Ministry of Education and Science of Ukraine
National Aviation University

Labs

subject **“Mechanics”**

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Lab 1

Determination of basic parameters cogwheels

The purpose of the work

1. Fixing knowledge of the geometry of gears.
2. Introduction to the simplest method for determining module gear.
3. Acquisition of practical skills in identifying key geometric parameters of spur gears.

Brief theoretical information

Involute circle equation and its properties

Nowadays, the technique used almost exclusively gears with involute gears gears. In involute gear tooth side profile is involute circle centered on the axis of the wheel.

Involute circle called the curve that describes any point in its direct rolling without sliding along this circle. The terms on which rolls straight line, called the primary, and direct - straight generatrix.

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Fig. 14 shows the main circle of radius Rv and generating

Fig. 10. involute circle

Acute angle between αu tt tangent to the involute at point Q and the current radius vector ru is called angle profile. It can be shown that the angle KuONu numerically equal to the angle αu. Therefore, it is indicated αu. Θu angle between the initial radius vector involute RCC and its current radius vector eye called involute angle or angle involyutoyu αu, that θu = invαu. Regulation anywhere involute completely defined by two parameters: the radius vector ru and involute angle θu.

Due to the fact that the direct claims by main circle rolls without slipping, be fair equality =. Substituting the length of the arc and the segment, we have:

Rv (θu αu +) = Rv αu where

θu = inv = αu αu - αu.

The relationship between the radius vector ru and the angle of the triangle αu vstanovlyuyetsya KuONu: ru.

The formulas for determining the parameters θu and ru is involute equations in parametric form.

For the theory of engagement are important properties such involute:

1) involute - symmetrical curve has two branches that

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April converge at a point on the main track; therefore involute no points inside the main circle;

2) nIn point is instantaneous center of rotation of direct claims and the center of curvature of involute at point Q; therefore normal to the involute at any point it is straight tangent to the main circuit;

3) KuNu segment is the radius of curvature at the point ρu Ku;

4) Profile αu angle and radius of curvature at the starting point ρu involute (April) are zero; at a distance from the main points of the circle involute profile αu angle and radius of curvature ρu increased;

5) while increasing the radius of curvature of the main circle involute profile gradually decreases and at Rv = ∞ involute turns into a straight line.

Options involute cylindrical gear

wheels without bias

Parameters gear called estimated values that define the basic dimensions of the wheel. These parameters are considered in any section of the wheel plane perpendicular to its axis, ie face section.

In the face of a cylindrical gear section (Fig. 15) depressions circle diameter df teeth limits of the body wheel, and on the other teeth restricted circle diameter DA peaks. The distance between the peaks and troughs community determines tooth height h. Involute tooth profile corresponds fully determined mainly circle diameter DB. In these circles in Fig. 15 shows the so-called pitch circle diameter d.

Pitch is called a circle that intersects the side involute tooth profile at the point for which according to the standard profile αu angle = α = 200. The equation involute obtain such a ruling relationship between the diameter and the main circles:

DB = d cosα.

If the length of the circle (a ruling, basic) divided by the number of teeth wheels, we get the length of the arc of the same name between the profiles of two adjacent teeth, called under step was to pitch circle and RV step on the main circle.

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Fig. 15. involute cylindrical gear without bias

So step gear is called the distance between the two points of the same name adjacent teeth measured along the arc of circle. Arcs p and PB correspond to the same angular pitch τ = p / r = PB / Rv. It follows that the steps proportional to the radius circles. The angular step can also be determined from the ratio τ = 3600 / z, where z - number of teeth of a gear.

An important parameter is the gear step was to pitch circle. Obviously, the step was multiplied by the number

teeth z, represent the length of the pitch circle:

π d = p z,

where d = m z.

The value of t, which is the ratio step was the number π, called module gear. The module is measured in millimeters. Its value depends on which stake it is measured. The value of the module by dividing a circle standardized. The standard has two rows of modules

(Table. 2). When choosing a module should be preferred front row.

