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SAFETY CLUTCHES IN STATIC AND DYNAMIC WORKING REGIME

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Abstract: The paper proposes a computer program for the computer designing of the safety clutches with balls. In this way, there are presented the program interface and its running manner. The program has the end in view the determination of a series of diagrams concerning the influence both, of the characteristic geometrical parameters, and the adjustment parameters of the safety clutches on the transmitted moment under static and dynamic working conditions. On these diagrams basis, finally there can be worded some designing conclusions and working recommendations.

1. COMPUTER PROGRAMME FOR THE $M_t = M_t(\varphi)$ CHARACTERISTIC PLOTTING

For the safety clutches with trapezium rabbets, the uncoupling process takes places in two stages [1]. In the first stage the ball moves on the plane surface of the active rabbets; this stage ends when the contact point between the ball and the active rabbet reaches the extreme point of the rabbet (the intersection point between the active plane surface and the connected zone). In the second stage, the ball turns around the extreme point of the rabbet; this stage ends when the ball becomes tangent to the exterior surface of the driven semi-clutch. Therefore, the calculus relations of the

- position, velocity and acceleration functions for the ball,
- the spring force and
- the resistant torsion moment thanked to the spring force and the friction forces,

must be particularized for the two stages [1].

Under static working conditions, the inertia forces are neglected and the moment transmitted by the clutch is given by the spring force and the friction forces, and it has the expression:

$$M_t = zR_n \frac{D_0}{2}\left[\cos(\alpha)\cos(\varphi_1-\varphi_3)+\mu_3\left(\sin(u)\sin(\varphi_1-\varphi_3)+\cos(u)\cos(\varphi_1-\varphi_3)\sin(\alpha)\right)\right], \quad (1)$$

where: z represents the assembled balls number; R_n – the normal reaction force between a ball and the driven semi-clutch [2]; $\varphi = \varphi1-\varphi3$ – the relative rotational angle between the two semi-clutches; u – the angle that determines the direction of the friction force between the ball and the driven semi-clutch; α - the contact angle between the ball and the driven semi-clutch [1].

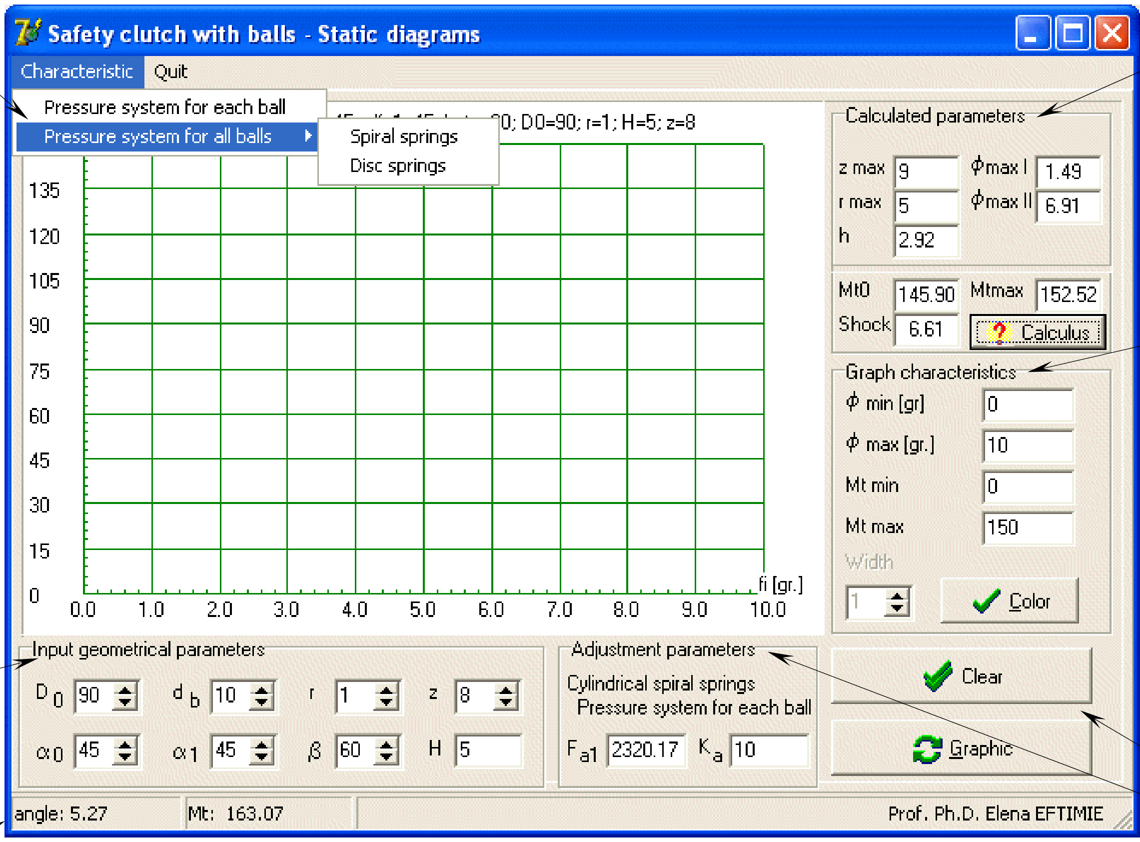
For the $M_t(\varphi)$ diagrams plotting, a computer programme was conceived, programme that allows the display of the variation diagrams of the torsion moment in static working conditions, for different vales of the geometrical and adjustment parameters (the total necessary pretension force for the transmission of a certain torsion moment in the complete connected working situation, the spring rigidity for cylindrical springs or the width for the disc springs). The menus and the sub-menus of the designed programme are presented in Figure 1.

