

Force turning off the torque limiter

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Summary. The article brightens scientific problem concerning the new ball coupling, which can be used in different branches of engineering. A comparative analysis of the results of research known freewheel. The design features a ball coupling on the basis of which it is easy to create a torque limiter evenly tightening bolted connections of various machines and mechanisms. Propositional necessary analytical fallow that describe the basic values of the forces off the torque limiter, which have become a benchmark for the development of a new design, which received a patent of Ukraine for utility models. Shows a schematic design of torque limiter, which is based on the known developed ball coupling s full description of its constituent parts and principle of operation. Based design features selected design scheme, which allowed for a mathematical model for the analysis of the power unit. Analytically describes the amount of force that acts on working balls at the beginning of the release of their engagement with the groove of the driven coupling half, i.e. an analytical expression effort off the clutch. On the basis of the formulas A quantitative analysis of the impact force of the spring by the amount of torque limiter for different angles of inclination grooves of the coupling halves. Made confirmation of the classical position that the dependence of torque limiter the wire diameter of the spring is the value is not linear. On the basis of current research findings and made practical recommendations for the implementation of the results of research opportunities in industry engineering.

Key words: torque limiter, friction, a ball coupling.

INTRODUCTION

Question to improve of quality, reliability, durability and efficiency of machines and mechanisms is closely linked to the need to improve, modernize and improve the quality of their individual components and assemblies. One of the important elements of machines and equipment are safety couplings. These improvements may be due to the modernization of existing safety clutches, and the creation of new safety clutches.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Commonly known safety clutches, which operate without destroying the connecting elements, primarily transfer energy through friction [1-5], that is separated at the end of the shaft torque increased to unwanted values by slippage of the clutch driving towards [6-8]. They are

known as freewheel or overtaking [3-8]. As first as these mostly transfer energy through friction except ratchet. This circumstance requires constant follow-largest force springs and tightening her time to adjust.

Moreover, increasing the workload of safety couplings requires rigid springs, which leads to an increase in the size of the devices, which is not desirable in the case of such couplings in the kinematic chain of portable instruments, for example, nuts, which are used during assembly and disassembly or repair operations threaded connections. And overtaking car starters couplings stiffness springs advantageous to have economy mode to provide more accurate off sleeves. Such opposite problem prompted the author and other experts of Mechanical Engineering and Transportation to develop preventive ball joints [9-10] on the basis of overtaking and overtaking with ball joints [11-16]. In this case the other transmit torque from the driving to the driven coupling not due to friction and gearing balls that are in the same slots as these coupling [17-20].

Developed at different times, such couplings acknowledged as a new and were patented. Some of them were put into production and learning process.

The preliminary analysis of kinematics showed that the rest of the couplings can be effectively used as a device for limiting torque wrenches or in the transmission now only from the electric starter gear crown wheel to the crankshaft main engine, but never vice versa. It is clear that the process of implementation of any mechanical means requires a comprehensive study of kinematics – force parameters and perform calculations on the strength of all the elements that are involved in transmission of torque.

OBJECTIVES

The purpose of this paper is to analyze the interaction of force balls with side surfaces of grooves coupling during off couplings, i.e. the performance of the automatic operation of separation ends of shafts of light friction between contacting elements in order to better select and customize the settings of spring time off clutches after shutdown energy.

THE MAIN PART OF ARTICLE

The paper summarizes the advantages and applicability of the prerequisite ballpoint overload clutch (Fig. 1), which operates on the principle overtaking clutch.