Gears in which the thickness of the tooth pitch S in a circle

(Fig. 15) is equal to the width of the depression, called wheels without offset. Such gear also called normal (or null-governmental). Worm-wheels formed without bias, called gears without bias (normal or null-governmental transfers). When transferring movement gears z'yavlya-

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yutsya so-called initial circles are rolled one by one without sliding. Parameter wheels on the initial range of prescription-tion index W. Thus, dW, p W, α W, so W - respectively, the diameter, pitch, angle profile, the module for the initial stake. In the gear wheels without offset initial range coincides with the pitch because dW = d; W = p p; α W = α; W = t t.

The initial range of wheel teeth divided by height in two parts: head height Ha of the tooth and tooth foot height hf. Formula for EID-identification-size gears without bias shown in the table. 3.

Table 2

The values of t gears module (GOST 9563-60)

1st row 2nd row 1st row 2nd

row 1st row 2nd row 1st row 2nd row

0.05 0.055 0.55 0.5 5.5 5 50 55

0.06 0.07 0.75 0.6 60 6 July 75

0.08 0.09 0.8 0.9 August 9 80 90

1 0.1 0.11 1.125 10 11 100

0.12 0.14 1.25 1.375 14 December

0.15 0.18 1.75 1.5 16 18
0.2 0.22 2.25 2 20 22
0.25 0.28 2.75 2.5 25 28
0.3 3.5 0.35 3 32 36
0.4 0.45 4 4.5 40 45
Note. The use of modules 3.25; 3.75; 4.25 mm in the automotive module and 6.5 mm in tractor industry.

Definition module gear

Module gear by dividing a circle can be determined through step by main circle: t.

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Table 3

The formulas for determining the parameters of gear without bias

parameter Formula
Tooth head height Ha = t
The height of the legs of the tooth hf = 1,25t
Tooth height h = 2,25t
Step on the pitch circle p = πm
Step by direct stake pv = πm cosα
The thickness of the tooth on the pitch circle S = r / 2 = πm / 2
The width of the depression on pitch circle e = r / 2 = πm / 2
The diameter of the pitch circle d = mz
The diameter of the main circle d = mz
The diameter of the circle tops DB = mz cosα
Diameter circle depressions DA = m (z 2)

Note. In the last two formulas lower marks relating to the wheel with internal zubfmy.

As seen from the formula, all sizes of gears proportions, no module on the pitch circle.

Step PB by main circle can be calculated if directly on the wheel to measure distance Ln and Ln + 1 (Fig. 16).

As involute formed by rolling

without sliding generatrix direct claims by direct stake RV step will be equal to the length of this line segment between involute E1 and E2, which form the profiles of two adjacent teeth. The length of this segment and thus step RVs can be calculated after measuring caliper distance Ln between left and right profiles n teeth and the distance Ln + 1 between the respective profiles n + 1 tooth.

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Then step on the main circle p

in = Ln + 1 - Ln.

When measuring segments Ln and Ln + 1 leg calipers have to touch the side profiles involute teeth within regions. This will occur if the number of teeth n measured choose from the table. 4.

Fig. 16. Scheme of measurement
segments Ln + 1 and Ln

Table 4

Determination of the measured zub'yiv gear

z	12-18	19-27	28-36	37-45	46-54	55-63
n	2	3	4	5	6	7

Knowing step PB by direct stake module so easy to calculate by dividing a circle. The resulting values may differ from the module standard. This is due to the inaccuracy of manufacturing wheel wear side surfaces of the teeth in the operation, and the inaccuracy of the measurements. Therefore, the calculated value module must be replaced nearest standard size, taken from the table. 2.

The execution of laboratory work

1. Count the number of teeth z wheel and determine on the table. 4 measured number of teeth n.

2. Measure the distance caliper Ln and Ln + 1 and determine the step gear on the main circle.

3. Calculate the module separating the wheel and circle round it to the nearest standard size, taken from the table. 2. Calculate the diameter of the pitch circle.

