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Influence of Elastic Element Design Parameters on Buckling Effect for Different „Periflex“ Shaft Couplings

EIvanova[1,1] and TVasilev[1,2]

1 – Nikola Vaptsarov Naval Academy, Department of Technical Mechanics, 9026, 73 Vasil Drumev Street, Varna, Bulgaria;

Corresponding author contact:1-e.ivanova@naval-acad.bg; 2- t.vasilev@naval-acad.bg

Abstract: In the article has made research into the buckling resistance of flexible shaft coupling with toroidal elastic element. It is made a comparison between four different designs of “Periflex” coupling, the received data are preparing and systemizing. The obtained data show how the con-struction parameters of the elastic element influence to the critical buckling torque. The data ob-tained can be used to design a shaft coupler that will transmission a higher torque with used of smaller quantity of material.

Key words: Periflex, Shaft Couplings, Buckling, Maximal Torque, Couplings Design

1. Introduction

The elastic element in the construction of the toroidal elastic couplings is the most responsive element that is used to reduce the dynamic loads when transmitted drive between leading and guided machinery. To ensure seamless operation of the coupling and its long service life, it is necessary to know all factors that affect to the normal exploitation.

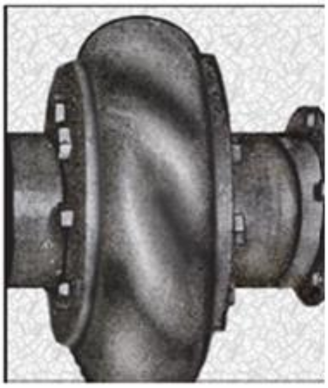


Figure 1. Pic of rubber elastic elements on flexible couplers in the moment when it is loss of resistance (buckling) [2]

The object of the study is the toroidal elastic element (Figure 1) of the Periflex coupling. It is a thin-walled element and therefore exhibits a propensity for loss of resistance (buckling).

Stretched with cord threads, the elastic element significantly changes its stiffness and its load capacity [1], such a coupling has been investigated and it has been proved that the reliability of the rubber thin-walled elements is largely determined by the mechanical properties of the materials [1,2]. Different manufacturers of toroidal elastic couplings show different nominal and maximum torque of the couplings at identical or close overall dimensions. These data are presented in Table 1.

Table. 1 Table with ext. dimension, maximal and nominal torques of different manufacturers [1]

Parameters\Manufacturers	By Standard MN5809-65	By Patent №RU2325566	Vielastic Modul Byala	Stromag GKN - Periflex
Nominal Torque – T_{nom}, Nm	750	1250	1200	3410
Maximal Torque – T_{max}, Nm	2250	3800	3600	7500
Dimensions of Coupler – D x L, mm	370 x 120	360 x 100	370 x 120	370 x 225

The basic objective of this study, is to determine what is the good design and dimensions of the rubber elastic element and how they affect to the load and buckling deformation process.

2. Body of the paper

The transmission of torque in the “Periflex” shaft couplings is doing with an elastic rubber element which is pressed from metal discs to the semi couplings and it is cut diametrically in one place for easy installation without decentralizing the semi couplings. The design and operation of the coupling is described in detail in [1]. The toroidal element has a different shape in the different companies producing elastic couplings. On the next Figure 2 are showing “Periflex” elastic elements used more often.

