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ELASTIC AND SAFETY CLUTCH WITH RADIALLY DISTRIBUTED ELASTIC DOWELS

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***Abstract*—**Within mechanical transmissions, clutches fulfil the function of transmitting the rotational movement from the shaft of a driving element to the shaft of a driven element. However, clutches can fulfil other functions necessary for the good operation of the transmission. From a constructive point of view, clutches can be simple or combined. This paper presents a simple mechanical clutch that is able to fulfil the properties of a mixed one. This new type of clutch represents an optimal solution from the constructive and functional point of view. The design of the clutch allows the combination of the functions of elastic and safety clutches. The clutch's intermediate element between the semi-clutches is the elastic dowel. The paper presents the assembly drawing and the calculus schemes used for the analytical modeling of the torque, which the clutch can transmit [1].

***Keywords*—**analytical modeling, elastic, mechanical clutch, multiple functions.

I. Introduction

THE clutches used in mechanical transmissions can fulfil different functions, which can ensure a good operation of these transmissions. The main function of these clutches is to transmit the rotational movement and the torque from a driving shaft to a driven shaft. The clutches must ensure the proper functioning of the transmission regardless of the technological and assembling conditions of its components [1].

In technological processes a series of disturbances occur, which negatively influence the operation of the transmission. The clutches are able to take over technological and assembling deviations, torsional vibration and shocks, protection and fitting vibrations of its component machine elements [1], [2], [3].

Besides fulfilling the main function of an elastic clutch and of a safety clutch, the proposed type of clutch is able to fulfil the secondary functions of these two types of clutches. The clutch is a simple clutch, which can have the same functions as a combined clutch by choosing the intermediate elements between the semi-clutches and their layout. The main advantage of the proposed clutch are its reduced dimensions and low cost [1], [4]. [5].

II. Construction the clutch

The design of the elastic and safety clutch with radially distributed elastic dowels is based on the following criteria [1], [6], [7]:

1) *The clutch has to absorb shocks and torsional vibrations;*
2) *The clutch must take technological and assembling clearance;*
3) *The elastic feature of the clutch has to be progressive, which would allow for kinetic energy storage with high damping capacity;*
4) *The load decoupling has to be free of shocks;*
5) *The clutch should allow the changing of rotation direction without shocks;*
6) *Small size and low cost;*
7) *The break of an elastic element should not lead to clutch failure.*

In Fig. 1, there is presented the elastic and safety clutch with elastic dowels. The components of this clutch are: *1* and *3* represent the two semi-clutches, *2* represents the elastic dowel, *4* represents the screws used for fixing the dowel, *5* represents the fitting used for sealing, 6 flanges, 7 represents the screws used for fixing flanges, and 8 grower washer.

The rotation is transmitted from semi-clutch *1* to semi-clutch *2* through the elastic dowels. Both of the semi-clutches have equidistant holes in the shape of a conical frustum. The operation of the clutch includes three stages, as follows:

1) *In the first stage, the movement is transmitted between the elastic dowels and the semi-clutch 1, the characteristic of the clutch being linear;*
2) *The second stage corresponds to the displacement of the elastic dowel on the conical frustum's generating line; during this stage, the clutch has a nonlinear characteristic.*
3) *The third stage corresponds to the load decoupling of the transmission when a resistive moment, which exceeds the maximum moment for which the clutch was designed, occurs.*