4. Measure the caliper diameter circles DA peaks and troughs df. If an odd number zub'yiv diameters DA and should df

determined through hole hub diameter wheels and distance from the sleeve to the top or hollow teeth.

5. Calculate the height of the tooth head height legs and teeth.

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6. Determine the height ratios head and legs ha tooth tooth hf. On wheels without bias must be ha = 1.0; hf = 1,25.

If the results of calculations differ significantly from these values, it indicates that the gear shift cut with an instrument or a shorter tooth.

7. Make a report of laboratory work (see. Ext. 2).

References: [1, c. 192 - 203]; [2, c. 72 - 78]; [3, c. 50 - 58].

Lab 2

RATIO DEFINITIONS Gear
gear mechanisms

The purpose of the work

1. Acquisition of practical skills charting gear mechanisms.
2. Consolidation of knowledge to determine the gear ratios of gear mechanisms.
3. Acquiring skills kinematic study of gear mechanisms experimental method.

Brief theoretical information

General information about Gear mechanisms

Called toothed mechanism in which the transfer movement is using gear units, gears, gear sector, gear racks. Often using gear mechanisms rotational movement is transmitted from one shaft to another.

Tooth mechanisms have become very widespread in-class technology. For example, in aircraft engines jagged metal-mechanisms for traffic transmitted from the main shaft to the other shaft that drives the generator, fuel, hydraulic and oil pumps, air compressors and other support units, to ensure the normal operation of the aircraft. Gear mechanisms for metal-can be found in each vehicle, a tractor as a co-

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Robock transmissions, differentials and other devices, as well as metal-processing machines, devices, mechanical watch and so on.

The easiest gear mechanism (Fig. 17) is made up of wheels 1 and 2 and 3. riser Gears 1 and 2 form a kinematic pair 2nd race, and each wheel of risers 3 - rotational kinematic pair 1st race. Note that the real connection gear shaft to indicate circuits cross the axis of the wheel (Figure 17).

Less gear mechanism called gear and more - wheel. Gear mechanisms with one degree of freedom called gears.

Gear transmission depending on the location of the axis gears are divided into three types: cylindrical, conical and hiperboloyidni. Cylindrical gears - a transfer of

Fig. 18. internal meshing gears

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Hiperboloyidni gears - a transmission formed by the wheels, axles are crossed. Hiperboloyidni transmission are of three types: spiral formed cylindrical gears; hypoid formed conical gears; Worm formed worm 1 and worm wheel 2 (Fig. 21). Gears 1 and 2 gear generally rotate at different angular velocities ω1 and ω2. The ratio of angular quick start-bones called the gear ratio and denoted by the letter u with respective indices. Thus, the value of

and

Gear ratio are the same transmission, but only in the first case is due to wheel to wheel 1 2 (), and the second - from wheel to wheel 2 1 ().

Fig. 19. Figure gears. 20. The conical gear
rail gearing transmission

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This event will take place at home affected wheel (Fig. 18).

If the gear mechanisms one of the gears carried in a rack (Fig. 19), the gear ratio of the wheel 1 to track 2 will equal nezkinchenosti ie = , for toothed rack 2 can carry only reciprocating motion (ω2 = 0). Of course, at this time.

In the gear mechanisms of the angular velocity of the output shaft may be lower or higher angular velocity of the input shaft. Mechanisms that reduce the rotational speed of the output shaft compared to the input, called a reducer, and the mechanisms that increase the rotational speed of the output shaft, called multipliers. So, gear Gear ratio

Multistage gears

Gears composed of two gears and risers, called single-gear

(See. Fig. 17 - 22). Her gear ratio,

where - rotation frequency units 1 and 2 (min-1); and - the number zub'yiv wheels 1 and 2.

Consequently, the value Gear ratio is always possible

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determined through the number of teeth of gears. In external gears mesh (see. Fig. 17) gears rotate in opposite directions, so the gear ratio to be negative:

.

In the internal transmission gearing (see. Fig. 18) gears rotate in the same direction as gear relat-tion is positive:

.