From the menu *Characteristic*, in the first stage of programme running it must be selected the arrangement of the pressure springs: for each ball or central spring for all balls, and the type springs: spiral cylindrical springs or disc springs. In view of a greater flexibility for the conceived program, this allows the setting of the diagrams display manner, depending on the user request. In this way, it is possible both the setting of the widths and colours for every diagram, and the display only of the desired diagrams.

- Setting of the minimum and maximum values corresponding to the desired limits for the abscissa and ordinate (the area from the diagram that presents interest can be brought in the graphic window)
- Selection of the desired colour and width for the diagrams plotting

- Allows the calculus of some geometrical parameters specific to the clutch with the end in view of the check-up of some assembling conditions
- Allows the calculus of the torsion moment transmitted by the clutch in the complete connected working situation, the maximum moment reached at the end of the uncoupling process and the theoretical shock took over by the clutch (the inertia moment are neglected for the static working

It allows the selection of the pressure system and the pressure springs type



Coordinates reading for some interest points on the diagrams, by their focus with the mouse

Setting of the desired geometrical parameters

It allows the selection of the spring characteristics, the total necessary pretension force of the springs, the rigidity for the cylindrical springs or the width of the disc arcs

- *Clear* allows the graphic window clear after the diagrams limits alteration or for the redrawing of some new diagrams
- *Graphic* allows the diagrams plotting

Figure 1. The programme structure for the plotting of the static diagrams of the moment

Depending on the entered geometrical elements – area *Input geometrical parameters* – the programme computes:

- the maximum number of balls - that can be assembled in the clutch, z_{max};
- the maximum filleted radius for the active rabbets, r_{max};
- the coalescence depth of the ball into the active rabbet, h;

- the maximum relative angle for the first uncoupling stage, $\varphi_{max\ I}$;
- the maximum relative angle for the second uncoupling stage, $\varphi_{max\ II}$.

Remark

The programme uses as an input data, the active rabbet depth H, depending on this, it computes the depth of ball penetration into the active rabbet, h (the depth of the ball penetration into the active rabbet is displayed on the graphical interface in the area of *Calculated parameters*; this area does not allow the alteration of these parameters from the keyboard).

$$h = H - \frac{d_b}{2} \frac{1 - \sin(\alpha_0)}{\sin(\alpha_0)}, \tag{2}$$

In order to allow a comparative study of different parameters influence, the paper will present some diagram examples of the resistant moment variation using superimposed static and dynamic diagrams.

2. THEORETICAL DETERMINATIONS OF THE SAFETY CLUTCH CHARACTERISTIC

The next step of the presentation proposes a few diagrams examples plotted for the torsion moment thanked to the spring forces and those of the friction forces, depending on the relative rotational angle between the semi-clutches $M_t(\varphi)$. These diagrams are obtained as a result of the presented programme running.

The moment diagrams allows the diagrams plotting for different values of the geometrical and adjustment parameters, starting from an initial characteristic, described by the following reference values (inscribed on every diagram) [1]:

- the semi-angle of the active frontal rabbets from the driven semi-clutch, α_0 =45°,
- the semi-angle of the radial rabbets from the driving semi-clutch, α_1 =45°,
- the angle of the adjusting washer, β =60°,
- the fillet corner of the active rabbets from the driven semi-clutch, r =1,
- the diameter of balls arrangement, D_0 =90mm,
- the active rabbet depth, H =5mm,
- the balls number, z =8.