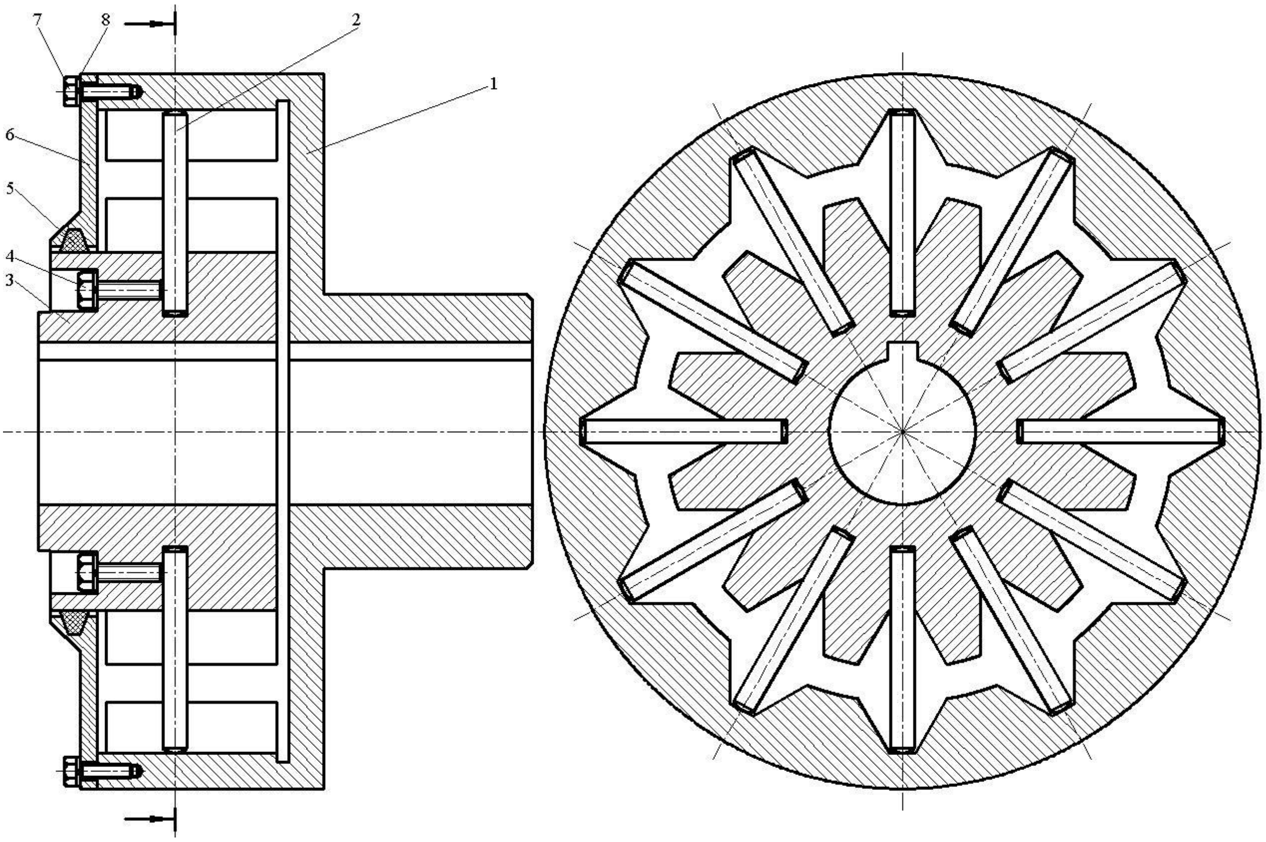

Fig. 1. The design of the clutch

The relative movement between the semi-clutches will take place from the small base to the big base of the decoupling takes place. In this way, the mechanical conical frustum. In that particular moment, the load transmission is protected. The clutch's stiffness is given by the number of holes and by the number of elastic dowels and their diameter, respectively. The relative rotation angle between the semi-clutches is a function of the number of holes equidistantly spaced and of the radius of the big base of the conical frustum.

III. Determination of the Torque

The elastic and safety clutches are characterized by a variable rigidity (nonlinear characteristic) as presented in Fig. 2 and refer to (1), [1], [8].

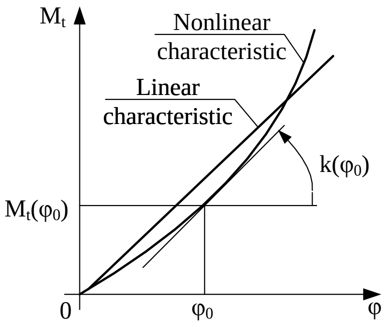

Fig. 2. The characteristics of the elastic clutches

The security condition of the mechanic transmission is presented in (1), [8], [9].