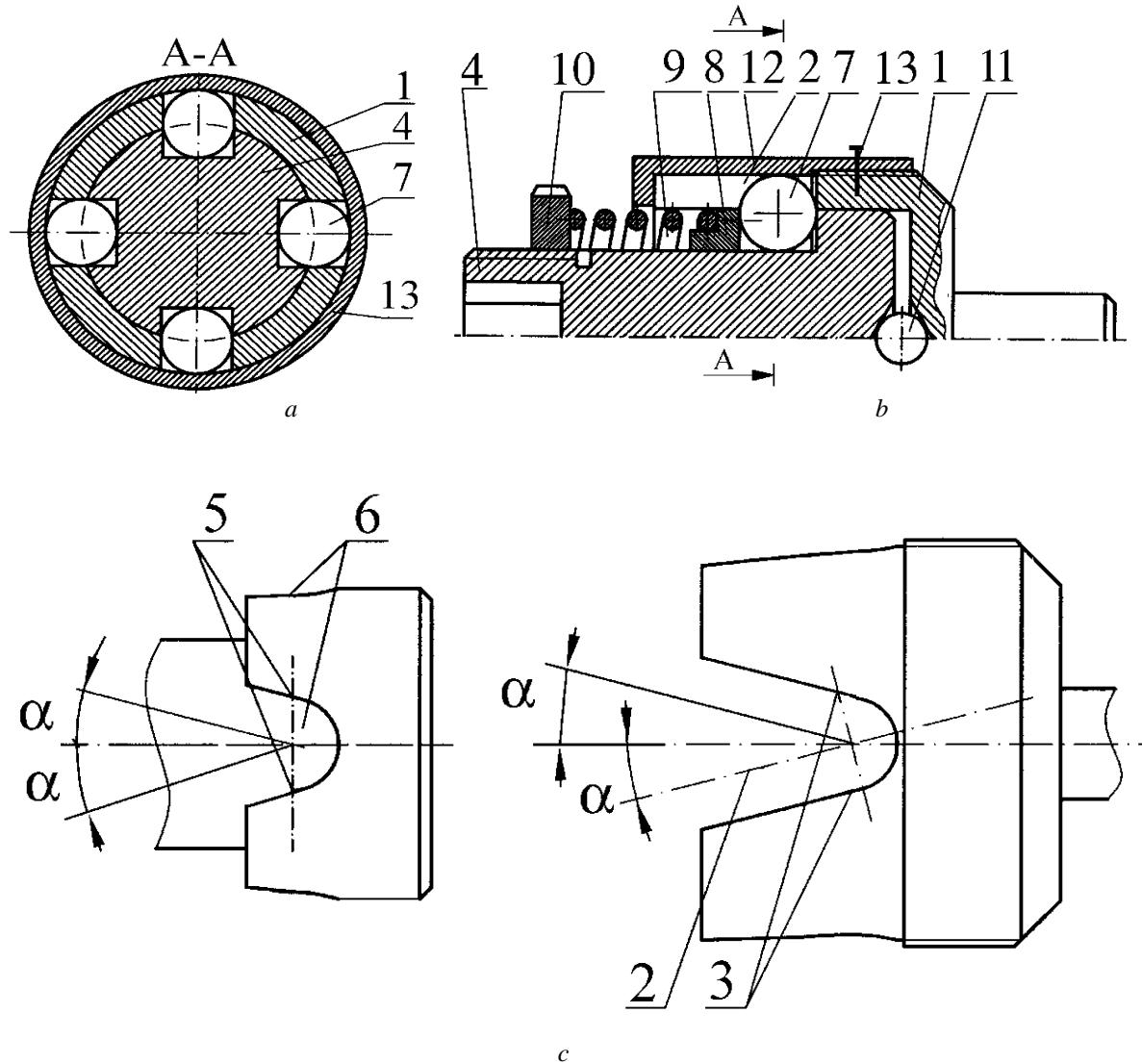


Fig.1. The structure of the torque limiter bilateral steps:
a – general view in context; *b* – section A-A general view; *c* – of the driven and driving coupling

It can be applied in practice for the mechanization of processes, for example, tightening of screws threaded connections with effort desired value during assembly and disassembly operations of various technical means. Developed clutch still has the main advantages: it makes manufacturing technology and its operation significantly easier, requires careful handling work surfaces lateral surfaces of grooves coupling; transmits torque through gearing, smaller size and strength delaying spring; suitable for tightening and unbolt thread connection right and left thread and others.