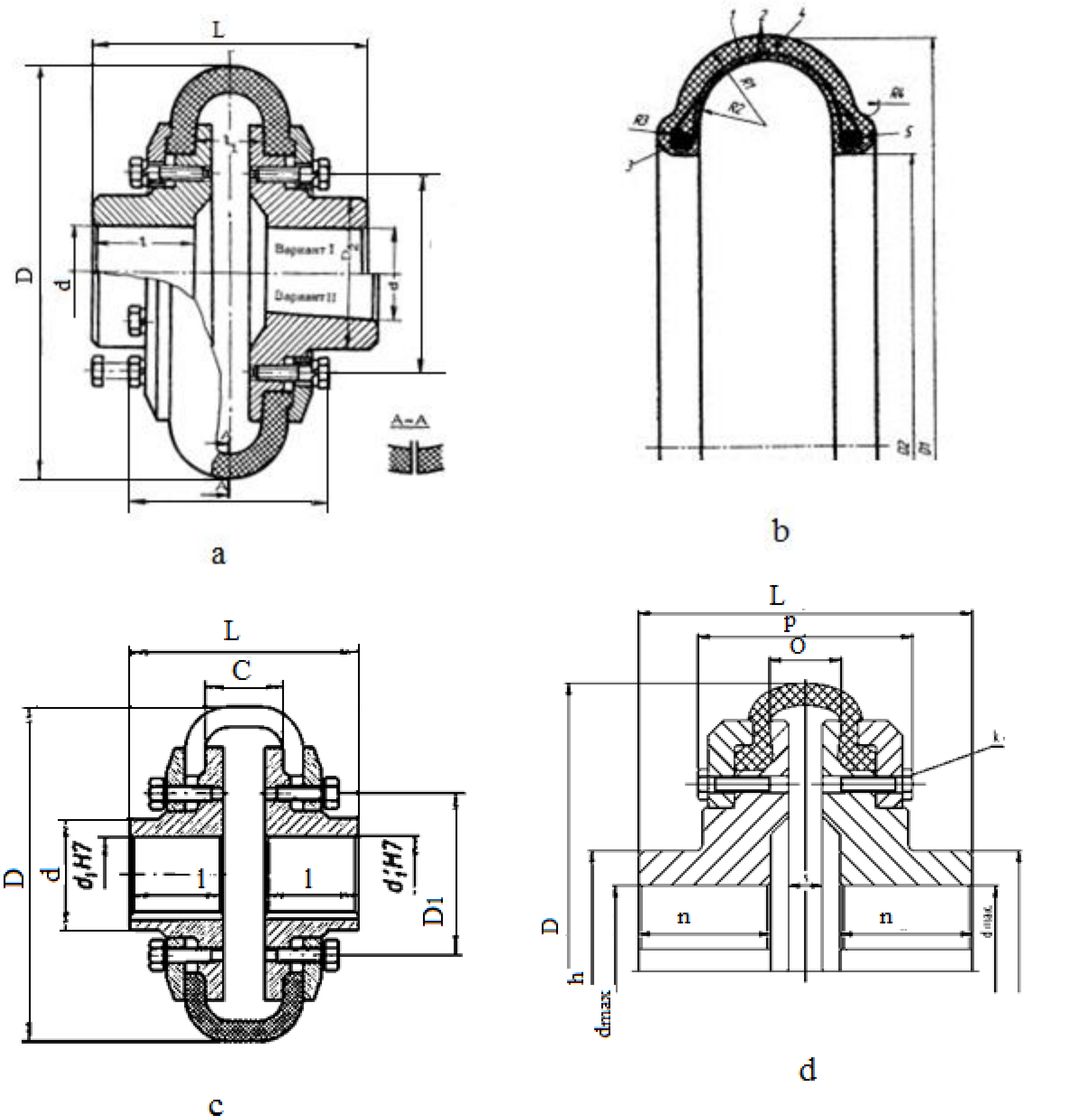
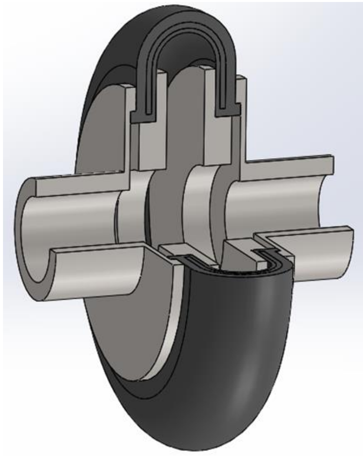
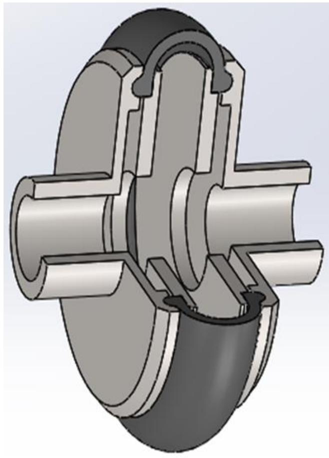


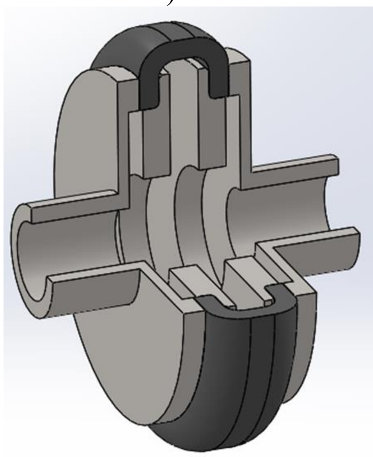
Figure 2. Shape of “Periflex” elastic elements for different manufacturers: a) Standard MN5809-65 [3]; b) Patent №RU2325566 [4]; c) Vielastic Modul Byala [5]; d) Stromag GKN – Periflex [6]

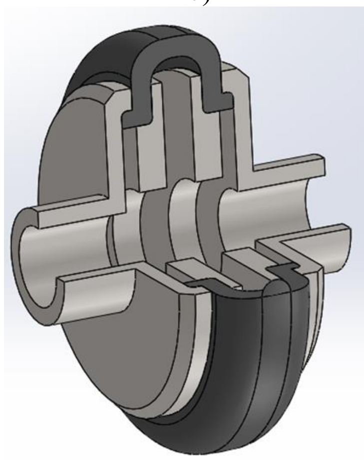
The differences in shape and dimensions are reflected on the 3D models created for beginning a simulation study in the CAE Software - Solid Works Simulation. The created models are shown in the next four pictures (Figure 3)





a) b)





c) d)

Figure 3. 3D models of different couplings: a) Standard MN5809-65; b) Patent №RU2325566; c) Vielastic Modul Byala; d) Stromag GKN – Periflex.

For each of the models is created simulation study for determinate the critical torque at which to the coupling elastic element is buckling. The model load: fixtures; torque; rotation; who are the equally located on all models are shown on the Figure 4.

