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AUTOMATED TIGHTENING OF THREADED JOINTS AND TESTING

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ABSTRACT
Reliability of threaded joints depends on technical level of construction, quality of threaded details and quality of assembly process. In this article are examined several methods of automated tightening of threaded joints.
Keywords: threaded joints, reliability, power characteristics, tightening torque, control

1. INTRODUCTION
Threaded joints are used practically everywhere: in designs of machines and products threaded joints make about 15…20% from other kinds of joints, but labor input of assembly of these joints amounts to 25…35% from overall labor input. In many cases threaded joints are the main elements in the constructions, strength and durability of which in many respects define reliability of operation of construction.
In the case, when threaded joint are not tightened enough the unit has not required rigidity and containment, bet if the threaded joint will be over-tightened, the unit will be destroyed.
It is necessary to note, that the automation of technological process plays the lead in determination of quality, operating characteristics and lifetime of constructions.
Reliability of threaded joints is characterized by joints' design, accuracy of calculations of efforts and tightening torques, accuracy of realization of calculation tightening during of assembly process. Required reliability of threaded joints is realized by the control of the tightening and perfection of technology of assembly process also.
Usually process of automated assembly of threaded joints has eight stages [1, 2]:
1) Prior test and accurate definition of starting dates.
2) First control of threaded joint.
3) Choice of method and order of tightening of threaded joint.
4) Definition of standardized quality coefficients and limits of its dispersion.
5) Choice of nut wrench and accurate definition of its characteristic.
6) Choice of method of control of tightening and method of realization.
7) Measuring of the main power characteristics of tightening threaded joint for take required adjustable parameters of nut wrench.
8) Analysis of results and decision-making.

So, reliability of threaded joints it is, at first, the guarantee of keeping of prior tightening force during operation. How to provide this?

2. POWER CHARACTERISTICS OF THREADED JOINTS

The main power characteristics of threaded joints are: minimal failure load P_f (N) and test load N (N). For strength classes from 6.8 test load is: N= 74-79% · P_f. Test load is a control parameter and this load threaded detail has to hold during the test process.
The next power characteristic is the force of prior tightening Q (N). Usually Q = 75-80% · N [3]. In Table 1 is shown values of tightening forces for several sizes of joints.

Table 1. Tightening forces Q (N) for several sizes of joints

Size of threading	Strength class 6.8	Strength class 8.8	Strength class 10.9
M6	7540	8700	12530
M8	12750	15900	22800
M10	19130	25280	36080
M12	27230	36680	52500

There are several methods of automated tightening of threaded joints: tightening up to fixed tightening torque, tightening up to fixed angle, tightening up to limit of elasticity, tightening up to plastic deformations and others.

3. TIGHTENING OF THREADED JOINTS UP TO FIXED TIGHTENING TORQUE

At tightening up to defined tightening torque to the one of threaded details have to apply tightening torque M_t, which usually is shown on the drawings or in the technical documentations.
According to degree of the responsibility of joints it is settled classes of threaded joints and maximums/minimums of tightening torque (Table 2) [3].

Table 2. Classes of threaded joints

Class of joint	Tightening torque tolerance M_t	
	maximums	minimums
I	+5	-5
II	+5	-15
III	+5	-35
IV	+5	-65

Rated tightening torque is calculated by formula [4]:

$$M_t = 0{,}001\ Q\ [0{,}16P + \mu_{th}\ 0{,}58d_2 + \mu_t 0{,}25\ (d_n + d_0)], \qquad (1)$$

where μ_{th} – coefficient of friction in the thread;
μ_f – coefficient of friction on the detail face;
d_n – diameter of the bolt or nut, mm;
d_0 – hole diameter, mm;
P – pitch of thread, mm;
d_2 – average diameter of the thread, mm.

Contact friction in the thread and on the detail face depends on quality of contact surfaces, covering form, is or not lubricant, error of pitch and angle of thread, deviation from squareness of detail face and axis of thread, speed of tightening. And all these, in turn, significantly influence on the quality of tightening operation. In Table 3 are shown reference values of constants of friction in the thread and on the detail face.

Table 3. Values of coefficients of friction in the thread and on the detail face

Form of covering	Coefficients of friction	Without lubricant	Machine oil	Synthetic grease	Machine oil with MoS_2
Without covering	μ_{th}	0,32-0,52	0,19-0,24	0,16-0,21	0,11-0,15
	μ_f	0,14-0,24	0,12-0,14	0,11-0,14	0,07-0,10
Zinc-plating	μ_{th}	0,24-0,48	0,15-0,20	0,14-0,19	0,14-0,19
	μ_f	0,07-0,10	0,09-0,12	0,08-0,10	0,06-0,09
Phosphating	μ_{th}	0,15-0,50	0,15-0,20	0,15-0,19	0,14-0,16
	μ_f	0,09-0,12	0,10-0,13	0,09-0,13	0,07-0,13
Oxidation	μ_{th}	0,50-0,84	0,39-0,51	0,37-0,49	0,15-0,21
	μ_f	0,20-0,43	0,19-0,29	0,19-0,29	0,07-0,11

For simplification of calculation of tightening torque M_t in formula usually use the average values of coefficients of friction.

4. METHODS OF CONTROL OF THREADED JOINTS

Method of control with torque spanner is the most-used method. Torque spanner precision is ±5%. Measuring error depends on using method. Usually there are three methods [5]:

Method A. Tightening torque is measured immediately in the beginning of rotation of bolt or nut in the direction of tightening. This method is used for fast control and happened no later that 30min after tightening.

Method B. Tightening torque is measured during rotation (rotation angle 10°-15°) in the direction of tightening. This method is more precise and used for periodical control.

Method C. Tightening torque is measured after second assembly of details. This method is used for control of joint with oxide, coloration and pollution.

At control measuring sizes of tightening torques have to be in the ranges shown in Table 4.

Table 4. Sizes of tightening torques

	Method A	Method B	Method C
From	1,25 $M_{t\,max}$	1,08 $M_{t\,max}$	1,05 $M_{t\,max}$
To	1,05 $M_{t\,min}$	0,92 $M_{t\,min}$	0,88 $M_{t\,min}$

In the case, when the measured tightening torque is insufficient, there are do the additional tightening of threaded joint up to fixed value.

So, it is shown, that tightening and control of threaded joints are based on the methods, where is applied the tightening torque.

5. CONCLUSIONS

1.Quality of tightening of threaded joints is depended on tightening force.

2. On the tightening of threaded joints depend many factors, and at the first time, friction conditions.

3. In design and technical documentations have to show force of prior tightening and tightening torque.

6. REFERENCES

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