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METHOD OF CALCULATING PROBLEMS RELATING TO THREADED JOINTS

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ANNOTATSIYA: *Бирикмаларни ҳисоблашга киришишдан аввал, ушбу бирикмаларга бириктирилаётган деталларни силжитишга интилувчи кўндаланг куч таъсир қилишини аниқлаб олиш лозим. Силжитувчи куч айланиш ўқига нисбатан деталлар мувозанати шартидан аниқланади*
KALIT SO'ZLAR: *Қирқимнинг жоиз кучланиши, Клеммали бирикма, Ричаг деформацияси, ишқаланиш бўйича захира коэффициенти, Кўндаланг юкламалар, ташқи силжитувчи куч, мутаносиб диаметрлар*

АННОТАЦИЯ: *Прежде чем приступить к расчёту узлов, необходимо определить, подвержены ли эти узлы действию поперечной силы, стремящейся сместить соединяемые детали. Сила перемещения определяется из условия равновесия деталей относительно оси вращения.*
КЛЮЧЕВЫЕ СЛОВА: *Допустимое касательное напряжение, зажатое соединение, деформация рычага, коэффициент запаса трения, поперечные нагрузки, внешняя сдвигающая сила, пропорциональные диаметры*

ANNOTATION: *Before proceeding to the calculation of joints, it is necessary to determine whether these joints are subject to a transverse force that tends to move the parts being joined. The moving force is determined from the condition of the balance of the parts relative to the axis of rotation.*
KEY WORDS: *Permissible Shear Stress, Clamped Joint, Lever Deformation, Friction Reserve Coefficient, Transverse Loads, External Shear Force, Proportional Diameters*

RESULTS

The figure shows a clamped connection of a lever to a shaft with a diameter of D=60 mm. Determine the internal thread diameter of the two bolts securing the clamped connection, where the force Q is 2000 H, the dimension R is 300 mm, and the dimension a is 50 mm. The coefficient of friction between the shaft and the lever is f=0.12. If the increase in the torsional stress for the deformation of the lever is taken as

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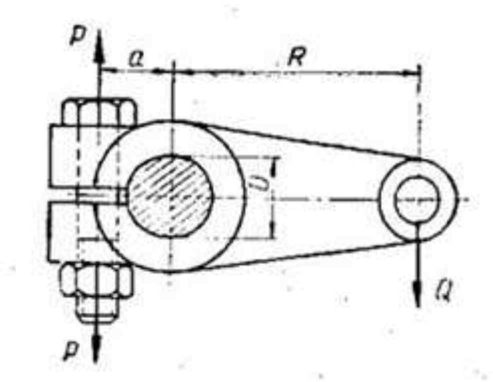
Kp=1.5 of the required torsional stress, the additional load on the bolt from the tightening of the nuts is taken as Кз=1.3 and the friction coefficient is taken as Кп=1.5. The allowable torsional



stress of the bolt is [σ]= 160 MPa.

Solving

1. We write the balance equation for the tension in the clamp connection and the tension from the torsion of the bolts:$P \cdot \left(a+\frac{D}{2}\right) \cdot z = F_n \cdot \frac{D}{2}$, here $F_n = 2 \cdot P \cdot \left(a+\frac{D}{2}\right) \frac{z}{D} = P \cdot \frac{(2 \cdot a + D)}{D}$, z- number of bolts

2. We write the equilibrium equation for the lever:

$2 \cdot f \cdot F_n \cdot \frac{D}{2} = Q \cdot R \cdot K_p \cdot K_з \cdot K_п$, or $P = Q \cdot R \cdot K_p \cdot K_з \cdot \frac{K_п}{f \cdot (2 \cdot a + D) \cdot z}$

3. From the condition of torsion resistance, we determine the diameter of the internal thread of the bolts: $\sigma = 4 \cdot P / \pi \cdot d^2 \cdot z \leq [\sigma]$, After permutations, we get:

$$d = 4Q \cdot R \cdot K_p \cdot K_з \cdot \frac{K_п}{([\sigma] \cdot \pi \cdot f \cdot (2 \cdot a + D) \cdot z^2)^{\frac{1}{2}}}$$

DISCUSSION: The solution of problems is usually carried out in the following order.

