OPTIMIZATION OF DIAPHRAGME SPRINGS FOR CLUTCHES MOTOR VEHICLES CLUTCHES

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Abstract- **The subject in of this paper is to show possible ways to optimize pressure force which act on diaphragm spring intended for use in motor vehicle clutch.**
During the exploitation of the clutch, because of friction linings wearing, pressure force which act on the diaphragm spring is changing. The difference of the acting force when it acts on the diaphragm spring and new linings, and when it acts on diaphragm spring and wear linings (in limits), must be kept in very tight limits. This means that the force in both cases has to be constant. Possible solution to achieve this condition is to have changes in diaphragm spring thickens and diaphragm spring finger angle, and during those changes the diameter of the diaphragm spring will stay unchanged.

***Key words**: diaphragm spring, pressure force, optimization, friction clutch, parameters*

INTRODUCTION

A frictional clutch is mechanism that is built between the engine and gearbox and transmits torque from the driving part to the driven part [8]. The pressure force between the friction surfaces is provided with coil pressed springs or diaphragm springs. At coil pressed springs with wear linings comes to reducing the pressure force and thus torque which is transmitted. At diaphragm springs the pressure force increases with wearing of friction linings up to a certain limit and then decreases. [3],[5]

Important features of diaphragm springs are:

- Large force of spring with minimal displacement;
- Maximum use of space for installation;
- According to the needs to obtain a linear or nonlinear characteristic, the clutches with diaphragm spring used nonlinear characteristic;

In the figure (Fig. 1) are given the reliability of pressure forces and disengaged forces depending from deflection for coil springs and diaphragm springs. Full line shows pressed force load, and dotted line shows the clutch unloading force.[9]

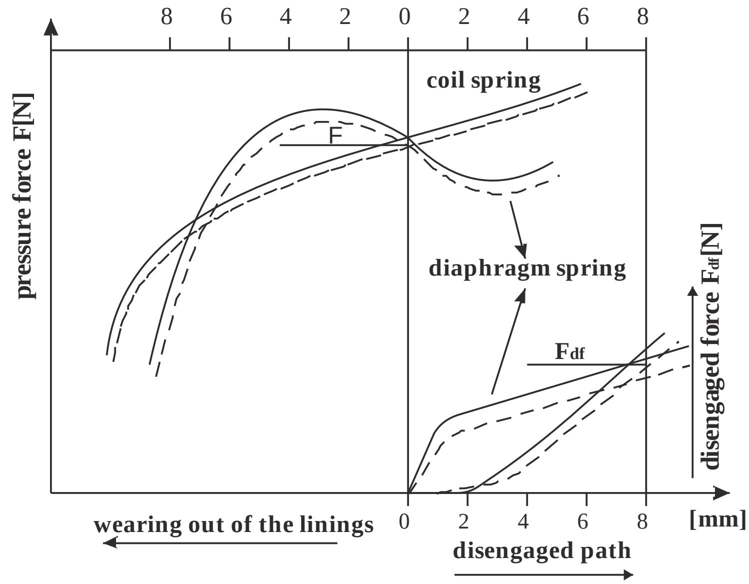

Fig.1 Pressure force for coil and diaphragm spring

It is obvious that when wearing of linings pressure force is increased when diaphragm springs, unlike the pressed coil springs, where there is a linear decrease the same.

Depending on the mode of action of disengaged force off the clutch, they are divided into pressed and towing

In pressed clutch pressure force is smaller, the disengaged force is greater. These clutches are more represented, because their development is of older date. Development of vehicles and higher demands are placed before them sought incorporation of lighter assemblies in the same. This contributes to develop towing clutches, which are characterized by a smaller force of disengagement, greater pressure force, compact construction and others.

The (Fig. 2) shows the change of pressure force of press and towing clutches.[9]