The elastic and safety clutches are characterized through a variable rigidity (nonlinear characteristic) – relation (1) – and the protection condition of the mechanical transmission is expressed with relation (2).

$$\mathbf{k(\varphi)=\frac{dM_t(\varphi)}{d(\varphi)}} \quad 1)$$

$$\mathbf{M_{t\,lim}(1+\Delta)\le M_{t\,maxa}} \quad (2)$$

where: $k(\varphi)$ - represents the tangent to the curve of the torque, which is written depending on the relative displacement; φ - the relative displacement angle between the semi-clutches; $M_t(\varphi)$ - the torque corresponding to the clutch deformation with the angle φ; $M_{t\ lim}$ - the torque when the clutch disengage; $M_{t\ max\ a}$ - the maximum torque admitted by the strength of the most weak clutch element; Δ - the relative error reset inputs in function of the clutch.

In Fig. 3 are presented the calculation schemes of the elastic and safety clutch with elastic radial dowels:

Fig. 3.a. the clutch is at rest;

Fig. 3.b. the clutch operates in a low load;

Fig. 3.c. the clutch operates under the action of the load, the contact is achieved between the dowel and the trapezoid-shaped surface of the rabbet from the driven semi-clutch 1.

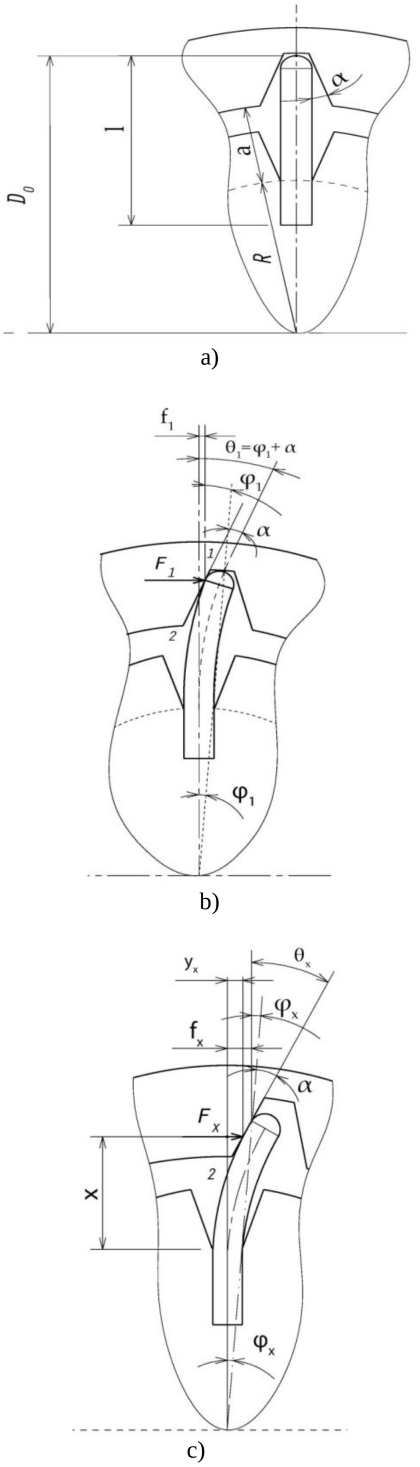

Fig. 3. Geometrical model used for torque determination

The elastic and safety clutches are characterized thought the next functions (functional technique criterions):

i) They make the bundle between two shafts (with relative fix variable position) and ensure the moment transmission and the rotation motion between the shafts (according to the general definition);

ii) The power transmission is braked off when the resistive moment outruns an imposed limit value; the energy flux braking off it is realized basis on an elastic element deformation.

From the analysis of the proprieties corresponding to the elastic and safety clutches, a distinct importance goes to the elastic element modelling, a thus as to ensure the every flux automated braking off, at the torque limit value [10].

The three schemes correspond to the three operation stages of the clutch [11].

In the first stage, which corresponds to a linear characteristic, the stiffness is constant until the elastic dowels are not in contact with the inclined surface of the notch (Fig. 3,a.).

The second stage corresponds to the increase of the transmitted torque, force application point moves continuously between the markers 1 and 2, the clutch characteristic being nonlinear (Fig. 3,b and Fig. 3,c). The third stage corresponds to the elastic dowel displacement in the contact point when the clutch load disengagement occurs.