1) A calculation scheme for the connection is drawn up and the load acting on the bolt (screw, stud) is determined.

External loads acting on a threaded connection, depending on the loading conditions, can be axial, transverse or mixed, and by the nature of the action - permanent or cyclic.

When transverse loads act, two types of connections are used:

— the bolt is inserted into the hole with a catch;

— the bolt is inserted into the hole without a catch.

a) With a bolt inserted, a friction force must be created on the surface of the connection with the screw that is greater than the external force that moves the load.

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In this case, the tensile force of the bolt (screw, stud) is determined as follows:

$$F_B = \frac{K \cdot F}{f \cdot z \cdot i},$$

here F_B — force acting on the bolt; F - external shear force; K - safety factor: under static load K = 1.3… 1.5, under variable load K = 1.8… 2.0; f - friction coefficient in the connection: f = 0.15... 0.20 - for steel and cast iron (steel); f = 0.3... 0.35 - for steel (cast iron) and concrete; f = 0.25 - for steel (cast iron) and wood; z - number of bolts; i - number of connections in the connection.

b) When the bolt is installed without a stud (by passing or tensioning), the friction force in the connection is not taken into account, since it is not necessary to tighten the bolts. In this case, the bolt rod is estimated based on the shear and crushing resistance condition.

Before proceeding to the calculation of joints, it is necessary to determine whether these joints are subject to a transverse force that tends to move the parts being joined. The moving force is determined from the condition of the balance of the parts relative to the axis of rotation: $\Sigma T_i = \Sigma F_i \cdot \frac{D_i}{2} = 0,$

where F_i is the shear force acting on the diameter of the bolt (screw, stud) location; D_i is the rotational force acting on the corresponding diameters, usually the resistance force of the parts being moved. This transverse force is balanced by the friction force at the junction of the parts being joined, ensuring a tight screw connection. In this case, the bolt (screw, stud) is stretched.

CONCLUSION: In the combination shown in Fig. 1, the torque of the friction forces must be 20... 25% greater than the shearing torque for accurate transmission to the rotary saw, i.e.

$T_{ИК} \geq 1{,}25 \cdot T_{ҚИРҚ}$ or $F_{ИК} \cdot (D_1 / 2) \geq 1{,}25\, F \cdot (D / 2)$, where F_{IK} is the friction force between the saw blade and the washer when tightening the nut $F_{IK} = f \cdot N$; f is the coefficient of friction between the saw blade and the washer, we take f = 0.12;

N is the pressure force in the connection resulting from the tightening force $F_B = N$.

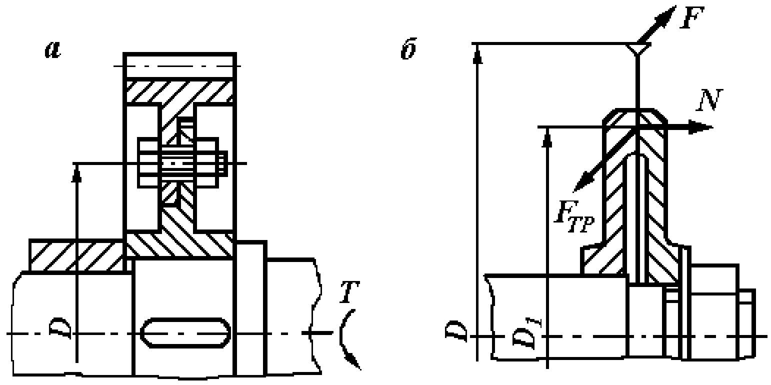

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Figure 1

In the connection (Fig. 2, a), the force F_B acting on the screw is determined from the condition of the hammer equilibrium (Fig. 2, b) $F \cdot (a + b) = F_B \cdot b$. Given that the stress is given asymmetrically, the acting load is divided into parts and transmitted to the center of gravity of the connection. If the number of bolts is not indicated in the problem, then their number is given.