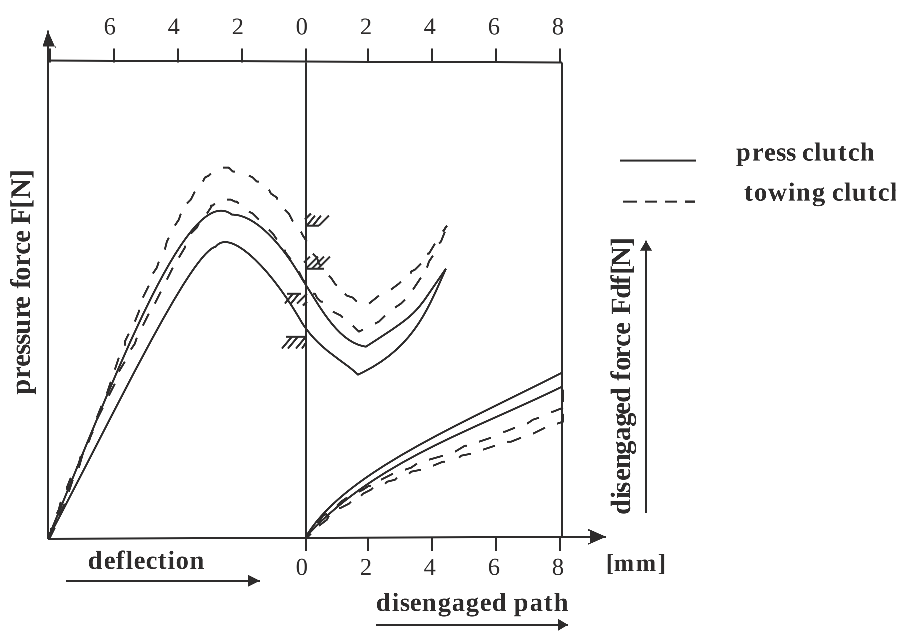

Fig.2 Pressure force and disengaged force for press and towing clutch

Aim of the research

Purpose of the study is to optimize pressure force which act on diaphragm spring intended for use in motor vehicle clutch, that the wearing of lining is variable

Research

The optimal pressure force can be realized with minimum difference of pressure force of the clutch in assembly position and pressure force when the clutch lining is wearing within the permissible limits. This is achieved by varying parameters: of thickness diaphragm spring angle of slope of the spring. For the calculation of the pressure force used formula ALMEN-LASZLO and appropriate software package.[2] [4]

The (Fig.3) is given diaphragm spring in unload condition. When analyzing the pressure force of spring takes the outer and inner diameter and points of relying on the spring to be fixed. Variable parameters are the angle of slope and thickness of the spring. When the angle of slope of the spring is equal to zero, then gets pressure force of spring (clutch in assembly position). With wearing of linings this angle changes, pressure force increases to certain value and then decreased (Fig. 2). With wearing of linings in limits, spring has a certain pressure force. The difference of these two forces should be made less so pressure force is relatively constant while running clutch.

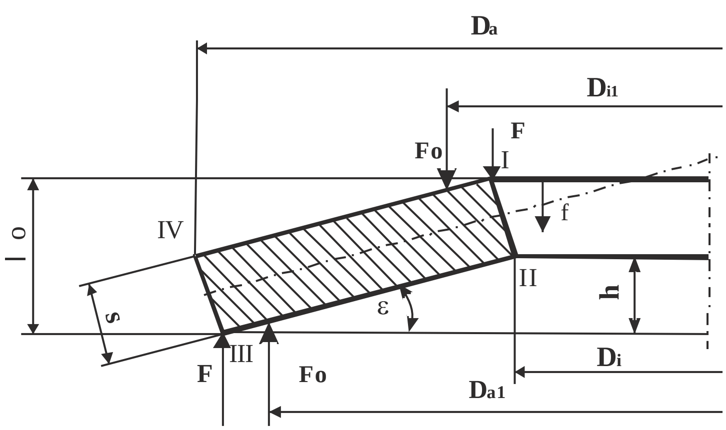

Fig.3 Diaphragm spring

D_a, D_i [mm]- outer and inner diameter of the spring;
D_{a1}, D_{i1}[mm]- outer and inner diameter of relying on spring;
ε[°]- slope angle of the spring;
s[mm]- thickness of the spring;
E[N/mm²]- modulus of elasticity of the spring;
μ- Poisson number
ℓ[mm]- disengagement path
F [N] - pressure force of the diaphragm spring at deflection **f**
Fo [N] –pressure force of the spring points of relying.
Foo [N]- required pressure force of spring,
f [mm]- spring deflection
ho - deflection at the flat position of spring
ℓo [mm]- height of not diaphragm spring loaded

- The force of the spring is determined by the expression:

$$F(f) = \alpha \cdot \frac{s^4}{Da^2 \cdot k_1} \cdot \frac{f}{s} \cdot \left[\left(\frac{h}{s} - \frac{f}{s} \right) \cdot \left(\frac{h}{s} - \frac{f}{2 \cdot s} \right) + 1 \right] \quad (1$$

k_1 , δ, α–coefficients

$$k_1 = \frac{1}{\pi} \cdot \frac{\left(\frac{\delta - 1}{\delta} \right)^2}{\frac{\delta + 1}{\delta - 1} - \frac{2}{\ln \delta}} \qquad (2)$$

$$\delta = D_a / D_i \qquad (3)$$

$$\alpha = 4 \frac{E}{1 - \mu^2} \qquad (4)$$

-Height of the diaphragm spring:

$$h(\varepsilon) = \frac{D_a - D_i}{2} \mathrm{tg}\varepsilon \qquad (5)$$

-Force of the spring points of relying is:

$$Fo = k_4 \cdot F \qquad (6)$$

$$k_4 = \frac{D_a - D_i}{D_{a1} - D_{i1}} \qquad (7)$$

-The force of spring in deflection f = h, and variables **s** and **ε** is:

$$F(s, \varepsilon) = \alpha \cdot \frac{s^4}{Da^2 \cdot k_1} \cdot \frac{f(\varepsilon)}{s} \cdot \left[\left(\frac{h(\varepsilon)}{s} - \frac{f(\varepsilon)}{s} \right) \cdot \left(\frac{h(\varepsilon)}{s} - \frac{f(\varepsilon)}{2 \cdot s} \right) + 1 \right] \qquad (8)$$