Due to the limitation of the overall dimensions of gear co-forest often in practice in implementing Single gear Gear ratio = 5 - 7. bevel gear 5.

Gear ratio worm gears as objectified also assigned to the formula. This - the number zub'yiv cherv'yach-foot wheel, and - the number of events worm. Usually = 1; 2; 4, and most often ranges from 32 to 80 (sometimes up to 300). So re-datochnyh ratio worm gears found typically in the range of 8 to 80 (in special cases up to 1000).

In practice, wide enough zastosovunnya acquired multistage gears, the transmission is composed of several series-connected single-stage gear. Such transfers allow to receive quite large gear ratio with relatively small dimensions and high coefficients of performance (COP).

Fig. 23 shows a four-gear,

which is composed of four series-connected single-stage gear.

Fig. 23. The four-gear

Gears of numbers of teeth and form a cylindrical external gearing transmission, wheels with teeth and numbers - the transfer of internal gears and toothed wheel with numbers and teeth and form a conical transmission.

Note that the marking of numbers zub'yiv different gears attributed to the z-index, which corresponds to the level. If one link (shaft), for example, link 2, fixed some wheels, their number of teeth indicate, etc. Of course, instead of the expression "with the number of gear teeth z" use short term "wheel z".

Gear ratio multi-gear gear ratios equal to the product of individual steps. Therefore, the transfer in question will be:

=,

where, - Gear ratio of individual stages (one-stage gear). Find the value of individual gear ratios degrees:

; ; ; .

Then the value Gear ratio mechanism:

.

If the gear is at least one degree of neparalel-governmental wheelbase, the gear ratio of the individual steps and overall Gear ratio signs (plus or minus) is not credited. A rotation direction of any link arrows define the rule, as shown in Fig. 23. For this set the direction, for example, direct link 1. A hand, placed on the shaft of the wheel indicates that the teeth of the wheel, visible observation-rihachu moving down. Accordingly, the arrows indicate the direction of movement of other units. The direction of output unit 5 of the arrow B.

Intermediate gear wheels

Multiple transfer can be done so that the same gear is a member of two single-stage gear. Fig. 24 shows a three-stage transmission, which has wheels and both form two external gearing transmission and the wheels and - the transfer of internal gearing. Thus, the wheel part of the first and second gears, and wheel - in the second and third gear.

The gear ratio of the transmission

=.

Replacing each multiplier is the ratio of the respective numbers zub'yiv and considering the signs, we get:

• =.

As seen from the results, the number of teeth and do not affect the value Gear ratio;

The execution of laboratory work

1. Be familiar with the work of the mechanism to investigate the character of its parts and to determine the type of mechanism.

2. Draw a diagram of the mechanism, managers and numbered gears mark.

3. Calculate the number zub'yiv gears.
4. Calculate the gear ratio of the individual stages and gear ratio of the whole mechanism.
5. Determine gear ratio mechanism of the experimental method.
6. Make a report of laboratory work (see. Ext. 3)
References: [1, c. 281 - 295]; [2, c. 65 - 69; 105 - 108]

Lab 3
STUDY DETAILS bolting,
Loaded SHEAR STRENGTH

The purpose of the work
1. Consolidation of theoretical knowledge from the "Threaded connection".
2. Definition of necessary force depending tightening the bolt from shear force details.
3. Calculate the required diameter of the bolt by tensile strength parts.
4. Building plot of shear force on the strength of tightening the bolt.

Brief theoretical information
In bolted connection loaded by the shift, the main condition is the lack of reliability relative displacement of parts. Consider two embodiments of the connection.
1. Bolt holes found in parts of the gap (Fig. 29 a).