During the uncoupling process, the resistant moment transmitted by the clutch under static working conditions, has an increase over the first stage, followed by a sudden decrease over the second uncoupling stage.

Figure 2 presents the influence of the pressure system – with central spring and with outlying springs, for the case of using the cylindrical spiral springs – on the moment transmitted by the clutch, during the two uncoupling stages, under static working conditions. Thus, it can be remarked that by the use of ”z” outlying springs adjusted for a total pretension force equal to the pretension force adjusted in the case of the central springs system, the maximum value of the resistant moment is higher.

3. CONCLUSIONS

The study of the safety clutches with balls under static working conditions has the end in view the following aspects:

- The wording of some conclusions concerning their design, that is the determination of the necessary values combination for the geometrical and adjustment parameters with the purpose of transmission of a certain torsion moment and the verification of some assembling conditions (such: ”The ball diameter is too small $h>d_b/2$!”, ”The input balls number is too big $z>z_{max}$!”, ”The input fillet corner radius $r>r_{max}$!”);

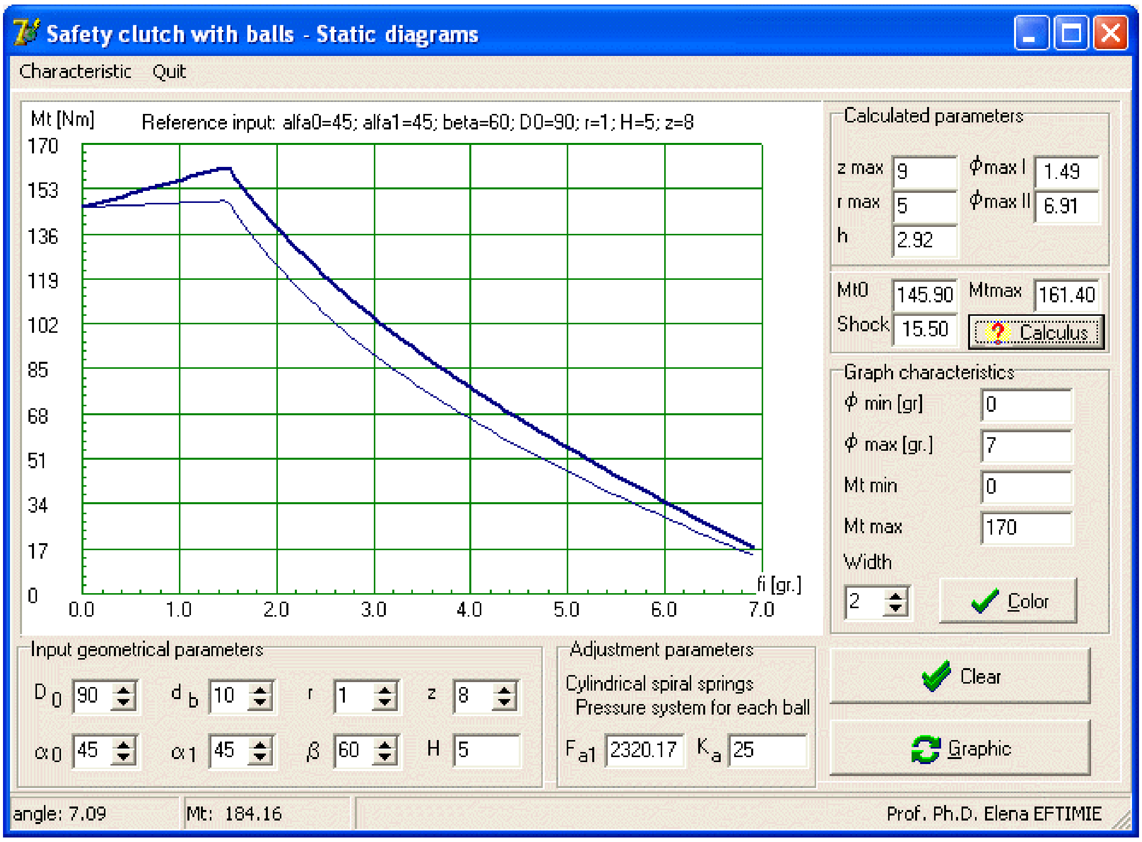


Figure 2. The influence of the pressure system on the transmitted moment under static conditions

