F A S T E N E R

Thread Strength Analysis Program

FASTENER

Thread Strength Analysis Program

Powerful yet easy to use PC Software which has been designed to assist you in solving problems, or potential problems, related to the failure by thread stripping of fasteners and threaded parts.

Fastener failure

Fastener failure on a product can have potentially disastrous consequences. In an attempt to ensure that such consequences do not occur, rigorous and extensive testing of a product is frequently completed. However in many applications, extensive testing is neither practical nor economical. In such instances, the Engineer usually relies upon analytical analysis together with his experience and judgement to ensure that failure does not occur. Failure of a threaded fastener during assembly generally occurs in one of three modes:

1. Failure by tensile fracture through the shank or threaded section of the fastener.
2. Shear failure through the thread profile (thread stripping) of the external thread.
3. Shear failure through the thread profile (thread stripping) of the internally threaded part.

Thread Stripping

Thread stripping is a shear failure of an internal or external thread that results when the strength of the threaded material is exceeded by the applied forces acting on the thread. Thread stripping can be a problem in many designs where tapped holes are required in low tensile material. In general terms thread stripping of both the internal and external threads must be avoided if a reliable design is to be achieved. If the bolt breaks on tightening, it is obvious that a replacement is required. Thread stripping tends to be gradual in nature and it may go unnoticed at the time of assembly. It starts at the first engaged thread, deformations causing this thread to carry the highest load; and successively shears off subsequent threads. This may take a number of hours to complete and so the product may appear fine at the time of assembly. The risk is therefore present that threads that are partially failed, and hence defective, may enter service. This may have disastrous consequences on product reliability.

Because of the more widespread use of angle control and yield control tightening methods, bolt preloads, for a given size and strength of a fastener can be greater than traditionally was the case. This coupled with the widespread use of automatic and semi-automatic tightening procedures increase the likelihood that thread stripping will occur.

The strength of a nut or bolt thread cannot be viewed in isolation without considering the inter-dependence that both elements have on the strength of the assembly. One of the problems in predicting thread stripping strength is that, without considering such effects as thread bending, nut dilation or bellmouthing, an optimistic result occurs. The actual stripping strength being lower than that calculated.

About the program

FASTENER is a computer program that provides a means of determining the forces required to strip the internal and external threads of a fastener. It also calculates the force required to fracture an external threaded fastener across the threaded section.

To precisely predict the force and mode of failure of a threaded assembly demands consideration of a large number of factors. Thread stripping is a complex phenomenon. The program considers the following factors when determining failure mode:

1) The effect of variation in the dimensions of the thread, such as major, pitch and minor diameters, has on fastener failure mode of both the internal and external threads.
2) Tensile and shear strength variations in the material for both the internal and external threads.
3) The effect of radial displacement of the nut (generally known as nut dilation) in reducing the shear strength of the threads. The tensile force in the fastener acts on the threads and a wedging action generates a radial displacement.

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4) The effect which the bending of the threads, caused by the action of the fasteners tensile force, has on both internal and external thread shear strength.
5) The effect which production variations in the threaded assembly, such as slight hole taper or bellmouthing can have on thread strength.
6) The effect that torque tightening a threaded fastener can have on the tensile strength capabilities of a fastener.
7) To assist and guide the Engineer, the program incorporates default values such as maximum and minimum thread dimensions based upon standard thread tolerances.

Using the program it is possible to allow at the design stage for anticipated variations in the forces required to cause failure. This variation is inherent due to dimensional and property differences between fasteners of the same size and property class.

Minimum system requirements

To use **FASTENER** on your computer, make sure that you have the following minimum system requirements:

i. Microsoft Windows 95, Windows 98 or Windows NT.
ii. 4 MB of RAM memory.
iii. A hard disk with 2MB free disk space.

Thread and Material Databases

The program accesses tables of standard values to allow the easy selection of the most appropriate fastener size and material. The program allows selection of metric fine as well as metric coarse threads, the table that the program accesses contains all the main metric thread sizes from 1mm to 100mm diameter. The inch based Unified thread table contains thread sizes from Number 0 (0.06" diameter) to 4 inch diameter. The user can enter sizes outside these values directly into the program.

The program also accesses material property tables for both metric and inch based fasteners; the tables contain the popular fastener materials defined in ISO, SAE, ASTM and BS standards. The program displays in metric units for metric fasteners and inches and lbs for unified threads.

Ease of Data Entry and Help File

The program uses spreadsheet style editing facilities, allowing each value to be individually changed without the need to re-enter all the input data. This gives the program a user-friendly feel and allows individual values to be specifically adjusted. The calculations can then be repeated to assess its effect. When possible the program will enter values automatically based upon the thread size of the fastener previously selected by the user; any value being able to be over-written.

An extensive help file is included that explains the main terms used and furnishes information relating to both the program and to threaded fasteners in general. The comprehensive user guide that is supplied that gives guidance on the use of the program and presents valuable background information on the failure of threaded fasteners.

Printing and Filing Facilities

The program has menu options to allow :
Printout of the results and the data to both the screen and printer.
The facility to store both input data and the results to disk.
The results to be directly loaded into Notepad for editing and inclusion in a user defined report.

Demonstration Program

A demonstration program is available for **FASTENER** from the Bolt Science website. Further details and clarification on any issue related to the program can be obtained by emailing info@boltscience.com

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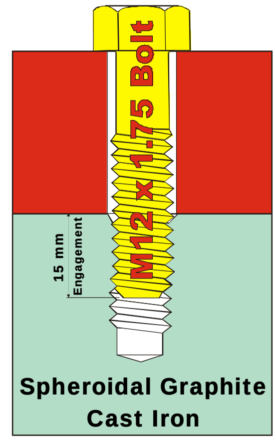
Example Problem

In this section an example analysis is presented, a file containing the input data for this example is included with the demo program in the directory that the program is installed into under the name example.fas.