-The force of the spring allowed wearing of linings **f = h-u** is:

$$H(s,\varepsilon)=\alpha\cdot\frac{s^4}{Da^2\cdot k_1}\cdot\frac{f(\varepsilon)-u}{s}\cdot\left[\left(\frac{h(\varepsilon)}{s}-\frac{f(\varepsilon)-u}{s}\right)\cdot\left(\frac{h(\varepsilon)}{s}-\frac{f(\varepsilon)-u}{2\cdot s}\right)+1\right] \qquad (9)$$

u[mm]- allowed wearing of linings

-The difference of these two forces F(s,ε), H(s,ε) is

$$R(s,\varepsilon)=F(s,\varepsilon)-H(s,\varepsilon) \qquad (10)$$

The difference between given pressure force spring (Foo) and calculated F (s, ε) is:

$$Ro(s,\varepsilon)=\left|F(s,\varepsilon)-Foo\right|\leq F_d \qquad (11)$$

F_d[N]- deviation of a given pressure force;

It is determined pressure forces which satisfy equation Ro(s, ε) of the possible variants. Then for these forces it is require from the equation R (s, ε) which has a minimum value,
Thus determine the values of variables (s), (ε).

Using the formula ALMEN-LASZLO pressure force and the software package made algorithm for calculation of optimal force.
Here are given only the results of this calculation for given values of the spring in Table nr.1 and (Fig.4)

Input data
Da = 328[mm] – outer diameter of the spring;
Di = 273[mm] – inner diameter of the spring;
ε = 13:0.5:14.5[°] – angle of slope of the spring;
s = 3.8:0.1:4.1[mm] – thickness of the spring;
E = 206000[N/mm²] – modulus of elasticity of the spring;
μ = 0.3 – Poisson number of spring steel;
Da1 = 322[mm] – outer diameter of relying on spring;
Di1 = 275[mm] – inner diameter of relying on spring;
u = 3[mm]; allowed wearing of linings;
Foo = 12000[N] required pressure force of spring;
F_d=800[N] – allowed derogation of the force;