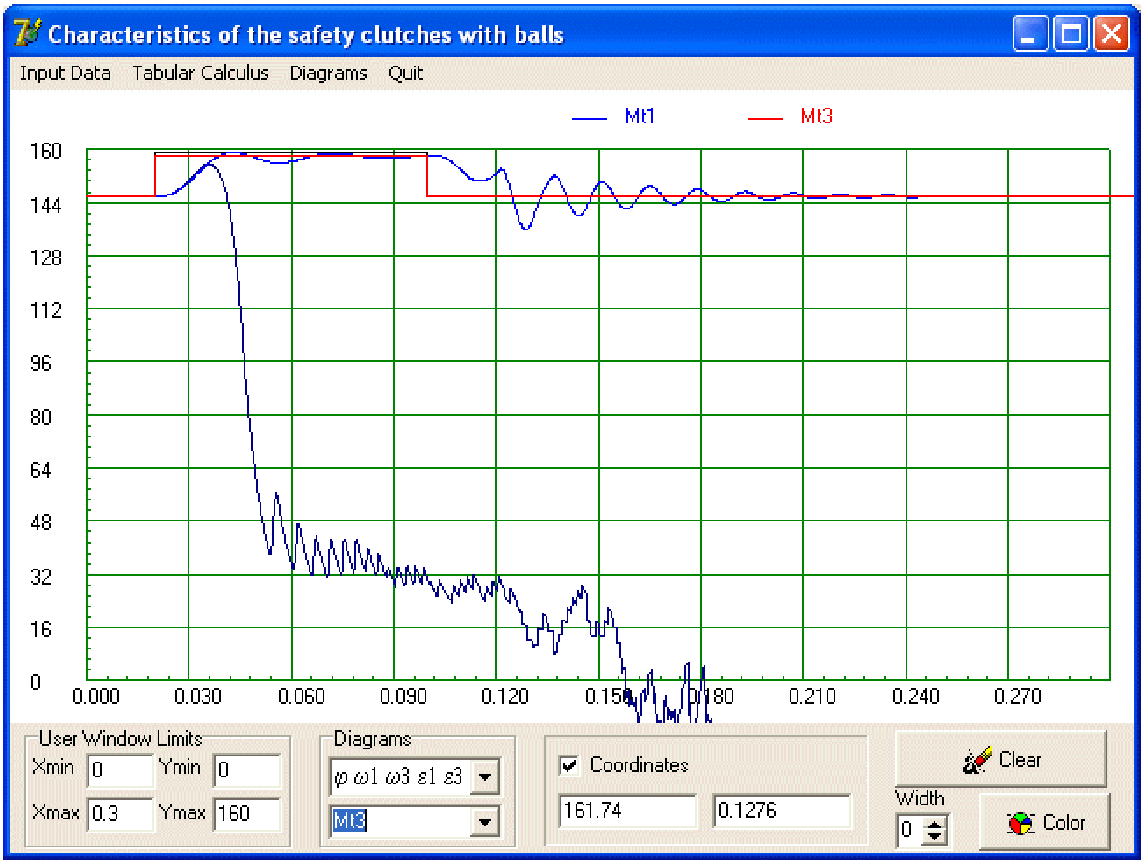
- The determination of the maximum moment transmitted by the clutch, that is the maximum moment obtained in the working process, its value being registered at the end of the first uncoupling stage. In this way, it is taken into consideration the fact that these clutches can take over a series of shocks whose values depend on this moment value.

  In the first uncoupling stage, the torsion moment has an increasing variation, reaching the maximum value at the end of this stage (Figure 1), the second uncoupling stage being characterised by a decreasing variation of the transmitted moment.