Fig. 29. bots connection: connection bolt, put
with a gap (a) without clearance (b)
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In this case, you must tighten the bolt with a force that
provides between parts that are charged, the friction force, which can be defined by the formula
,
where - coefficient of friction at the junction
planes; - The number of pairs of planes junction.
The absence of shear connection details looks
,
where - external power shift parts.
If you enter a safety factor connection, you can define the desired effect tightening bolt

The coefficient is selected: - under static load connection;
- Under the influence of variable load.
In the considered connection external power directly to the transmission bolt. Therefore, bolt count only on static strength at the right tightening force even when exposed to variable time external force. The required internal diameter
carving determine conditions of strength bolt tension:
,
where - allowable tensile stress, which can be defined as follows:
,
where - the border of the yield stress of the bolt;
- Safety factor bolt ().

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2. Bolt holes found in details without gap (Fig. 29 b).
External power is directly transmitted to the bolt, so the friction force between the parts are neglected, and the delay of the bolt is not required.
Bolt in this connection calculated by shear strength:
,
where - according the calculated and allowable stresses
cut; - Cross-sectional area; - Diameter rod bolt.

This bolt is cut in two planes, so

.

The required diameter rod bolt can be measured
expression:

Comparing the two options of setting screw (with a gap and without gap), it should be noted that the first option is cheaper than the other, because it does not require exact dimensions and bolt hole. However, the same external power connection required bolt diameter set with a gap substantially larger than the diameter of the bolt installed without a gap.

Description of the laboratory setup

For the laboratory work using universal press DM30, which reinforce the working node doslidzhuvalnoho bolting DM23M. The kit includes the necessary equipment: a calibration key calipers, rizbomir set of bolts with nuts M16; M16h1; M16h1.5; M18h1; M18h1,5; M20; M20h1; M20h1,5. Set in sleeves M16 bolts; M18; M20, a set of plates and inserts roughness surfaces have a height of roughness profile

m.

In rys.30 given constructive scheme DM30 press.

It consists of a base 10, which stipulates Table 7. Cherv'yachno-

Fig. 31. wrenches
key

coordinate with the standard and determine the average diameter of the thread of the bolt -.

2. Perform calculations: a) to determine the angle of ascent spiral thread by the expression:

,

b) determine the allowable tightening strength by strength
rod bolt tensile and torsional

,

where the coefficient of 1.3, taking into account torsion bolt at zatyazhtsi;

- Allowable stress stretching. For steel bolts
Marks St0, CT2, ST3 can take MPa;

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c) determine the time of screwing the expression:

,

where - elevated angle of friction in the thread;

- Coefficient of friction at the junction of parts.

In this paper coefficients of friction.

Consolidated angle of friction in the thread is determined by the expression:

,

where: - the coefficient of friction in the thread; - The angle of the thread profile. For metric thread:; ;
Accepted;

d) determine the shear strength of parts for screwing points equal; ; ; and by the expression:

1. Make a desktop unit laboratory work. Line on inserts must coincide with the upper line on the plate.

2. Draw a diagram of the laboratory setup.

3. Tighten the bolt connection key to a calibration point.

4. Establish a working node installation on desktop press.

5.Pidvisyty tip screw press to lock and load 8 bolted connections before the liner relative displacement of the plates. This point is determined by the indicator arrow jumps dynamometer. For a calibration graph determine appropriate shear force.

6. Conduct testing in the bolting violently

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moments screwing equal; ; ; and. During the tests should follow that line to insert not come out for the bottom line on the plate, or get out the gap between the parts and the bolt will pidverhnutyy strain.

7. Draw conclusions about the causes of the difference calculation results with the experimental data to explain why with increasing time of screwing increasing power shift.

8. Make a report of laboratory work (see. Dod.5).

References: [4, p. 29-31]; [5 s.112-114]

Lab 4

RESEARCH tighten the bolted connection loaded with axial external FORCE

The purpose of the work

1. Definition of the load on the rod bolt at the joint of the force and tightening external axial force.
2. Definition of previous tightening the bolt, providing undisclosed parts and junction tightness.
3. Calculate the required diameter of the thread of the bolt strength by stretching.