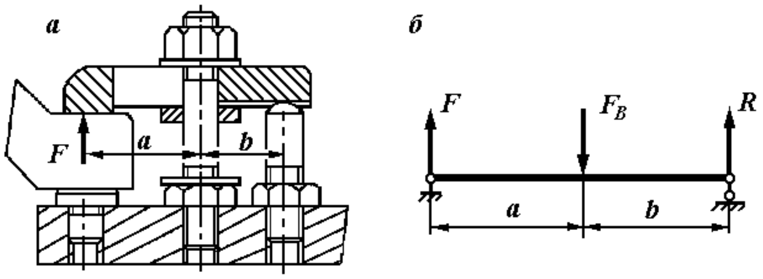

Figure 2

Let's look at the compounds in the problems (Figures 3 and 4). In these cases, an asymmetric applied load will open the circuit (and cause the details to move). Solving such issues is a mixed bag. The acting load is divided into parts - axial and transverse, and then transferred to the center of gravity of the connection. It is also possible to use the recommendations given in solving the problems of the first group.

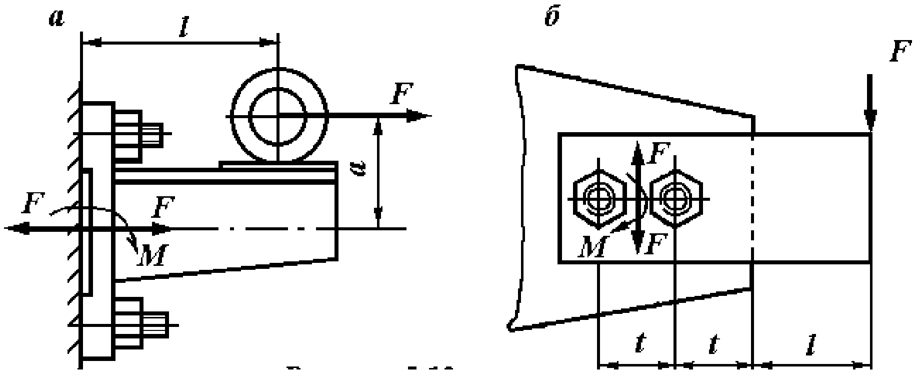

Figure 3

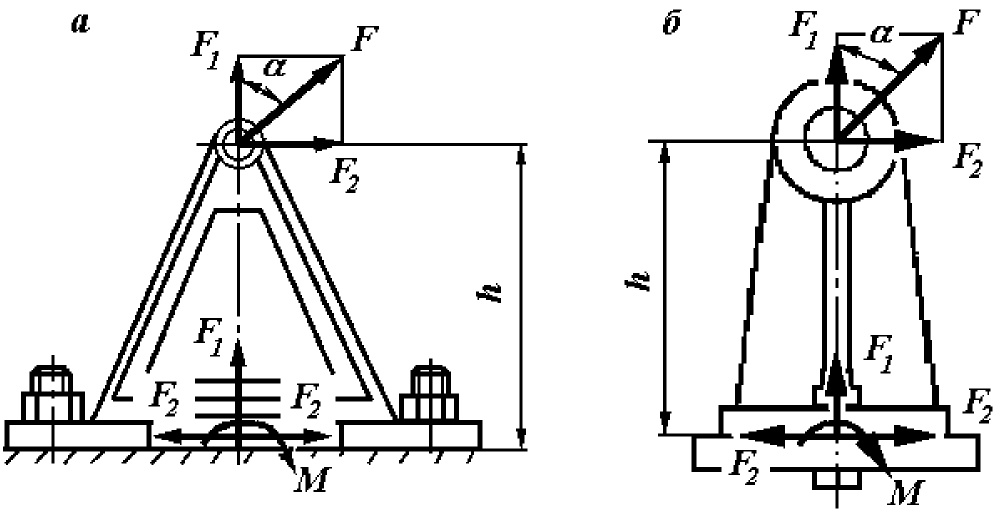

Figure 4

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As a result, the joint is subjected to axial and transverse forces, which are generally equally perceived by all threaded parts, and a moment tending to open the joint. From the equilibrium equation - the equation of moments with respect to the center of gravity of the joint - additional forces acting on the bolts (screws, studs) in the axial direction are determi ned.The inner diameter of the thread is calculated based on the maximum value of the axial (breaking) force from the condition of the tensile strength of the bolt (screw, stud) rod. The bolts are pre-tightened in the joint (Fig. 5), which ensures the joint is tightly closed.