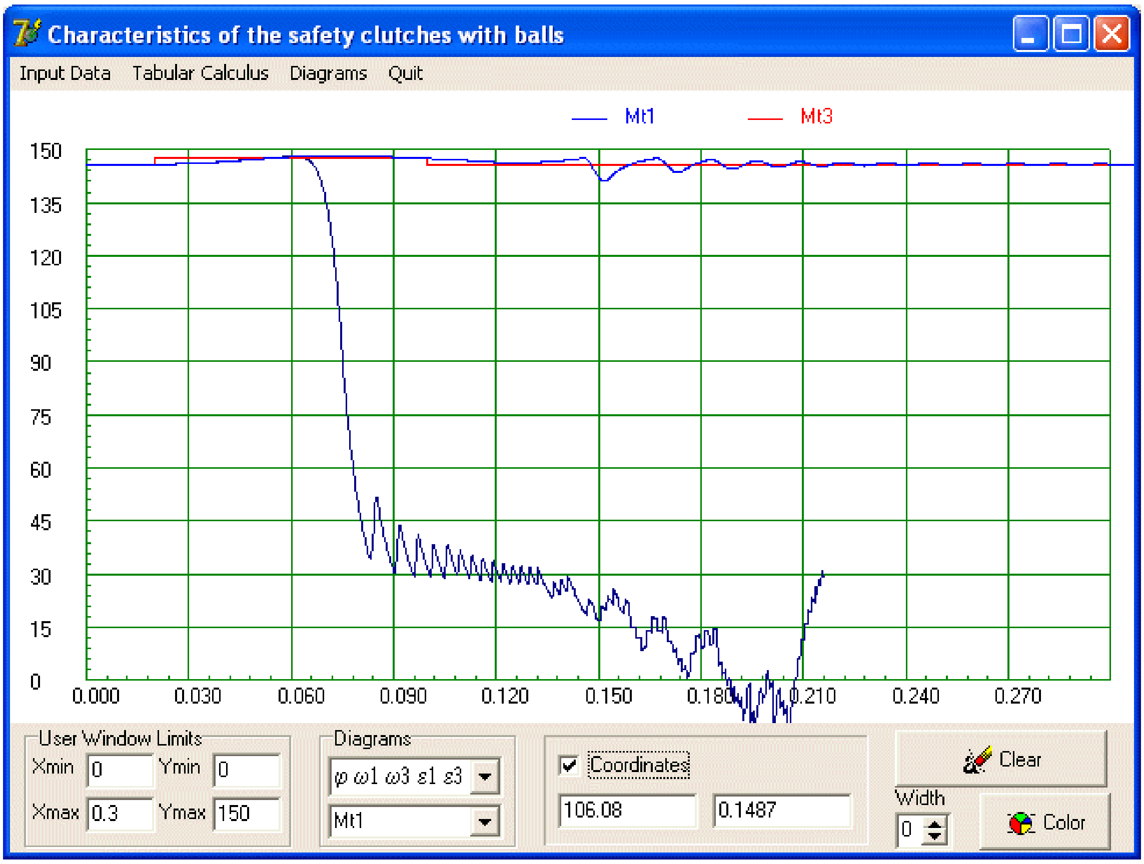
  The maximum value of the transmitted torsion moment is influenced, in a great measure, by the used pressure system and by the springs type and in a less measure (but still significant) by the geometrical parameters of the clutch, namely: the balls diameter, the coalescence depth of the ball into the active rabbet, the filleted radius for the active rabbets, the diameter of balls arrangement, the semi-angle of the active frontal rabbets from the driven semi-clutch and the angle of the adjusting washer.

  Taking into consideration this aspect, it is trying that, by the study of the static diagrams, to determine the shocks values that can be taken over under dynamic working situation. In this way, Figure 3 presents two working situation under dynamic conditions for clutches having the same geometrical parameters but with different pressure systems (Figure 3,a – pressure system for each ball and Figure 3,b pressure system for all balls). From the analysis of the static diagram, Figure 1, it can be seen that the maximum torsion moment reached by the clutch, at the end of the first uncoupling stage has bigger values for the clutch with pressure system for each balls.

  For example, for the considered clutch, from the static diagram it results a value of 15.5 Nm, for the maximum shock that can be taken over by the clutch.



a. pressure system for each ball (shock =12 can be take over; shock =13 cannot be take over)



b. central pressure system (shock =1.6 can be take over; shock =1.7 cannot be take over)

Figure 3. The influence of the pressure system on the transmitted moment under dynamic conditions

From the dynamic diagram proposed in Figure 3,a it is ascertained that shocks of 12 Nm can be took over while shocks of 13 Nm cannot be took over. Therefore the safety clutches with balls can take over torsion moments with values close to the maximum value reached at the end at the first uncoupling stage (when the ball reaches near the filet corner of the rabbet, the clutch cannot take the resistant moment any more).

REFERENCES

1. Eftimie, E. Kinematic and static modelling of the safety clutches with balls. Annals of the Oradea University, Fascicle of Management and Technological Engineering, Oradea, may 2006, p. 663-668. ISSN 1583-0691
2. Eftimie, E. Dynamic loads in the working process of the safety clutches with balls. International Conference Research and Development in Mechanical Industry – RaDMI 2006, Budva - Montenegro, Session A, 13-17 September 2006. ISBN 86-83803-21-X (HTMS)