From Fig. 3, the following parameters can be determined:

The tangential force

$$\mathbf{F_x = \frac{M_x}{z(R_0 + f_x)}} \tag{3}$$

The angle of the median string:

$$\boldsymbol{\theta_x = \varphi_x + \alpha = \frac{F_x x^2}{2EI}} \tag{4}$$

For which the following assumptions are considered:

$\mathbf{\tan\theta_x \cong \theta_x}$

$\mathbf{\tan(\varphi_x + \alpha) \cong (\varphi_x + \alpha)}$

The arrow:

$$\mathbf{y_x = \frac{F_x x^3}{3EI}} \tag{5}$$

$$\mathbf{y_x = \frac{2}{3} x(\varphi_x + \alpha)} \tag{6}$$

From equations (3) and (4), the arrow at the end of the elastic dowel can be determined as:

$$\mathbf{f_x = (l - x)(\varphi_x + \alpha)} \tag{7}$$

$$\mathbf{f_x = (\varphi_x + \alpha)\left(l - \frac{x}{3}\right)} \tag{8}$$

$$\mathbf{M_x = zF_x[R_0 + (\varphi_x + \alpha)(l - x)]} \tag{9}$$

The relative rotation angle of the semi-clutches φ_x results as:

$$\boldsymbol{\varphi_x = \frac{M_x - zF_x R_0}{F_x (l - x)} - \alpha} \tag{10}$$

M_x - represents the transmitted torque, z represents the number of the clutch's elastic dowels, F_x represents the tangential force, R_0 represents the disposing radius of the elastic dowels, l represents the active length of the dowels, and x represents the distance made by the dowel on the frustum's generating line [12].

In Fig. 4 it is presented the theoretical characteristic of the proposed elastic and safety clutch with axially distributed elastic dowels, which was derived from Eq (1), [1].

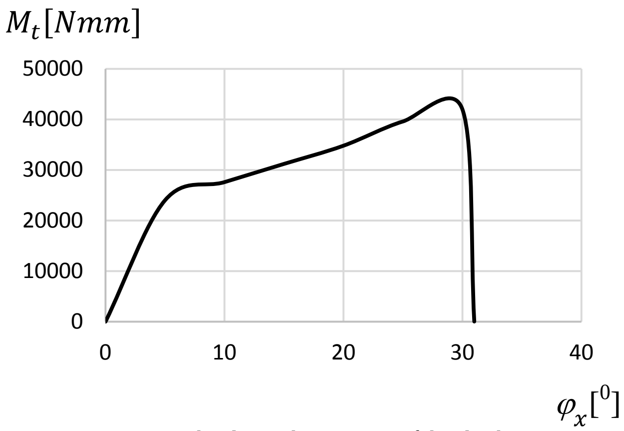

Fig. 4. The elastic characteristic of the clutch.

Calculation of elastic and safety clutch with radially distributed elastic dowels:

Torque calculation

$$\mathbf{M_{tc} = M_2 = kM_t} \tag{11}$$

Tangential force calculation

$$\mathbf{F_{tc} = F_2 = \frac{M_{tc}}{z(R+a)}} \tag{12}$$

Average fiber angle

$$\mathbf{\theta_c = \varphi_c + \alpha = \frac{F_{tc}a^2}{2EI}} \tag{13}$$

The relative rotation angle between the semi-clutches

$$\mathbf{\varphi_c = \alpha\frac{3l - a^2}{3R + a}} \tag{14}$$

The unity bending effort

$$\mathbf{\sigma_i = \frac{M_i}{W} = \frac{Fl}{2}\frac{1}{2\pi d^3}} \tag{15}$$

Elastic dowels diameter

$$\mathbf{d^3 = \frac{Fl}{4\pi\sigma_{ai}}} \tag{16}$$

Number of elastic dowels

$$\mathbf{z = \frac{2M_t}{FD_0}} \tag{17}$$

IV. CONCLUSION

The elastic and safety clutch with elastic dowels has the following advantages, [1]:

The clutch can take shocks and torsional vibrations;

The characteristic of the clutch is progressive;

The relative rotation angle between the semi-clutches is a function of the dimensions and the frustum's angle between the generating line and it is based and of numbers of elastic dowels;

When the maximum torque, for which the clutch was designed, is exceeded, the transmission load decoupling takes place, the clutch fulfils the safety function;

The clutch can take over technological and assembling deviations;

The clutches ensure the compensation of axial, radial and angular deviation in relatively large limits;

The clutch might be designed for different torques; moreover, it has a small size and a low cost.

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