Its disadvantages include increased requirements for convergence of the initial allocation of slots coupling and their inclination to agree with the direction of rotation of the executive instrument, i.e. the direction of rifling.

The structure of the torque limiter or tightening force nuts threaded connections has: driving coupling 1 of grooves 2, with two sloping surfaces 3; driven coupling 4 of grooves 5 which are also inclined surfaces 6 under the same angle as the in the leading coupling; balls 7, located

both in the grooves of driving and driven coupling; screw drive 8, which nestles on the balls spring 9; adjusting nut 10, the ball 11 for centering, housing 12 with screws 13 for fixing it.

Its device is effective because it allows tighten nuts threaded connections with right and left carving. Moreover, he can function well with any source of rotary motion, particularly because it can easily change the direction of rotation. It could be an electrical current that has a switch to the movement, or other special wrench etc.. In this case the device to its right end can be secured in a holder an electrical outlet while inserting driven coupling useful tool. Allow you to use a wide range of tools: screwdrivers, wrenches, drill, etc. The value of torque is set by adjusting nut that with the right force compresses the spring that holds the ball in the grooves driven coupling. To increase the torque or force tightening screw joints during assembly operations more nut enough to click on the spring.

The principle of overload clutches like overtaking and is evident from its design. However, in its work is some of the features. Therefore, we consider the process of clutch operation, starting with its working condition (Fig. 1, *a*), i.e. when it rotates as a unit and the torque applied to the manufacturing facility of execution given operation, i.e. in case of nuts, is tightening the nut to the desired reassigned efforts. With the growth of the moment resistance of the nut axial component of the total force overcomes the elastic force and the spring pushes the ball out of the groove driven coupling, thus separating the end of the shaft. Coupling becomes idle. This process is accompanied by some knocking, which facilitates the completion of the process. More fully working principle of the device described in [8].

Here again, remember that a full cycle of operation ballpoint overload clutch can be divided into four specific parts:

- entrance balls in grooves driven coupling, its switching;
- working condition couplings, perform basic technological operations;
- out balls with grooves driven coupling it off;
- slip balls on the ends driven coupling (idling).

Of course, the interaction force between the clutch parts in different modes of work is changing, the laws which must precisely know the first stage in the design of safety devices, which require adjustments of torque with

high accuracy. It is clear that one of the keys to identifying the desired accuracy of analytical adequacy ratios is dynamic schemes that underpin this identification. So when determining the value of the torque necessary to consider the manifestation of friction at the points of contact of the ball grooves coupling work surfaces. Then the significant factors can additionally become more cross-sectional shape and orientation in space grooves movement of balls that can be made of different types of cutters. Here we consider only important process timely completion tightening nuts when clutch is overloaded and begins to shut down. Strength of interaction in this case is shown in Fig. 2.

For a visual comparison of two cases is, that in Fig. 2, and shows all the forces acting on the ball if the friction between contacting elements can be neglected. It is during the previous calculations. An in Fig. 2, *b* – a similar process, however with the friction. It should also be noted that throughout the process considered off clutch balls are still within the grooves driven coupling.

But more common is a condition of early release balloons with these grooves when the balls start to put pressure on the clamping ring draw toward it and compressing the spring. Then there are already efforts elastic springs F_{np} and – the total force acting on the ball by semi-coupling Fig. 2, *b*.

