Static force analysis in screw jack engineering essay

Static friction is friction between two solid objects that are not moving relative to each other. For example, static friction can prevent an object from sliding down a sloped surface. The coefficient of static friction, typically denoted as Î¼s, is usually higher than the coefficient of kinetic friction.

The static friction force must be overcome by an applied force before an object can move. The maximum possible friction force between two surfaces before sliding begins is the product of the coefficient of static friction and the normal force: . When there is no sliding occurring, the friction force can have any value from zero up to . Any force smaller than attempting to slide one surface over the other is opposed by a frictional force of equal magnitude and opposite direction. Any force larger than overcomes the force of static friction and causes sliding to occur. The instant sliding occurs, static friction is no longer applicable and kinetic friction becomes applicable.

An example of static friction is the force that prevents a car wheel from slipping as it rolls on the ground. Even though the wheel is in motion, the patch of the tire in contact with the ground is stationary relative to the ground, so it is static rather than kinetic friction.

The maximum value of static friction, when motion is impending, is sometimes referred to as limiting friction, although this term is not used universally.

Screw jack

All metallic constructions and a accurately machine cut screw with a pitch of 5 mm crrying a double flanged turn table of about 20 cm dia fitted on a heavy cast iron base and complete with two adjustable pulleys cord & hooks without wts.

Small size, experimental demonstration type model with an aluminum turned pulley of about 10 cm dia is fitted on a screw jack which is fitted on a 12cm dia metallic circular base with an adjustable pulley and a linear vertical scale, over all height is about 15 cms with out wts.

A screw is a shaft with a helical groove formed on its surface. Its main uses are as a threaded fastener used to hold objects together, and as a simple machine used to translate torque into linear force.

Screw thread mechanics

There are always three major components in practical applications of the screw thread mechanism :

the screw – a generic name applied to a setscrew, leadscrew, bolt, stud or other component equipped with an external thread,

the nut – refers to any component whose internal thread engages the screw, such as the nut of a nut & bolt or a large stationary casting with a tapped hole into which a stud is screwed, and

the thrust bearing – that is the contact surface between two components which rotate with respect to one another. Examples of thrust bearings include :

the under-surface of a screw head which is being tightened by a spanner;

the spherical seating of a G-clamp screw in the stationary self-aligning anvil.

A nut can spin and move freely along a screw without contacting another component, ie. without the need for any thrust bearing, but a thrust bearing comes into existence immediately contact occurs and the mechanism is put to practical use.

Clearly there is relative motion in the thrust bearing, and also between the nut and the screw – and where there is relative motion there is friction. We now examine the role of friction since it dominates the behaviour of the mechanism unless special (read ' expensive') means are taken to minimise its effects. When considering friction it doesn't matter which component rotates and which is stationary – it's the relative motion which is important. We shall therefore analyse the jack shown here to deduce the general effect of friction on screw thread behaviour.

The jack's screw is fixed; the nut is rotated by a spanner and translates vertically. The thrust collar's only motion is vertical translation as it is prevented from rotating by contact with the load, one corner only of which is pictured. Since there is relative rotation between contacting nut and collar, the contacting surface assumes the role of thrust bearing.

The nut shown here in plan is in contact with three bodies :

the spanner exerts the torque T which tends to raise the load (analogous to tightening a nut and bolt)

the screw thread which exerts the frictional torque Tt , and the thrust bearing which exerts the frictional torque   Tb .

We are interested in the tightening torque   T, and, if the nut is in equilibrium then

(i)   T   =   Tt + Tb

from which we can evaluate   T once   Tt and   Tb are found individually.

Consider the thrust bearing first. We shall assume that the contact surface of area   A is in the form of a narrow annulus of mean radius   rb on which the uniform pressure is   W/A, where   W is the load supported by the mechanism. If the coefficient of friction in the bearing is   Î¼b then the torque exerted by the frictional force on an area element Î´A is   Î´Tb   = Î¼b Î´N rb   =   Î¼b rb (W/A) Î´A. Integrating over all the contact area

(ii)   Tb   =   W Î¼b rb

Consider now the thread which is square, of mean radius   rm and lead angle Î». The nut engages the screw with friction coefficient   Î¼ corresponding to a friction angle Ï† = arctan Î¼. The static and kinetic coefficients of friction are taken to be essentially equal for this preliminary analysis.