Brief theoretical information

Examples of loading, axial-TION connections prior tighten the bolt (the direction of the external force parallel to the axis of the bolt) is the most common in practice. For most of these compounds should keep certain conditions in the plane of the junction (leak, failure to disclose the junction etc.) By the action of an external load. Examples include bolted flange connections of pipelines, tanks of high pressure covers, brackets and various other parts. Fig. 33 is a diagram of the load bolting. It consists of parts 1 and 3, connecting pads 2, 4 bolt and nut 5.

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ratio, taking into account the share of external load, which sees rod bolt is called the external load.

The task sharing between the external load F bolting parts are statically indeterminate. The solution to this problem are provided with equal deformation rod bolts and parts of the junction in the form:

(1)

where - compliance bolt, which is its deformation in a single load; - Total compliance connection details.

From equation (1) determine the estimated coefficient of external load:

.

Compliance bolts are using the expression

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Absolute lengthening rod stretched the law Hooke.

The result is:

, (2)

where - the length of the deformed section rod bolt;

- Cross-sectional area of the rod bolt;
- Modulus material bolt.

Compliance is determined at the junction of details assumption that the compressive deformation connection details of the nuts and bolt heads distributed cone angle of . dorivnyuye the angle of about 30 °, meaning tg ( ) 0,5. Sizes smaller base of the cone and take equal outer diameter D1 bearing surface of the nut (size turnkey). To simplify the calculations cones replace conventional pressure cylinder with a diameter DC which are equating volumes of cones and cylinders.

And (3)

where - the thickness of the connection details;

- Thickness gaskets.

Cross-sectional area equivalent cylinder pressure junction details:

And (4)

where - the diameter of the hole in the details of the connection.

For different values of elastic modulus material connection parts E1 and E2 E3 and laying compliance is:

. (5)

For details of the same material connection (E1 = E3 = Ed) and

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availability pads have:

, (6)

where.

If the connection details done without pads E1 = E3 = ed, the compliance is:

. (7)

The value of the previous tightening efforts is determined by the formula:

,

where - coefficient of tightening the bolt.

In case of failure to disclose the crossroads:

at constant load = 1,25-2;

with alternating load = 2,5-4.

By the condition of the tightness of the junction:

with soft lining = 1,3-2,5;

with metallic shaped lining = 2-3.5;

with metallic flat gasket = 3-5.

The total load perceives rod bolt is found in the form of:

.

After substitution we get:

.

Based on these relationships experimental value of effort,, F define experimental values of the external forces:

.

For details of connections without pads or metal pads coefficient external load varies 0,2..0,3. In the presence of elastic gaskets

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rate reaches higher values and could be close to one.

Description laboratory facility

The work performed on the screw press and DM30 DM 22M special device, the design of which is shown in (Fig. 34).

The base unit 1 is fixed to the table 25 with the help of the press, my 24 bolts with washers 23 and nuts 22. from 1 through 18 and the gasket washer 2, 3 screw with a spherical head

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fixed stand 6, which turn 4. Details fix pins 8, 17 and 16 laying coupling bolt and nut 15 utvo-ryuyut test compound. In zatyazhtsi nut bolt from the scroll kept variable lock 5, which is enshrined in the doorway stands 6 screw 19.

Parts 17 screw-in base 6. Item 8 based Burt reference to the glass 14, which consists of two halves. The top of the cup 14 has protochki participation delight 9. 14 cup halves stitched ring 13 which is held in the raised position 10. Capture 9 pins fastened with screws 11 to ring dynamometer 12 press DM 30.

Based on 1 installation mounted three terminals 21 to 20 are connected wires from strain gauges resistance test on the rod stuck bolt 16 screwing nuts 15 previous tightening efforts produced a compound which is measured using strain gauges on the rod bolts 16. The outer lifting the burden on fittings form a screw press through capture 9 and 14. The value of this glass of load dynamometer measured 12.

The kit includes devices, DM 22M bolts M12, M16, M18, M20 stuck with their rods and nuts load cells 15 and with a size variable parts 5, 8, 17 and 7 pads.

The execution of laboratory work

1. Measure the thickness and diameter of the hole for the bolt parts 8, 17 and 7 test pads connect to the appropriate standard size bolts.