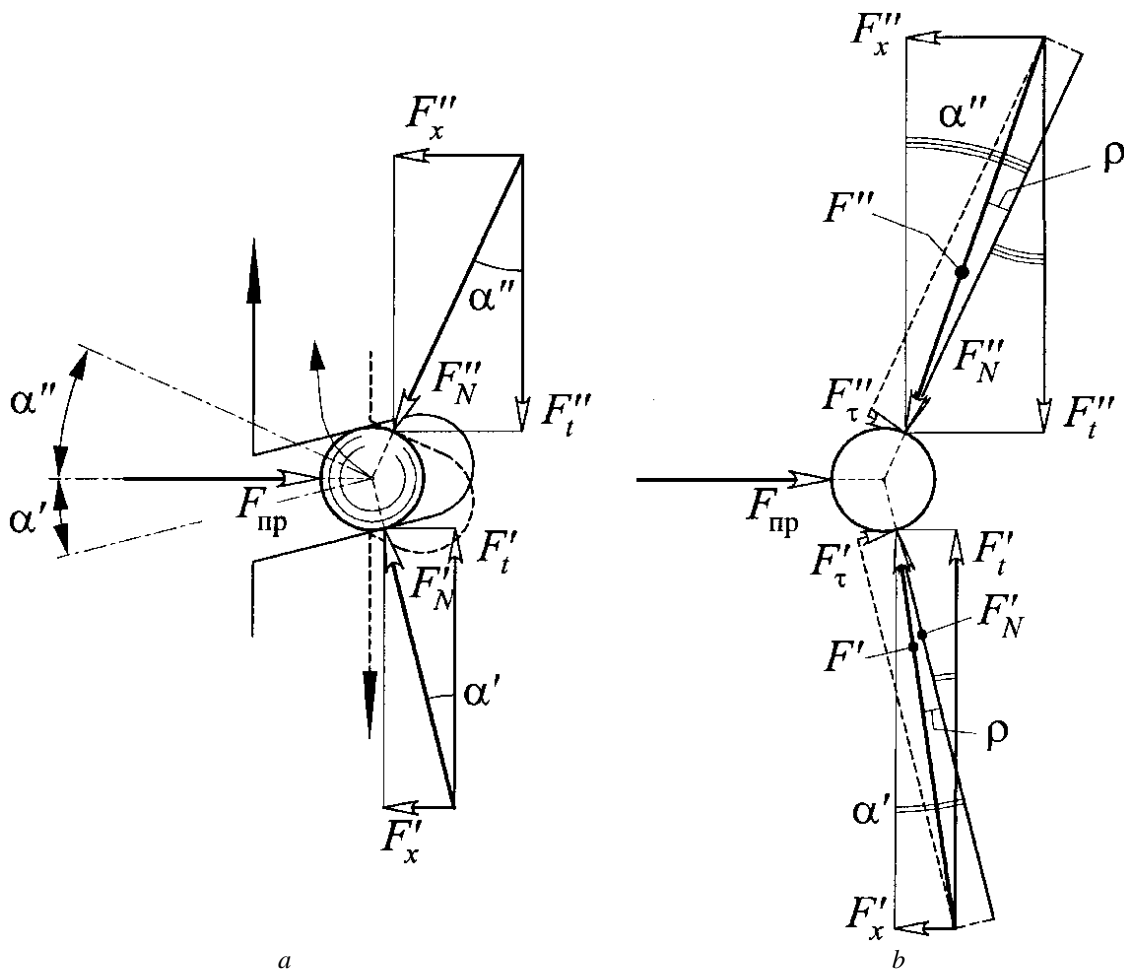


Fig. 2. Power interaction between the ball and side surfaces of the grooves coupling during off coupling: *a* – friction is not included, *b* – considering friction

From a design scheme (Fig. 2, b) derive obvious ratio [8]:

$$\begin{aligned}
 F''^2 &= F_N''^2 + F_\tau''^2 = F_x''^2 + F_t''^2, \\
 F_t' &= F_t'' = F_t, \\
 F_x' + F_x'' &= F_{np}, \\
 \frac{F_\tau'}{F_N'} &= \frac{F_\tau''}{F_N''} = \mu = \operatorname{tg} \rho, \\
 \frac{F_x'}{F_t'} &= \sin(\alpha' - \rho), \\
 \frac{F_x''}{F_t''} &= \operatorname{tg}(\alpha' - \rho), \\
 \frac{F_x''}{F_t''} &= \operatorname{tg}(\alpha'' - \rho). \quad (1)
 \end{aligned}$$

