the margin of safety (MOS) for internal & external threads and compares with the required design criteria limit. Hence, the reduction in thread capability is analyzed in terms of shear and bearing strength of threads. This paper also emphasizes the Industry-standard repair techniques such as Helical inserts, Oversize inserts, and Twinserts with limitations and expected process/techniques. Advanced thread repairs in the market such as solid-body thread inserts (key-style, Time-sert, Big-sert) are also discussed
Keywords: Thread damages, Shear strength, bearing strength. STI (Screw thread insert)

I. INTRODUCTION

During assembly and disassembly of bolted-joint components, thread damage and deformation may occur. When a reliable design is achieved, screw joints are designed so that the effective cross-section area is determinative for the assembly's strength, i.e., the screw fails instead of the internal or external threads strips. The minimum length of the screw engagement should be sufficient to hold the complete load necessary to interrupt the screw. If not, thread stripping will start at the very first engaged thread and shears off subsequent threads. This joint may appear fine at the time of assembly but will fail in service. The size of a screwed fastener is first determined by calculating the required tensile area and factor of safety. If the joint is fixed using a nut and bolt from a comparably similar grade, there is no need to size the nut while the standard length of the nut is sized in such a way that the screw will be failing before the thread gets stripped off. If the bolt fastens into a tapped hole with low strength material, checking the thread engagement length is required. The formula defines the shear strength of a material $F_s = \tau A_{th}$ where τ = shear strength and A_{th} = thread shear area. The internal thread (in the tapped hole) is more robust in shear than the external thread, and the threads are of the same material. For optimum results of the thread stripping strength, the effects like nut dilation (impact of radial displacement), thread bending, and tolerances of thread dimensions have been dis-regarded.

Calculating the required thread engagement length in a joint is a complex problem. To ensure that thread stripping does not occur from rigorous and extensive tests, thread strength needs to be calculated by the different range of engagement lengths.

A. Thread Inserts

In repair applications, inserts are utilized to restore damaged tapped holes or existing damaged inserts previously installed in tapped holes. This has empowered industries to use lighter-weight materials like aluminum without surrendering the thread strength of their fasteners. Wire thread inserts are helically coiled fastening devices that provide permanent, wear-resistant screw threads that surpass the strength of most parent materials (like aluminum, zinc die castings, wood, magnesium, etc.). The inserts are designed to guard tapped holes against failures due to stripping, seizing, corrosion, and wear. The helically formed coils of diamond-shaped stainless steel wire or phosphor bronze wire screw into a threaded hole form an internal mating thread for a screw or stud. Two types of Heli-Coil thread repair kits are available to correct STI errors and standard tapped holes. Twinserts and Oversize inserts facilitate the use of the original bolt size after the repair has been made. Oversize inserts are primarily used to correct Heli-Coil insert assemblies, which need to gauge oversize due to tapping errors. Effective repair and correction are achieved through a more extensive wire cross-section. Twinserts offer better repair by enlarging the diameter and installing one insert inside another. This larger diameter allows repair of off-center STI, stripped STI holes, and standard tapped hole damages. Holes tapped with the incorrect diameter and pitch also can be repaired.

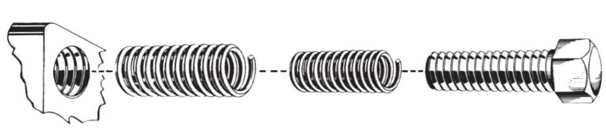


Figure 1: Assembly of Twinsert-Helical insert-Bolt

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

B. Shear Stress and Bearing Stress Calculation

1) *Shear Stress:* Thread shear is a crucial failure mode for a bolted joint, and it occurs when the threads shear off either of the bolt (external thread shear) or the nut or tapped part (internal thread shear). There should be sufficient engagement between the bolt and internal threads so that the bolt fails in tension before the threads shear. This will make sure that the full strength of the bolt is developed (therefore, there is no "wasted" bolt strength), and it will avoid the task of drilling and re-tapping the internal thread. Thread shear should be assessed for both the external (bolt) thread and the internal thread.

Following formulae calculate shear areas of external and internal threads:

$$A_{se} = \pi n K_{n,max}\left(\frac{1}{2n} + \frac{1}{\sqrt{3}}\left(E_{s,min} - K_{n,max}\right)\right) L_e$$

$$A_{si} = \pi n D_{s,min}\left(\frac{1}{2n} + \frac{1}{\sqrt{3}}\left(D_{s,min} - E_{n,max}\right)\right) L_e$$

$$\sigma_{se} = \frac{F}{A_{se}}$$

$$\sigma_{si} = \frac{F}{A_{si}}$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