2. To take the test bolted connections (with and without lining pads) in DM 22M unit and fix it on the table press DM 30m and attach delight to 9 ring screw torque

3. Connect the recording device to the appropriate terminals on load cells, test rod stuck on bolt.

4. Perform calibration recording device.

For this nezatyahnutyy bolt with a screw press load stepwise axial force after 2 kN to a value that does not exceed the permissible values obtained from strength conditions for this type of size

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testing of steel bolts ST3: M12 kN .; M16 kN; M18 kN; M20 kN.

The value of axial load dynamometer press record, and recording device using strain gauges.

5. Create the previous tightening efforts, recommended sizes for testing bolts. : M12 kN; M16 kN; M18 kN; M20 kN.

6. The load experienced prolonged bolted connections with external efforts with a screw press. Load carry successively through 1..1,5 kN until corresponding disclosure junction, connecting parts, when all external load will be perceived core bolt. External load which is applied to the details connecting dynamometer measured 12 newspapers and magnitude of the axial force that is perceived rod bolt, as well of the external load equal to, the registration device gage chain.

7. Determine the experimental values of the external load based on experimental data obtained by the formula:

.

8. Determine the estimated value of compliance and bolts details of the junction of the formula:

,

9. Find the value of external load perceived rod bolt and a portion of that goes to reduce compression junction details:

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Determine the total axial force on the shaft bolt:

.

10. Build a schedule devic-research work of variables efforts tempted connection

(Fig. 35).

11. Based on the estimated coefficient to determine the external load and part load and tightening efforts, zadavshys rate of previous tightening. Find the estimated total axial force of the bolt as follows:

Perform comparative analysis of the data are based on tests and calculations.

12. If you know the total axial force on the bolt, calculate the required internal diameter of the bolt thread provided tensile strength:

,

where - allowable stress in tension. For bolts of steel grades CT2, ST3, ST5 value - 120 MPa.

13. Make a report on laboratory work.

References: [4, s.31-37]; [5 s.114-117].

Lab 5

RESEARCH WORK GROUP bolted joints

The purpose of the work

1. Determination of the estimated power for the most loaded bolt theoretically and experimentally.
2. The calculation of the required diameter of the thread of the bolt provided tensile strength.
3. Building plot of forces acting on the bolt from external forces.

Brief theoretical information

Examples of group bolted connections can be bolted connection of different arms loaded with external force, which lies in a plane perpendicular to the junction with the base bracket. In the study of these compounds enter the following assumptions:

- Details of connections and enough hard surface junction parts remain flat after loading the connection;
- All connection bolts are the same size.

The calculation of group bolted joints - the definition forks calculated for the most loaded bolt. After this calculation is performed umoly bolt tensile strength.

In connection randomly loaded all external forces must be reduced to the center of gravity of the junction of parts. The result will have a load connection axial forces and the forces acting in the plane of the junction of parts.

Consider a simplified version of bolting bracket with the base (Fig. 36) to the loaded external force F, which lies in a plane perpendicular to the junction at the center of its weight.

Force F decompose into two mutually perpendicular components:

and.

The effect of these components will replace the action of the same forces, but applied at the center of the junction Oh, and the action of the moment.

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Fig. 36. Scheme of connection

The most loaded bolts in the connection bolts are placed to the left of center of gravity junction (see. For strength and direction (Fig. 36, b). Therefore, the total external axial force on

most loaded bolt:

.

The estimated strength of the bolt provided undisclosed junction

determined by the expression:

,

where - coefficient tightening bolt;

- Coefficient accounting twist bolt at zatyazhtsi;
- Ratio of the external load.

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For standard metric thread -. In case of failure to disclose details of the junction connection -. For soft joints without gaskets between parts -.

Determination of the estimated force to prevent bolt subject to shear connection details

Offset bracket can occur under the influence of F1. The power shift is perceived one bolt connection -.