After solving the system of equations (1) received important for this case the relationship between the driving (circular) force that depends on the magnitude of the torque, which rely sleeve, elasticity and strength springs in such general terms:

$$F_t = \frac{Gd_\delta^4 \lambda}{\operatorname{tg}(\alpha' - \rho) + \operatorname{tg}(\alpha'' - \rho) 8D^3 i_p}. \quad (2)$$

Designating:

$$\frac{Gd_\delta^4 \lambda}{8D^3 i_p} = F_{np},$$

and assuming that $\alpha' = \alpha'' = \alpha$ the expression (2) beneficial simplified and, in particular, becomes public appearance:

$$F_{np} = \frac{F_t}{2 \operatorname{tg}(\alpha - \rho)}, \quad (3)$$

confirming the reliability of the research results.

A characteristic of the spring is determined by the dependence:

$$C = \sqrt[3]{\frac{Gd_\delta \lambda \operatorname{tg}(\alpha - \rho)}{F_t i_p}}, \quad (4)$$

for which appointed need spring.

According to the analytical expressions (1)-(4) Quantitative analysis of the impact of basic geometric design parameters developed by the amount of torque on the following initial values: the diameter of the circle center balls $D_0 = 50$ mm; the number of balls $i = 4$; balls diameter $d = 10$ mm; wire diameter springs $d_\delta = 0,5 \dots 4$ mm; axial deformation of the spring is equal to the depth of the groove $l = 4 \dots 10$ mm; spring average diameter $D = 45$ mm; number of turns of the spring working $i_p = 5$.

Results of quantitative analysis of the relationships between the elastic force of the springs and wire diameter and torque are respectively in Fig. 3 and 4.

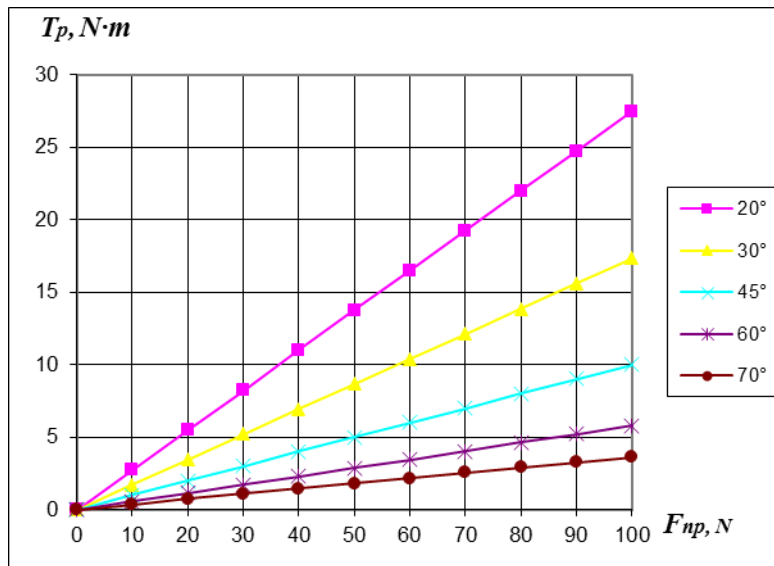


Fig. 3. The relationship between the strength and elasticity of the spring torque clutch operation