Where,

A_{se}: Shear area of External Thread
A_{si}: Shear area of Internal Thread
F: Total load acting at joint location
($F_{preload} + F_{mechanical\ load}$)
σ_{se}: Shear stress of External thread
σ_{si}: Shear stress of Internal Thread
$E_{s,min}$: External thread Min. Pitch Dia
$D_{s,min}$: External thread Min. Major Dia
$K_{n,max}$: Internal thread Max. Minor Dia
$E_{n,max}$: Internal thread Max. Pitch Dia
n: No of threads per inch

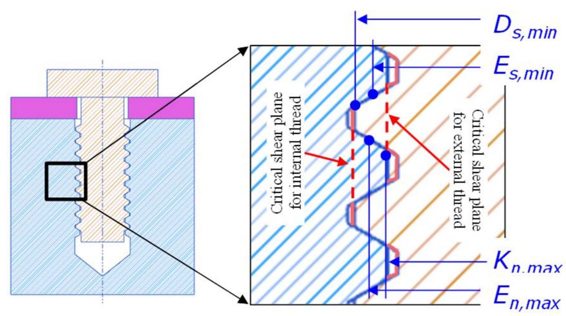


Figure 2. Critical shear plane for External/Internal thread

2) *Bearing Stress:* Bearing stresses are induced due to forces that are acting on the hole and bolt which goes through. A bearing test is to determine if there is any deformation of the hole. Preloading will reduce bearing forces, but not all bolted joints are preloaded. To calculate bearing stress, force is divided over the contact area between the fastener and hole. Theoretically, it is the simple area of the bearing surface. Usually, the load is transmitted through the contact between the plate and the bolt shank by high bearing stress in the plates around the bolt holes and the bolts. The bearing pressure causes high compressive stress in the bolt-plate contact. Initially, a small contact area and high compression stress yield the plate material at less load, allowing hole elongation in the plate material. Bearing area & load acting on threads are the same for external & internal threads. Hence, induced Bearing stress is the same for both external & internal threads. However, MoS will not be the same since material bearing strength properties are different.

$$\sigma_b = \frac{F'}{{A_b}'}$$

$$F' = F \times \cos(90 - \theta)$$

$$Ab' = \frac{A_b}{\cos(90 - \theta)}$$

$$A_b = \frac{\pi}{4}\left[D_{s,min}{}^2 - K_{n,max}{}^2\right] nL_e$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

Where,
σ_b : Bearing stress of External & Internal thread
F': Total load acting normal to bearing surface
A_b': Bearing area of External & Internal Thread
F: Total load acting at joint location ($F_{preload} + F_{mechanical\ load}$)
A_b: Bearing area normal to the hole axis
$D_{s,min}$: External thread Min. Major Dia
$K_{n,max}$: Internal thread Max. Minor Dia
n: No of threads per inch
L_e: Thread length
θ: Thread angle

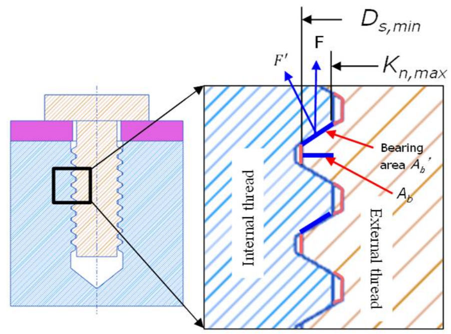


Figure 3. Bearing area for External/Internal thread

C. Length of Thread Engagement

The length of thread engagement is a predominant factor that impacts the threads whether they will experience shear failure or not. A general rule is that length of engagement equal to the bolt diameter is sufficient to protect against thread shear. However, shear calculations should be performed as per the subsequent sections for safety. In a bolted joint with a nut, as long as the bolt protrudes beyond the end of the nut, then the length of thread engagement can be assessed by the nut height, hnut. In reality, there will be some loss of engagement because of the chamfering around the threaded hole in the nut. In a taped joint, the depth of the threads within the final part should equal the minimum of the tapped part thickness, tp, or the bolt nominal diameter, dnom, the length of thread engagement can be estimated the minimum of those values. Note that these estimates do not account for chamfering at the end of the bolt or around the threaded hole in the part. Generally, for thread strength calculation, below formulae are used to calculate thread engagement length,

Nominal Length of thread engagement (Ln) = 1.5*D
No. of threads covered by damage length (N) = (L_d x n) threads
Total no. of net effective threads damaged by thread damage (Ne) = $\left(\frac{W_d}{\pi \times D_m}\right) x\ N$ *threads*
Thread disengagement length due to damage $L_{damage} = \frac{N_e}{n}$

Where,
D : Nominal dia of thread
L_d : Thread damage length. (Axial)
W_d : Thread damage Width. (Circumferential)
n: no of threads per inch
Dm : Min Minor Dia of Thread

II. CASE STUDY

Considerations for thread strength calculations:

1) Thread details: Unified Thread Form Fine Threads (UNJF)
2) Thread Shape: V Shape
3) Thread size: 0.3125-24
4) Preload: 3000 lbf (Assumed)

A. Shear Stress Calculation

Shear stress area of external thread A_{se} is given as.

$$A_{se} = \pi n K_{n,max}\left(\frac{1}{2n}+\frac{1}{\sqrt{3}}(E_{s,min}-K_{n,max})\right)L_e$$

Where,

$L_e: Length\ of\ thread\ Engagement$

$$A_{se} = \pi \times 24 \times 0.275\left(\frac{1}{2\times 24}+\frac{1}{\sqrt{3}}(0.283-0.275)\right)0.469$$

=0.244 inch²

Shear stress area of internal thread A_{si} is given as.

$$A_{si} = \pi n D_{s,min}\left(\frac{1}{2n}+\frac{1}{\sqrt{3}}(D_{s,min}-E_{n,max})\right)L_e$$

$$A_{si} = \pi x 24 \times 0.305\left(\frac{1}{2\times 24}+\frac{1}{\sqrt{3}}(0.305-0.289)\right)0.469$$

=0.326 *inch²*

$$\sigma_{se} = \frac{F}{A_{se}} = \frac{3000}{0.244}$$

$$= 12.31\ ksi$$

$$\sigma_{si} = \frac{F}{A_{si}} = \frac{3000}{0.326}$$

$$= 9.19\ ksi$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

$$M.S\ of\ external\ thread = \frac{69.2-12.31}{12.31} = 4.63$$

$$M.S\ of\ internal\ thread = \frac{69.2-9.19}{9.19} = 6.53$$

B. Bearing Stress Calculation

Bearing stress calculation for checking the impact of the thread

$$A_b = \frac{\pi}{4}\left[{D_{s,min}}^2 - {K_{n,max}}^2\right] n L_e$$

$$= \frac{\pi}{4}[(0.3053)^2 - (0.2799)^2] \times 24 \times 0.4688$$

=0.131 *inch²*

$$Ab' = \frac{A_b}{\cos(90-\theta)}$$

$$= \frac{0.131}{\cos(90-60)}$$

$$= 0.152\ inch^2$$

$$\mathrm{F'} = \mathrm{F} \times \cos(90-\theta) = 3000 \times \cos(90-60)$$

$$= 2598\ lbf$$

$$\sigma_b = \frac{F'}{A_b{}'} = \frac{2598}{0.152}$$

$$= 17.13\ ksi$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

$$M.S\ of\ external\ thread = \frac{138.0 - 17.13}{17.13} = 7.06$$

$$M.S\ of\ internal\ thread = \frac{89.0 - 17.13}{17.13} = 4.20$$

C. Strength Variation Due to Damage

A sample visual damage has been considered to calculate the impact on Thread strength due to damage.

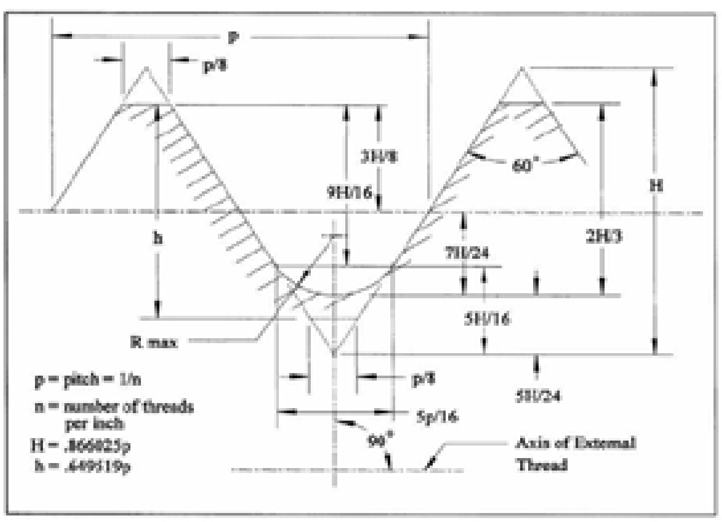


Figure 4. V shape thread.

Thread damage with an axial length of 0.05 Inches and width in circumferential is 0.1 inches is considered on Threads to check the impact on Thread. Thread size of 0.3125 inches of both internal and external threads is supposed to calculate thread damage's shear and bearing stress.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

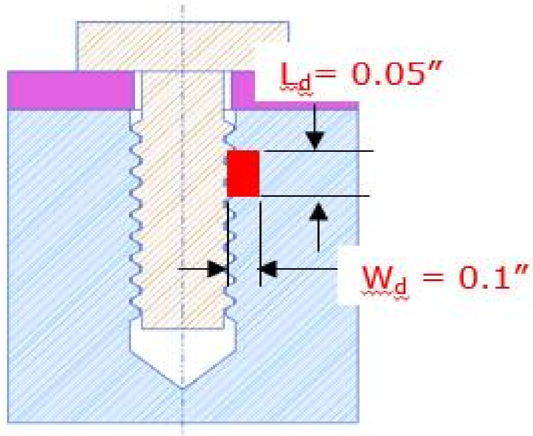


Figure 5. Thread damage details.