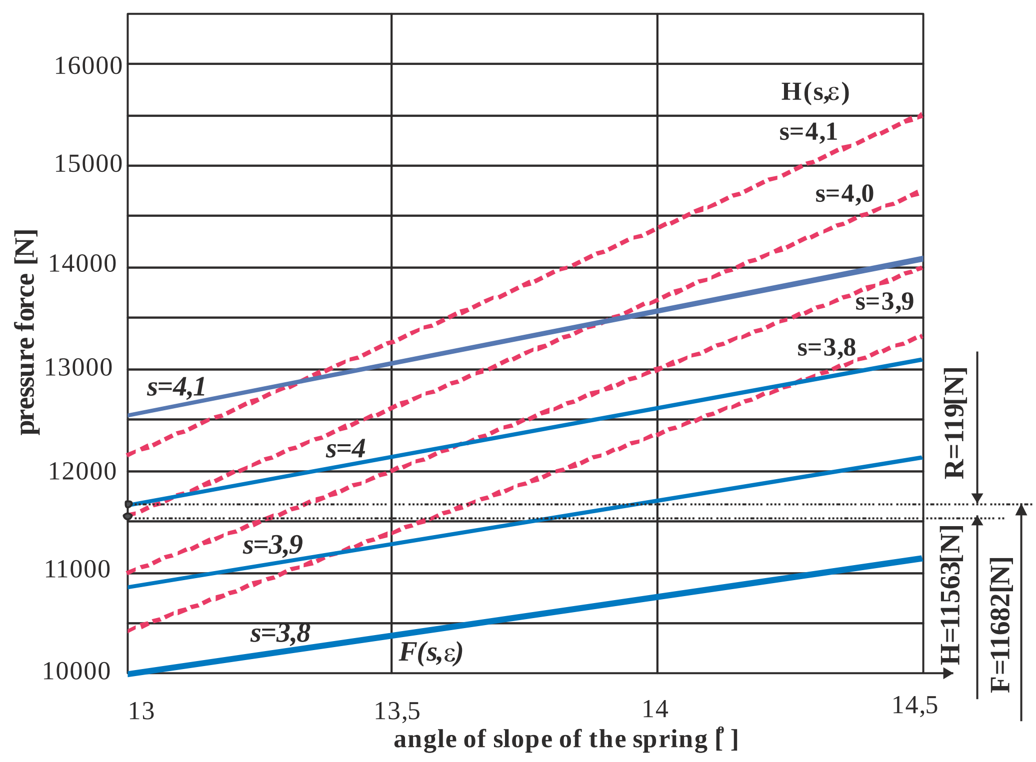

Fig.4 The results of calculation for given values of the spring

TABLE.1 The results of calculation for given values of the spring

Angle of slope of the spring ε[°]	Thickness of the spring s[mm]	Pressure force of the diaphragm spring at deflection **f** F [N]	The force of the spring allowed wearing of linings H[N]	The difference of these two forces F(s,ε), H(s,ε) R[N]	The difference between given pressure force spring (Foo) and calculated F (s, ε) Ro[N]
13	3,8	10016	10414	-398	1984
13	3,9	10828	10977	-149	1172
13	4,0	11682	11563	119	318
13	4,1	12580	12172	409	580
13,5	3,8	10416	11351	-935	1584
13,5	3,9	11260	11961	-701	740
13,5	4,0	12148	12595	-447	148
13,5	4,1	13082	13254	-171	1082
14	3,8	10817	12313	-1496	1183
14	3,9	11694	12970	-1276	306
14	4,0	12616	13653	-1037	616
14	4,1	13586	14363	-777	1586
14,5	3,8	11220	13301	-2081	780
14,5	3,9	12129	14006	-1877	129
14,5	4,0	13086	14739	-1652	1086
14,5	4,1	14093	15500	-1407	2093

In (Fig.5) is a change of optimal pressure force of the spring depending on deflection

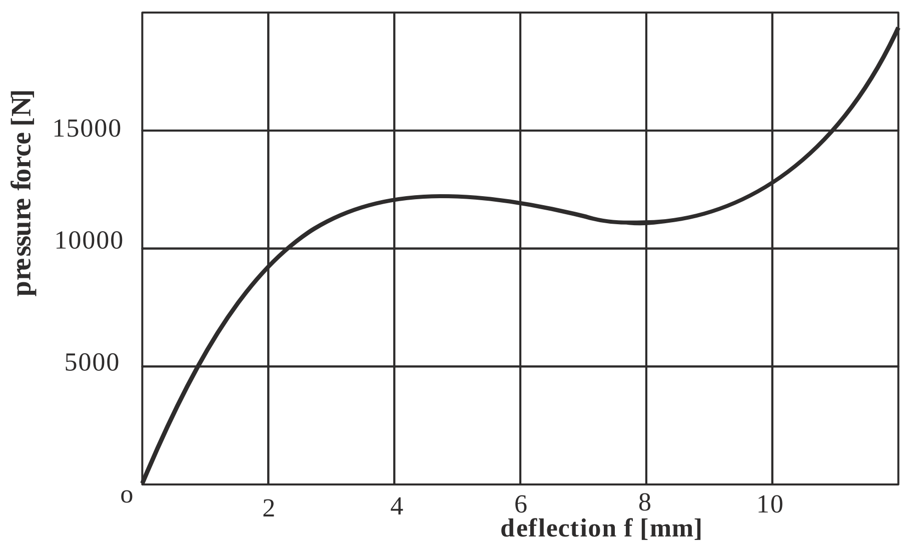

Fig.5 Dependence on the pressure force on deflection

When taking into account the points of relying on the spring, the pressure force of the spring is:

$$\mathbf{Fo = k_4 \cdot F = 1{,}17 \cdot 11682 = 13668[N]}$$

$$\mathbf{k_4 = \frac{D_a - D_i}{D_{a1} - D_{i1}} = \frac{328 - 273}{322 - 275} = 1{,}17}$$

ANALYSIS OF RESULTS AND CONCLUSIONS

In Tab.nr.1 the results of pressure force obtained by calculation using the software package are given. The yellow markers are marked variants that satisfy the requirement $\mathbf{Ro(s,\varepsilon) = |F(s,\varepsilon) - Foo| \leq F_d}$ Then from these forces is elected pressure force that has the smallest difference $\mathbf{R(s,\varepsilon) = F(s,\varepsilon) - H(s,\varepsilon)}$ **, (R=119N).** This spring force corresponds to **s = 4 mm, ε = 13º**.
In Fig. are given diagrams of the change of forcec F (s, ε), H (s, ε), and can determine optimal pressure force.
In Fig. given change of pressure force depending дефлецтион ит has nelinerna change

We can make the following conclusions:

- A method of optimization of pressure force with variables parameters of diaphragm spring: thickness and slope of the spring using the software package is determined.
- By increasing the thickness and slope of the spring increases the pressure force.

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