The condition preventing displacement of the bracket approximately (upward connection reliability) is written as:

,

where f - coefficient of friction at the junction of parts, f = 0,1-0,2 for steel parts;

K - coefficient of reliability of connection, K = 1.3-1.5 under static load.

External force F2 is taken with the sign "-" because it promotes the junction unloading of parts. It also takes into account the effect the moment M, because time does not change the total force of friction in the joint.

Need bolt tightening force:

.

Rated power according to bolt can be written as:

.

According to this formula determined by the estimated power in setting the bolts with a gap. If the bolts are placed without a gap, then test their strength is performed directly on the strength Fb1.

So we have two formulas to determine under the two-set conditions. The diameter of bolts is determined by the higher of the settlement obtained by force.

Determination of the estimated strength to bolt provided disclosure junction connection

In disclosing the junction axis of rotation of the bracket is displaced from the axis of symmetry to the edges of the joint.

Consider one of the options bolts fastening bracket loaded external force F, directed perpendicular to the junction (rys.37). Bracket

three pairs of bolts fastened to the frame. In the absence of tightening bolts rotation axis is an edge junction (O-O).

From the force F arises tipping point relative to the axis O-O:

.

As a result of the moment to bolt the forces of reaction F1, F2, F3, which form a counteractive moment:,

where z - number of bolts in a row (in this connection z = 2);

, - The distance to the axis of tipping bolts first, second and third rows.

To ensure the strength bolting necessary to counteracting moment was greater than the overturning ().

Putting the system of equations:

;

; .

Solves this system of equations, we find efforts bolts F1, F2, F3. The load between the rows of bolts unevenly distributed, but each row of bolts loaded equally.

Most are loaded bolts third row, respectively

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F3 is the maximum power, and the checking of their strength is performed on a stretching force F3:

,

where Ab - cross-sectional area of the bolt threaded section; - Allowable stress in tension. Bolt steel grades with Article 2, Article 3 values = 120 MPa.

Description of the laboratory setup

Installation is considered above-secured version of the three pairs of bracket bolts 3 to the frame 2 (Fig. 38).

Fig. 38. Scheme of laboratory setup mounting bracket

To the body through the console beam 6 applied external force F, directed perpendicular to the junction. External power cos-ryuyetsya screw jack 4. Action dynamometer is

determining the elastic deformation staples proportional force,

measured. The value of strain staples is determined by means of the dynamometer center indicator clock type. To transfer values deflection indicator of the value of the measured force is a calibration graph.

From the action of overturning moment Mper deformation occurs screws , , - respectively for the first, second and third rows.

The magnitude of this deformation is recorded indicators clock type, attached to brackets on one of the two bolts each row.

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The execution of laboratory work

1. To make the calculation scheme for determining the efforts screwed. Find the position of the axis turning bracket, measure and record the shoulders, each row and shoulder bolts l external force with respect to that axis.

2. To make the system of equations to calculate theoretical values and efforts bolts of each series of overturning moment values for multiple external force F. Estimated value of foreign forces asked the teacher.

3. Construct a graph of efforts bolts F1, F2, F3 on the size of the external force F.

4.Vymiryaty size bolt connections, find them modulus depending on the material and determine the stiffness of the formula:

,

where DL - modulus material bolts, bolt made of steel;

Ab - cross-sectional area of the bolt;

- The length of the bolt deformed.

5. Set to zero arrow indicators on the dynamometer and bolts. With a first jack handle

teacher defined external force F. Control value external force is performed using indicator dynamo meter. Record first value under external force performance indicators screwed.

6. Repeat the measurements are the same for the next set of values external force.

7. Define performance indicators for bolt size of their elongated , , , taking into account the scale interval indicators.

8. Calculate the amount of force acting on each bolt series for all values given value of external force formula Hooke.

9. The graphs in paragraph 3 apply experimental

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meaning forces acting on each row of bolts for different values of external force.

10. Release the bracket from the action of external forces and monitor the return arrow indicator to zero position.

11. Check the report for laboratory work.

References: [4 s.3-35]; [5 s.114-119].