No. of threads covered by damage length (N) = (L_d x n) = 0.05*24 = 1.2 threads

Total no. of net effective threads damaged by thread damage (Ne) = $\left(\frac{W_d}{\pi \times D_m}\right)$ x N = $\left(\frac{0.1}{\pi \times 0.3215}\right)$ x 1.2 = 0.1189 threads

Thread disengagement length due to damage $L_{damage} = \frac{N_e}{n} = \frac{0.1189}{24}$ = 0.005 inch

D. Shear Stress Calculation of Damaged Thread

Shear stress area of external thread A_{se} is given as.

$$A_{se} = \pi n K_{n,max}\left(\frac{1}{2n} + \frac{1}{\sqrt{3}}\left(E_{s,min} - K_{n,max}\right)\right)\left(L_e - L_{damage}\right)$$

Where,

L_{damage}: $Length\ of\ thread\ Engagement\ \ due\ to\ damage$

$$A_{se} = \pi \times 24 \times 0.275\left(\frac{1}{2 \times 24} + \frac{1}{\sqrt{3}}(0.283 - 0.275)\right)(0.4688 - 0.005)$$

=0.241 inch²

Shear stress area of internal thread A_{si} is given as.

$$A_{si} = \pi n D_{s,min}\left(\frac{1}{2n} + \frac{1}{\sqrt{3}}\left(D_{s,min} - E_{n,max}\right)\right)\left(L_e - L_{damage}\right)$$

$$A_{si} = \pi x 24 \times 0.305\left(\frac{1}{2 \times 24} + \frac{1}{\sqrt{3}}(0.305 - 0.289)\right)(0.4688 - 0.005)$$

=0.323 *inch²*

$$\sigma_{se} = \frac{F}{A_{se}} = \frac{3000}{0.241}$$

$$= 12.44\ ksi$$

$$\sigma_{si} = \frac{F}{A_{si}} = \frac{3000}{0.323}$$

$$= 9.29\ ksi$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

$$M.S\ of\ external\ thread = \frac{69.2 - 12.44}{12.44} = 4.57$$

$$M.S\ of\ internal\ thread = \frac{69.2 - 9.29}{9.29} = 6.45$$

E. Bearing Stress Calculation of Damaged Thread

Bearing stress calculation for checking the impact of the damaged thread with the variation of thread sizes.

$$A_b = \frac{\pi}{4}[D_{s,min}{}^2 - K_{n,max}{}^2]n(L_e - L_{damage})$$

$$= \frac{\pi}{4}[(0.3053)^2 - (0.2799)^2] \times 24 \times (0.4688 - 0.005)$$

$$=0.130\ inch^2$$

$$Ab' = \frac{A_b}{\cos(90-\theta)}$$

$$= \frac{0.130}{\cos(90-60)}$$

$$= 0.150\ inch^2$$

$$\mathrm{F}' = \mathrm{F} \times \cos(90-\theta) = 3000 \times \cos(90-60)$$

$$= 2598\ lbf$$

$$\sigma_b = \frac{F'}{A_b{}'} = \frac{2598}{0.150}$$
$$= 17.32\ ksi$$

$$M.S = \frac{Allowable\ stress - Induced\ stress}{Induced\ stress}$$

$$M.S\ of\ external\ thread = \frac{138.0 - 17.32}{17.32} = 6.97$$

$$M.S\ of\ internal\ thread = \frac{89.0 - 17.32}{17.32} = 4.14$$

➔ Due to damage both shear and bearing stress MOS is reduced approximately 1.3%

III. VARIATION OF INDUCED SHEAR AND BEARING STRESSES ON THREAD WITH RESPECT TO THREAD

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

DAMAGE SIZE

A. Considerations

1) Thread size considered : 0.3125-24
2) Thread Damage Size: 0.1 ~ 0.4 inch
3) Preload : 3000 lbf

B. Criteria

Shear Strength MOS > 0, Bearing Strength MOS > 0

C. Results

1) Shear and Bearing induced stresses are tabulated concerning Thread damage size.
2) Shear strength of thread fails early than Bearing Strength.
3) Shear strength of Thread of 0.3125-24 fails at a Damage size of 0.4”.