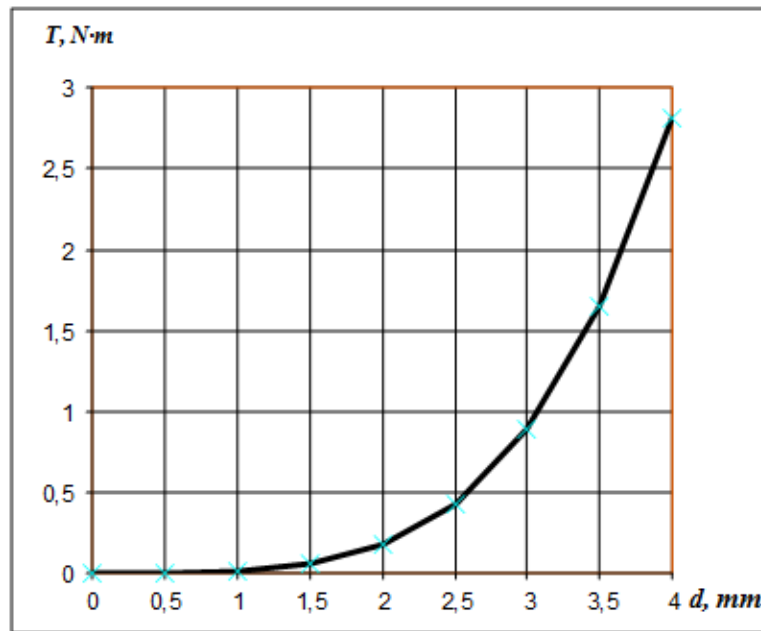


Fig. 4. The relationship between the diameter of the wire springs and torque clutch actuation $\alpha = 45^\circ$

CONCLUSIONS

1. The analytical expressions (2) (3) and (4) have practical value, which is the ability to choose convenient geometric parameters and the desired characteristics of spring stiffness, knowing only the specific loading factors of the device, i.e. the desired value the efforts of previous tightening of screws threaded connections.

2. The results of the power analysis can be an important basis for further research and calculations on the strength of elements not only safety, however also overtaking couplings used in various fields of engineering.

3. Determination of the maximum torque or transmitted is proportional to the strength of the elastic springs. What does the angle of inclination of the working surface grooves moment torque value decreases, allowing the use of softer springs, or with greater force to tighten adjusting nut.

4. The diameter of the spring wire has a cutting effect on the torque transmitted.

5. In general it can be argued that the proposed analytical dependence (4) enables a wide range of maneuver in choosing the standard springs and its tightening force depending on the desired value of torque during assembly and disassembly of threaded connections of various cars and mechanisms.

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УСИЛИЕ ВЫКЛЮЧЕНИЯ ОГРАНИЧИТЕЛЯ ВРАЩАЮЩЕГО МОМЕНТА

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Аннотация. В статье рассматриваются научные проблемы относительно новой шаровой муфты, которые могут быть использованы в различных отраслях техники. Проведен сравнительный анализ результатов исследований известных научных работ, касающихся подобных механизмов. Авторы описали особенности конструкции шаровой муфты, на основе которой можно легко создать ограничитель крутящего момента для равномерного затягивания болтовых креплений различных машин и механизмов. Предлагаемые необходимые аналитические зависимости описывают основные значения отключающих сил ограничителя крутящего момента. Схематическая конструкция ограничителя крутящего момента разработана на основе известного шаровой муфты и полное описание его составных частей, и принцип работы, изложено в статье. На основе конструктивных особенностей выбрана схема проектирования, что позволило создать математическую модель для силового анализа устройства. Величина силы, которая действует на шарики в начале выхода их из зацепления с пазом ведомой полумуфты, была описана аналитически, т.е. получили аналитическое выражение силы выключения. На основании полученных формул авторы провели количественный анализ влияния силы пружины на величину крутящего момента для различных углов наклона канавок в соединительных полумуфтах. Подтверждением классического положения является то, что зависимость ограничителя крутящего момента от диаметра пружинной проволоки является нелинейным. На основе проведенных исследований сделаны соответствующие выводы и практические рекомендации, касающиеся возможностей реализации результатов в области машиностроения.

Ключевые слова: ограничитель крутящего момента, трение, шариковая муфта.