We wish to find the torque   Tt which must be exerted on the nut to offset thread friction and maintain the load   W in equilibrium – that is either static or moving at constant speed. A torque which tends to raise the load is reckoned positive; a negative torque is one which tends to lower the load.

Threaded Fastener

A screw used as a threaded fastener consists of a shaft, which may be cylindrical or conical, and a head. The shaft has a helical ridge or thread formed on it. The thread mates with a complementary helix in the material. The material may be manufactured with the mating helix, or the screw may create it when first “ driven” in. The head is specially shaped to allow a screwdriver to grip the screw when driving it in. It also stops the screw from passing right through the material being fastened and provides compression.

Screws can normally be removed and re-inserted without reducing their effectiveness. This may make them preferable in some applications to nails, which are frequently unusable after being removed.

A screw that is tightened by turning it clockwise is said to have a right-hand thread. Screws with left-hand threads are used in exceptional cases, when the screw is subject to anticlockwise forces that might undo a right-hand thread.

Mechanical Analysis

A screw is a specialized application of the wedge or inclined plane. It contains a wedge, wound around an interior cylinder or shaft that either fits into a corresponding plane in a nut, or forms a corresponding plane in the wood or metal as it is inserted. The technical analysis (see also static’s, dynamics) to determine the pitch, thread shape or cross section, coefficient of friction (static and dynamic), and holding power of the screw is very similar to that performed to predict wedge behavior. Wedges are discussed in the article on simple machines.

Tensile Strength

Screws and bolts are usually in tension when properly fitted. In most applications they are not designed to bear large shear forces. When, for example, two overlapping metal bars joined by a bolt are likely to be pulled apart longitudinally, the bolt must be tight enough that the friction between the two bars can overcome the longitudinal force. If the bars slip then the bolt may be sheared in half, or friction between the bars (called fretting) may weaken them. For this type of application, high-tensile steel bolts are used and these should be tightened with a torque wrench.

High-tensile bolts are usually in the form of hexagonal cap screws with an ISO strength rating stamped on the head. The strength ratings most often used are 8. 8 and 12. 9. The number before the point is the ultimate tensile strength in N/mm2 (or MPa) divided by 100. This is the stress at which the bolt will fail, i. e. break in half.

The number after the point is the yield strength as a percentage of the ultimate tensile strength, divided by 10. Yield strength is the stress at which the bolt will receive a permanent set (an elongation from which it will not recover when the force is removed) of 0. 2%.

Mild steel bolts have a 4. 6 rating. High-tensile bolts have an 8. 8 rating or above.

Types of screw jack

Cap screw: – has a convex head, usually hexagonal, designed to be driven by a spanner or wrench.

Wood screw: – has a tapered shaft allowing it to penetrate unrolled wood.

Machine screw: – has a cylindrical shaft and fits into a nut or a tapped hole, a small bolt.

Self-tapping screw: – has a cylindrical shaft and a sharp thread that cuts its own hole, often used in sheet metal or plastic.

Drywall screw: – is a specialized self-tapping screw with a cylindrical shaft that has proved to have uses far beyond its original application.

Set screw:- has no head, and is designed to be inserted flush with or below the surface of the workpiece.

Dowel screw:-is a wood-screw with two pointed ends and no head, used for making hidden joints between two pieces of wood.

Shapes of Screw Head

(a) Pan (b) Button (c) Round (d) Truss (e) Flat (f) Oval

Pan Head: disc with chamfered outer edge.

Button or dome head: cylindrical with a rounded top.

Round: dome-shaped, commonly used for machine screws.

Truss: lower-profile dome designed to prevent tampering.

Flat or Countersunk: conical, with flat outer face and tapering inner face allowing it to sink into the material, very common for wood screws.

Oval: countersunk with a rounded top.

Types of Screw Drive

Modern screws employ a wide variety of drive designs, each requiring a different kind of tool to drive in or extract them. The most common screw drives are the slotted and Phillips; hex, Robertson, and torx are also common in some applications. More exotic screw drive types may be used in situations where tampering is undesirable, such as in electronic appliances that should not be serviced by the home repairperson.