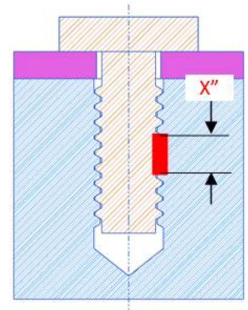


Figure 6. Length of the Damage

Shear Strength variation w.r.t Thread Damage length:

Damage Size (Length -inch)	With Damage Induced Shear Stress (ksi)		Margin of Safety	
	External Thread	Internal Thread	External Thread	Internal Thread
0.1	15.64	11.69	+3.43	+4.93
0.15	18.10	13.52	+2.83	+4.12
0.2	21.46	16.03	+2.23	+3.32
0.25	26.37	19.7	+1.63	+2.51
0.3	34.18	25.54	+1.03	+1.71
0.35	48.57	36.29	+0.43	+0.91
0.4	83.90	62.68	-0.17	+0.10

Bearing Strength variation w.r.t Thread Damage length:

Damage Size (Length -inch)	With Damage Induced Bearing Stress (ksi)		Margin of Safety	
	External Thread	Internal Thread	External Thread	Internal Thread
0.1	21.78	21.78	+5.34	+3.09
0.15	25.19	25.19	+4.48	+2.53
0.2	29.88	29.88	+3.62	+1.98
0.25	36.71	36.71	+2.76	+1.42
0.3	47.59	47.59	+1.90	+0.87
0.35	67.63	67.63	+1.04	+0.32
0.4	116.81	116.81	+0.18	-0.24

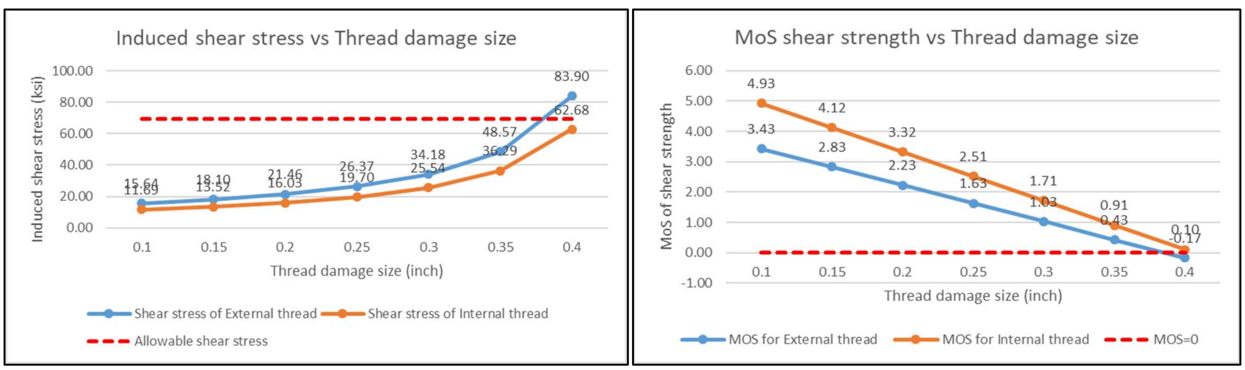


Figure 7. Variation of Induced shear stress and MOS with respect to Thread Damage Size

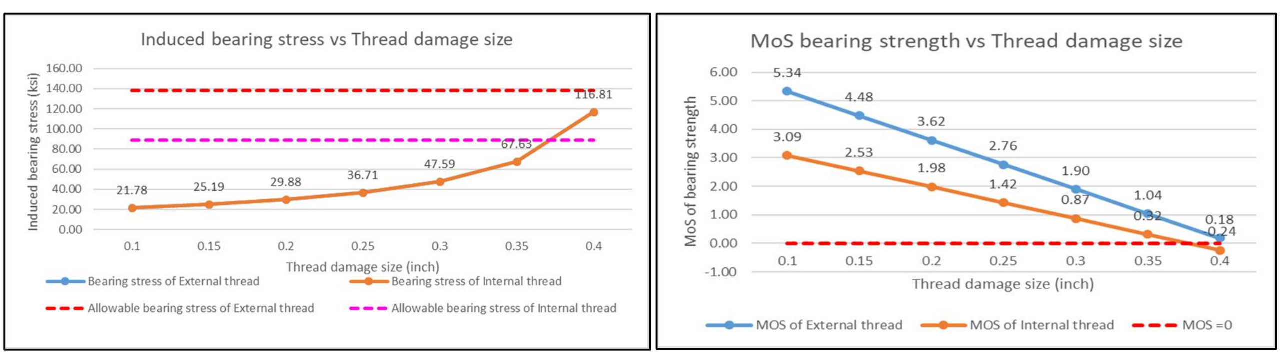


Figure 8. Variation of Induced bearing stress and MOS with respect to Thread Damage Size.

➔ If the thread's shear and bearing strength fail to meet the requirements, the hole needs to be repaired. Some repair techniques are discussed below.