In this example a M12 bolt (property class 10.9) is used to secure a bracket to a casting that is made from spheroidal graphite cast iron. The tolerance class of the bolt thread is 6g and that of the internal thread is 6H. A tapping drill of 10.2 mm diameter was used to form the internal thread and the hole is countersunk to aid starting the thread. There is also a chamfer at the start of the bolt thread. The ratio of shear strength to tensile strength for the SG cast iron is taken as 0.9 - this is based upon published test results.

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          FASTENER - THREAD STRIPPING STRENGTH PROGRAM

Analysis of an M12 bolt secured into a block made from SG cast iron.

                      THREAD DETAILS
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Fastener Diameter                          = 12.000 mm
Thread Pitch                               = 1.750 mm
Thread: M12 x 1.75 - 6g/6H Coarse Thread Series

EXTERNAL THREAD
Maximum Major Dia.                         = 11.966 mm
Minimum Major Dia.                         = 11.701 mm
Maximum Pitch Dia.                         = 10.829 mm
Minimum Pitch Dia.                         = 10.679 mm
Maximum Minor Dia.                         = 10.072 mm
Minimum Minor Dia.                         = 9.602 mm
Material: Property Class 10.9 (Diameter Range M5 - M100)
Minimum Tensile Strength                   = 1040.00 MPa
Maximum Tensile Strength                   = 1230.00 MPa
Ratio of the shear to tensile strength     = 0.580
Minimum Shear Strength                     = 603.00 MPa
A chamfer is present on the end of the thread.
Length of Chamfer                          = 2.000 mm

INTERNAL THREAD
Minimum Major Dia.                         = 12.000 mm
Maximum Pitch Dia.                         = 11.063 mm
Minimum Pitch Dia.                         = 10.863 mm
Maximum Minor Dia.                         = 10.441 mm
Minimum Minor Dia.                         = 10.106 mm
Note: The Tapping Drill Dia. has been used to determine the
shear area of the internal thread rather than the maximum
size of the Minor Diameter. However, using the maximum size
of the Minor Dia., if this is applicable, will give a lower
thread stripping strength!
Tapping Drill Diameter                     = 10.200 mm
Radial engagement with the external thread = 83.8%
Thread Engagement Length                   = 15.00 mm
Bellmouthing Ratio                         = 1.03 mm
Length of Bellmouthing                     = 6.00 mm
Material: Spheroidal Graphite Cast Iron
Minimum Tensile Strength                   = 500.00 MPa
Ratio of the shear to tensile strength     = 0.900
Minimum Shear Strength                     = 450.00 MPa
The hole is countersunk on one side only.
Countersink Diameter                       = 13.000 mm
Countersink angle                          = 90.00 degrees
Thread Friction Details
Black oxide steel external thread, internal thread in cast
iron, no lubricant.
Thread Friction Value                      = 0.120

                   DERIVED INFORMATION
                   ___________________

Basic Pitch Dia.   d2                      = 10.863 mm
Basic Minor Dia.   d1                      = 10.106 mm
Nominal Minor Dia. d3                      = 9.853 mm
Stress Diameter of the Thread              = 10.358 mm
Theoretical Stress Area - External Thread  = 84.267 mm²
Minimum Stress Area - External Thread      = 80.762 mm²
Maximum Stress Area - External Thread      = 85.776 mm²
Nominal Root Area of the External Thread   = 76.247 mm²

                        RESULTS
                        _______

Effective Length of Thread Engagement      = 12.932 mm
Shear Area of the Internal Thread per mm   = 26.117 mm²
Shear Area of the Internal Thread          = 337.743 mm²
Shear Area of the External Thread per mm   = 21.086 mm²
Shear Area of the External Thread          = 264.728 mm²

Internal to External Thread Strength ratio = 0.61337
Boss/Nut Dilation Factor C1                = 1.00000
External Thread Bending Factor C2          = 0.89700
Internal Thread Bending Factor C3          = 1.02258

Direct Forces to fail the Fastener:
Minimum Tensile Force to fail the Fastener = 83992.781 N
Maximum Tensile Force to fail the Fastener = 105504.050 N

Fastener Failure Forces Allowing for Combined Tension-
Torsion Loading:
Minimum Tension-Torsion Failure Load       = 74263.460 N
Maximum Tension-Torsion Failure Load       = 93883.693 N
When the bolt/screw is being tightened it experiences both
tension and torsion. The effect of this is that the
bolt/screw will fail at a lower force then if only a
directly applied force is applied. Higher the thread
friction value, higher will be the induced torsion and lower
will be the direct force that results in fastener failure.
Thread Stripping Forces:
Minimum External Thread Stripping Force    = 143188.827 N
Minimum Internal Thread Stripping Force    = 155416.303 N
Relative to Torque Tightening:
Factor of Safety - External Thread         = 1.525
Factor of Safety - Internal Thread         = 1.655
Critical Length of Thread Engagement       = 10.547 mm

NOTE
Because the upper limit of the force to cause tensile fracture
of the fastener of 105504 N is smaller than the external thread
stripping force of 143189 N and the internal thread stripping
force of 155416 N; the fastener will fail by tensile fracture
before either the internal or external thread will strip. If
bolt breaks on tightening, it is obvious that a replacement is
required. Thread stripping tends to be gradual in nature. If
the thread stripping mode can occur, assemblies may enter into
service which are partially failed, this may have disastrous
consequences. Hence, the potential of thread stripping of both
the internal and external threads must be avoided if a reliable
design is to be achieved.
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