(a) Slotted, (b) Phillips, (c) Pozidriv, (d) Torx, (e) Hex, (f) Robertson, (g) Tri-Wing, (h) Torq-Set, (i) Spanner

(a) Slot

Head has a single slot, and is driven by a flat-bladed screwdriver. The slotted screw is common in woodworking applications, but is not often seen in applications where a power driver would be used, due to the tendency of a power driver to slip out of the head and potentially damage the surrounding material.

(b) Cross-head or Phillips

Screw has a "+"-shaped slot and is driven by a cross-head screwdriver, designed originally for use with mechanical screwing machines. The Phillips screw drive has slightly rounded corners in the tool recess, and was designed so the driver will slip out, or cam out, under strain to prevent over-tightening.

(c) Pozidriv

it is patented, similar to cross-head but designed not to slip, or cam out. It has four additional points of contact, and does not have the rounded corners that the Phillips screw drive has. Phillips screwdrivers will usually work in Pozidriv screws, but Pozidriv screwdrivers are likely to slip or tear out the screw head when used in Phillips screws. Pozidriv was jointly patented by the Phillips Screw Company and American Screw Company.

(d) Torx:-is a star-shaped or splined bit with six rounded points.

(e) Hexagonal or hex:- screw head has a hexagonal hole and is driven by a hexagonal wrench, sometimes called an Allen key, or by a power tool with a hexagonal bit.

(f) Robertson :-drive head has a square hole and is driven by a special power-tool bit or screwdriver (this is a low-cost version of the hex head for domestic use).

(g) Tri-Wing:- screws have a triangular slotted configuration, and are used by Nintendo on its Gameboys to discourage home repair.

(h) Torq-Set:- is an uncommon screw drive that may be confused with Phillips; however, the four legs of the contact area are offset in this drive type.

(i) Spanner:-drive uses two round holes opposite each other, and is designed to prevent tampering

Engineering Mechanics: Force Analysis in Static

It is said that a chain is as strong as its weakest link, so is true for a structure. For a structure or a truss to sustain load all its members should be able to stand force acting on them. For optimal design of a structure it is essential to know the forces in the members, compressible or tensile.

Structures are made to support loads. Structure is an assembly of number of members arranged in certain manner. When load acts on a structure this load is distributed to the constituent members of the structure in different proportions. Members experiencing large forces can be made stronger, members experiencing less force can be made lighter and redundant members with no force to support can be removed altogether. Thus static force analysis of structures can help to build cost effective, light and strong structures.

Static Force Analysis in Structures

Force acting on a member of a structure can be compressible or tensile. For the purpose of force analysis a sign convention can be assigned to the forces. Tensile forces, acting outwards the members and having a tendency to extend the member, is assigned positive sign. The force acting inwards any member and tending to compress the member is called as compressive force and assigned negative sign. Although a sign convention opposite to this one can also be followed with equal validity but the same sign convention should be adhered to throughout the analysis of a structure.

There are mainly two approaches for static force analysis in structures. One approach is to section the structure under consideration and find the unknown forces by balancing the forces. Other approach is based on the principle that net force at any joint or node for static structure is zero. In either of the approaches force calculation is started from the support points as it is easier to determine the forces at the support points and further calculation of forces in the members of the structure becomes easier after knowing the forces at supports.

Section Approach

In the Section Approach the structure under consideration is sectioned at certain part such that the number of unknown forces is not more than two, for two dimensional structures. Unknown forces are assigned variables and components of the forces are taken along and perpendicular to any one of the unknown forces. For each of the two directions force balance equations are framed and solved for the unknowns. The components of the forces can also be taken along any fixed coordinate axis. For three dimensional structures the section taken can have up to three unknown forces.

Nodal Approach

In the other approach, to find forces in the members of a structure, net force at any joint is set to zero. Any joint connecting two or more members can be called as a node. One by one different nodes are considered for force analysis. To start with such a node will be taken which has not more than two unknown forces. Unknown forces are determined by writing net forces along any set of orthogonal axes and equating them to zero.

For a simple structure one of the two approaches may be sufficient to determine the forces in members. But for complex structures single force analysis approach can become cumbersome for force analysis, therefore, a tricky combination and use of the two approaches can simplify the static force analysis in structures.