D. Repair Technologies

The Failure of Bolted Joints due to the thread damage mentioned above can be a significant source of concern to propose repair techniques. Failure of a bolted joint may also occur to the bolt or joint due to any of the following shortcomings.

- Thread form deviations.
- Not meeting thread strength criteria (Ex: damages, minor dia deviations etc).

To correct these failures, some repair techniques are used industrially. Helical insert

→ Twinsert
→ Oversize inserts
→ Keensert or Keysert
→ Time-sert
→ Big-sert

Helical wire inserts are precision-formed continuous wire coils that provide permanent, wear-resistant threads that exceed the parent material's strength. Three typical applications for using Helical wire inserts are 1) to repair damaged threads in parts that would otherwise have to be scrapped; 2) to strengthen threads against failures due to stripping, seizing, or corrosion; 3) to convert threads between inch and metric sizes. They are available in unified coarse, unified fine, taper pipe, 14 millimeter, and 18-millimeter metric thread sizes. The installation process is simple and requires three basic steps: drilling, tapping and installing.

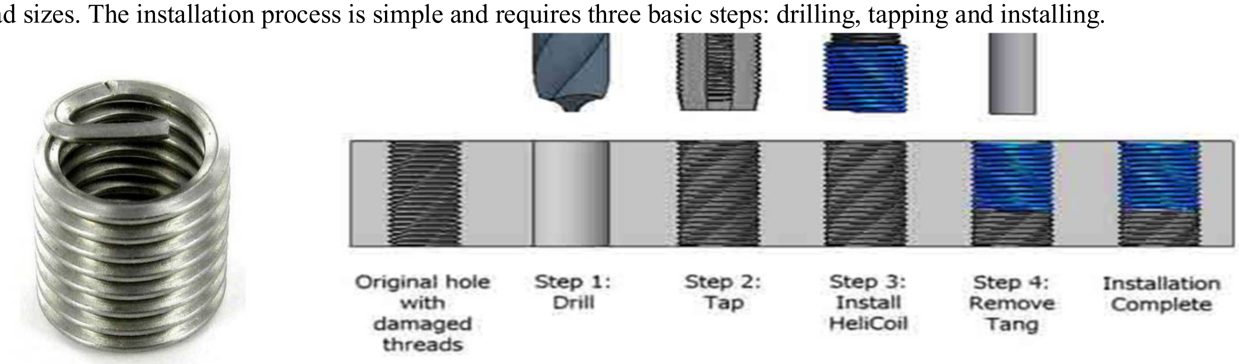


Figure 9. Helical insert and installation procedure

Twinsert assemblies, as the name implies, consist of two Helical Inserts: an Outer Insert, always Free-Running, and an Inner Insert which can be either Free-Running or Screw-Lock. Twinserts are used to correct STI* or standard tapped holes that are stripped, off-center, damaged, or beyond the correction range of Oversize Inserts or standard Helical Inserts.

Oversize inserts, both free-running and screw locking, are made of slightly larger wire and are usually identified by yellow markings on the tang and first coil. They are used to repair insert assemblies where an error has occurred in tapping to install inserts.

The Key-locking threaded insert (Keensert) is a solid bushing style insert threaded on both the inside and the outside and has wedges or "keys" attached to the top of the insert. These externally threaded inserts distribute loads and repair or strengthen threads against failures due to stripping, seizing, or corrosion. Key-locking inserts are commonly used in high torque and high-temperature situations and in applications where fasteners may be repeatedly removed and reassembled. Key-locking inserts are often referred to as Keenserts and Keyserts.

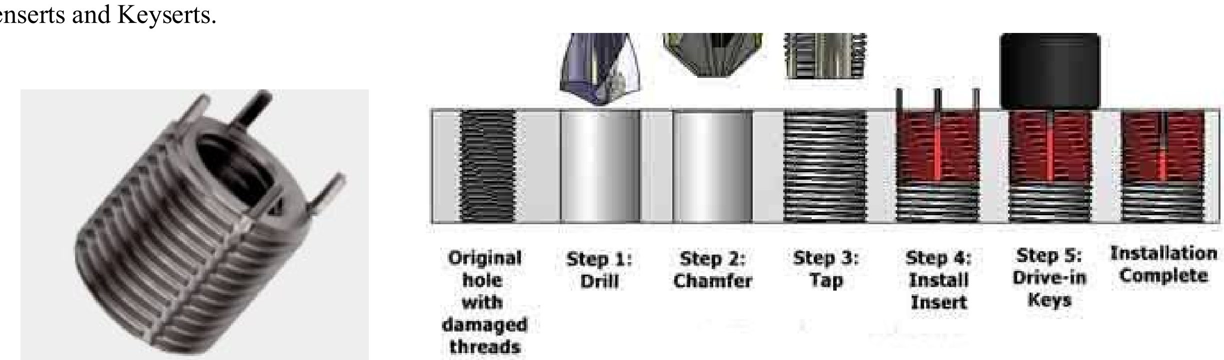


Figure 10. Keysert and installation procedure.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Time-sert is a solid bushing insert. It is thin-walled due to synchronized internal, external threads. This guarantees easy installation and allows for full load use of tapped holes, ensuring protection against stress and vibration. A thin cross-sectional area allows for installation in areas of limited space and clearance material.