The external force F_B acting on the bolted joint reflects the internal pressure of the air compressed in a container with a diameter of D:$F_B = P \cdot (\pi \cdot D^2 / 4)$

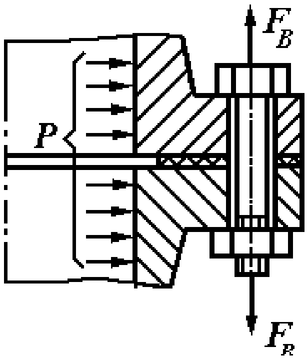

Figure 5

2) *The material of the bolt (screw, stud) is selected, and if necessary, the material of the parts to be joined. Fasteners for general use are made of low and medium carbon steels such as 10 steel ... 35 steel.*

3) Depending on the operating conditions of threaded parts, the permissible tension for tightening, crushing or shearing is found.

The permissible tension for tightening for bolted joints $[\sigma_p]$ found in the absence of plastic deformations. It is the yield strength of the screw material σ_T depends on and $[\sigma_P]= \sigma_T / [s_T]$ is equal to.

Here $[s_T]$ — strength reserve factor. $[s_T]$ It is recommended to select the quantitative value of the reserve coefficient depending on the assembly technology. If such assembly is performed with a torque wrench that allows for strict control of the tightening torque, then $[s_T]$=1,3…1,5. The tightening of the screw in this version of the assembly is called controlled. However, in most cases, the wrenches for tightening do not have means for controlling the torque, as a result of which the tightening force remains uncertain. The assembly performed with such a wrench is considered uncontrolled. In this case, it is necessary to increase the value of the reserve coefficient and $[s_T]$ = 1,5… 4,0 It is advisable to take it equal to . In addition, the largest values in the indicated range should be chosen for small diameters of screws (d ≤ 10 mm), since the possibility of stretching is much higher in them. The permissible shear stress can be determined from the following relationship:

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$[\tau_{CP}] = (0{,}2\ldots\ 0{,}3)\ \sigma_T$,

Permissible crushing stress: $[\sigma_{CM}] = (0{,}35\ldots\ 0{,}45)\ \sigma_T$.

4) *The inner diameter of the thread is d1, the bolt (screw, stud) with the largest inner diameter of the thread is selected.*

5) A verification calculation is performed.

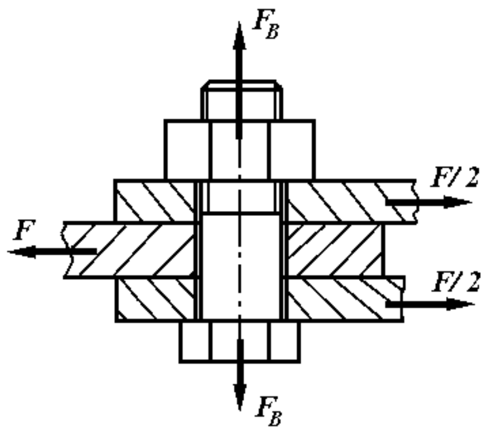
6) If necessary, the connection can be checked for the absence of movement along the base, in which the moving part is compared with the friction force that occurs when turning the bolt (screw, stud).

If the base material is not strong enough compared to the material of the bolts, for example: a cast-iron bracket is attached to a concrete wall (base), then the wall is checked for maximum compressive strength.

$$\sigma_{CM} = \frac{\Sigma F_i}{A_{CT}} \le [\sigma_{CM}],$$

here ΣF_i – the total load on the base compressing (crushing) bolt; A_{CT} – base surface, $[\sigma_{CM}]$ — Permissible crushing stress for the strength of the threaded pair is less detailed.

Permissible compressive stress at the joint for a brick wall built in a mortar mixture — 0.7...1.0 N/mm^2; for a brick wall built in cement mortar — 1,5...2,0 H/mm^2; for concrete — 2...3 N/mm^2; for wood — 2...4 N/mm^2



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