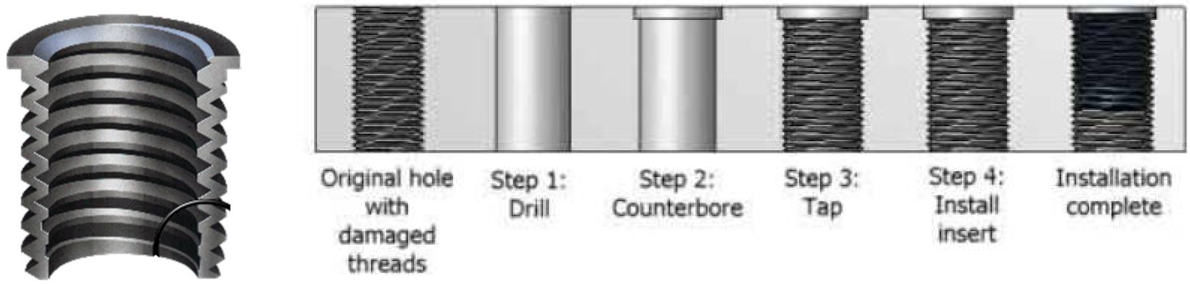


Figure 11. Time-sert and installation procedure.

Big-sert is used for threads that have been previously repaired and failed. These kits will repair holes that were repaired by Helical inserts, uni-coil, recoil, or any other similar coil style insert that has failed. BIG-SERT is a heavy wall solid bushing, easy to install with positive placement. It gives increased load protection for critical use and will repair oversize holes which have previously been repaired.

Figure 12. Big-sert.

1) Advantages of using Inserts to Repair Thread Damages
- Permanent high strength and wear-resistant
- Corrosion and temperature resistant
- Easy and quick mounting
- Design Flexibility
- Stronger Assemblies
- Minimize Space & Weight
- Quality & Reliability

2) Disadvantages of using Inserts
- Depending on the design of the base material housing, the threaded fastener installation mounting hole may weaken the part as the material is removed in a thin cross-section.
- Due to enlarging the hole for installation of insert, the wall thickness of the material will reduce. We need to check that the min thickness is maintained after repair.
- Ex: Minimum thickness around the hole shall be maintained as 2.54mm for Titanium part to install the oversize & twinsert. Similarly, each material has its requirement, which needs to confirm before repairing the part.
- If not installed correctly, some thread inserts can work out of their base material, mounting holes over time.

3) Here Are A Few Industries That Rely On Threaded Inserts

- Aerospace and aviation: The first threaded inserts were used to secure deicers to airplane wings.
- Automotive: Inserts are used throughout car bodies, including well nuts that use rubber bodies to cut vibration and inserts to secure metal and plastic body parts.
- Boatbuilding: Threaded inserts are used in wooden and fiberglass boats to secure hull and trim. These inserts are made of brass, coated steel, and other materials that resist corrosion.
- Green energy: Threaded inserts are built to last, and they are commonly used for green energy applications such as securing solar panels or constructing windmills.

IV. CONCLUSION

A specific standard size of thread (0.3125-24) is considered, and Shearing and Bearing strength have been calculated for both external and internal threaded fasteners. A case study has been extended to a damaged thread in the bolted joint (Considered visual damage of size 0.05 inch× 0.1 inches (L× W)).

The margin of safety for both Shear and bearing strength is reduced by approximately 1.3 % due to damage. To check the impact of damage size on the thread, a variation in the size of the damage from 0.1 inches to 0.4 inches is considered. It is observed that the Shear and bearing strength of the thread is failing at 0.4-inch thread damage size. Graphs are plotted to show the variation in Shear and Bearing strengths concerning the size of the damage.

For this type of damages, repair techniques are proposed to restore damaged tapped holes. The process of installing the Insert in a damaged hole is explained. The overall advantages and disadvantages of using the different types of Inserts are listed.

REFERENCES

[1] Croccolo, D., M. De Agostinis, and N. Vincenzi. "Failure analysis of bolted joints: Effect of friction coefficients in torque–preloading relationship." Engineering Failure Analysis 18, no. 1 (2011): 364-373.

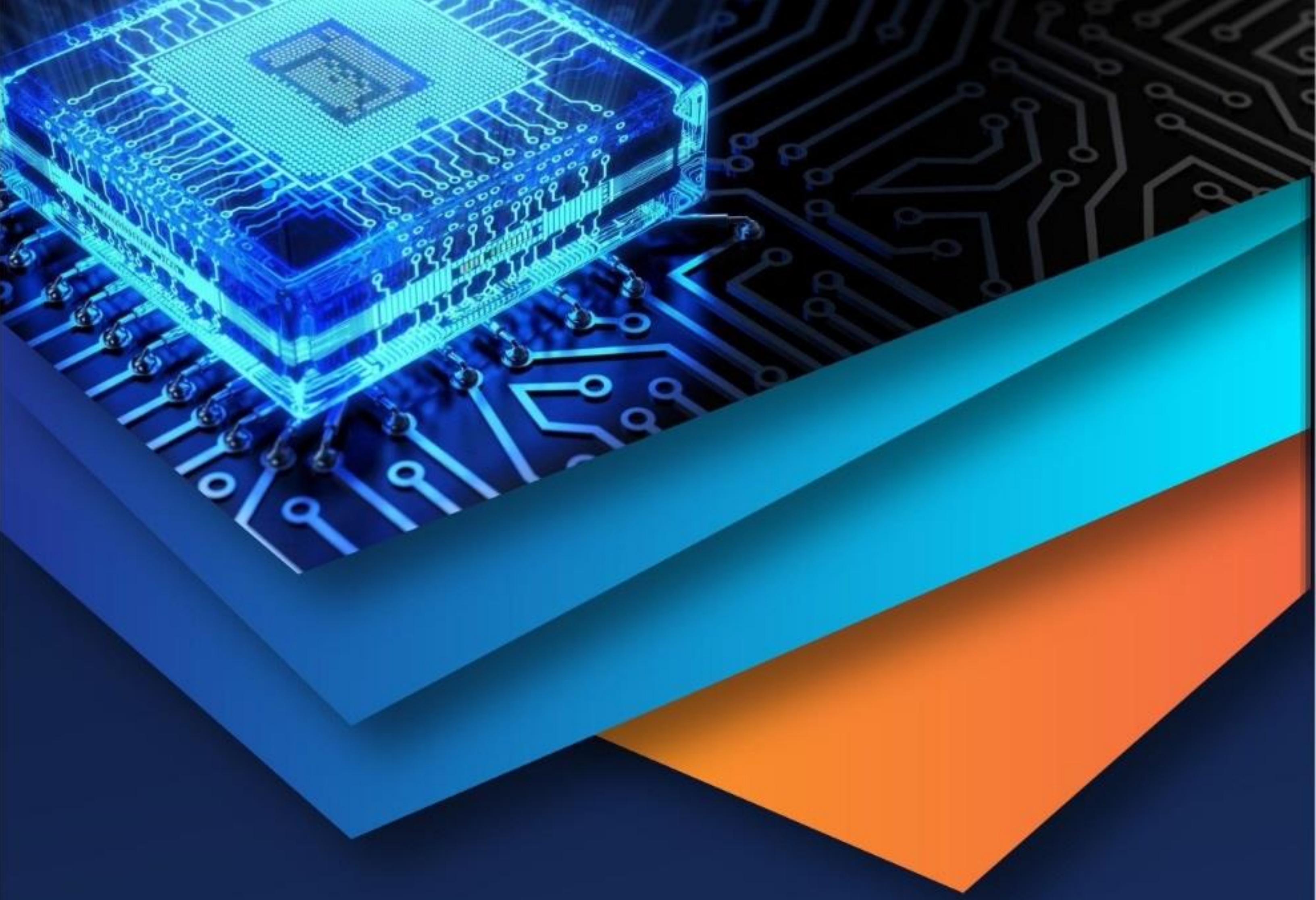
[2] Cheatham, C. A., C. F. Acosta, and D. P. Hess. "Tests and analysis of secondary locking features in threaded inserts." Engineering Failure Analysis 16, no. 1 (2009): 39-57.

[3] Liu, Mei, Xulin Zhu, Peijun Wang, Wulan Tuoya, and Shuqing Hu. "Tension strength and design method for thread-fixed one-side bolted T-stub." Engineering Structures 150 (2017): 918-933.

[4] Her, Shiuh-Chuan, and Dong-Lin Shie. "The failure analysis of bolted repair on composite laminate." International journal of solids and structures 35, no. 15 (1998): 1679-1693.

[5] Meram, Ahmet, and Ahmet Can. "Experimental investigation of screwed joints capabilities for the CFRP composite laminates." Composites Part B: Engineering 176 (2019): 107142.

[6] Budynas, Richard G., and J. Keith Nisbett. Shigley's mechanical engineering design. Mc Graw Hill, 2015.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)