If we disclose the overall design features and dimensions of the elastic element of the four different couplings, as well as their effect on stability, we can reach the following summary scheme of a type coupling (Figure 5).

In the following Table.2 are displayed the values of the individual parameters for the different couplings.

The properties of the material for the individual elements are the same as the data are taken from reference [1; 7; 8; 9; 10]. For rubber material the modulus of elasticity is set as 6 MPa and Poisson ratio $\mu = 0.49$, for rotation speed on the coupling – 1600 rev/min.

Table. 2 Shaft coupler elastic element dimensions for different models

Parameters\Manufacturers	**By Standard MN5809-65**	**By Patent №RU2325566**	**Vielastic Modul Byala**	**Stromag GKN - Periflex**
Diameters of middle contact surface – d, mm	220	262	310	250
Height of rubber – h, mm	61	43.5	30	46
Width of rubber – l, mm	72	40	61	64
Tightness of the rubber – δ, mm	18	11	15	18

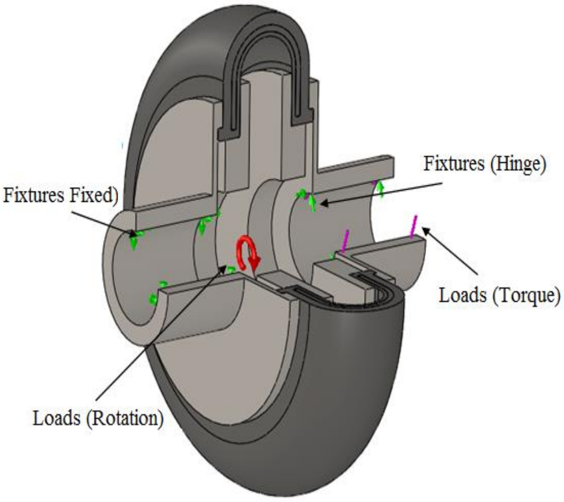


Figure 4. Load of the models in Solid Work Simulation system

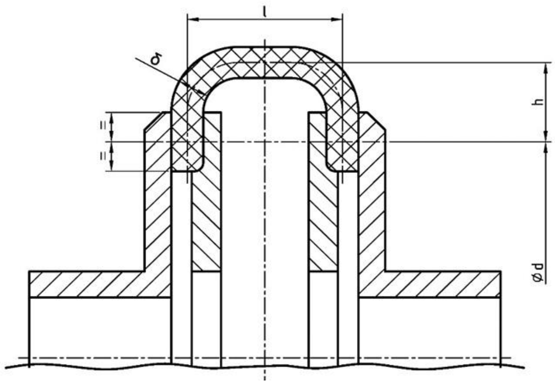


Figure 5. Summarized drawing of elastic coupling “Periflex” type

3. Result and discussion

As a result, for the critical torque the program is reporting Buckling Factor of Safety (BFS) and plot of amplitude buckling model. When multiplicate BFS and load torque can be determinate maximal working torque. In the Solid Work Help for buckling study is write:

“A model can buckle in different shapes under different levels of loading. The shape the model takes while buckling is called the buckling mode shape and the loading is called the critical or buckling load. Buckling analysis calculates many modes as requested in the Buckling dialog. Usually interested in the lowest mode because it is associated with the lowest critical load. When buckling is the critical design factor, calculating multiple buckling modes helps in locating the weak areas of the model. The mode shapes can help to modify the model or the support system to prevent buckling in a certain mode. The ratio of the buckling loads to the applied loads is the factor of safety against buckling (BFS)”.

The following table illustrates the interpretation of possible BFS values.

Table 3. A table showing the meaning of factor of safety against buckling – BFS [11]

BFS Value (factor of safety)	Buckling Status	Notes
1 < BFS	Buckling not predicted	The applied loads are less than the estimated critical loads. Buckling is not expected.
0 < BFS < 1	Buckling predicted	The applied loads exceed the estimated critical loads. Buckling is expected.
BFS = 1	Buckling predicted	The applied loads are exactly equal to the estimated critical loads. Buckling is expected.
BFS = -1	Buckling not predicted	The buckling occurs when the directions of the applied loads are all reversed. For example, if a bar is under tensile load, the BFS should be negative. The bar will never buckle.
-1 < BFS < 0	Buckling not predicted	Buckling is predicted if you reverse all loads.
BFS < -1	Buckling not predicted	Buckling is not expected even if you reverse all loads.

Table. 4 Critical of buckling load for different couplings

Parameters\Manufacturers	By Standard MN5809-65	By Patent №RU2325566	Vielastic Modul Byala	Stromag GKN - Periflex
Maximal Simulation Torque, Nm	2200	1207	4570	1273
Maximal Theoretic Torque – Tmax, Nm	2250	3800	3600	7500
Different Between Torques, %	2.22	68.2	-26.9	83.0

From the simulation studies performed and the consideration of the buckling task was determined the maximal torques and the graphs on the amplitudes of the buckling are shown in Figure 6. On the Table.4 is shown critical buckling load torque for different shaft couplings.

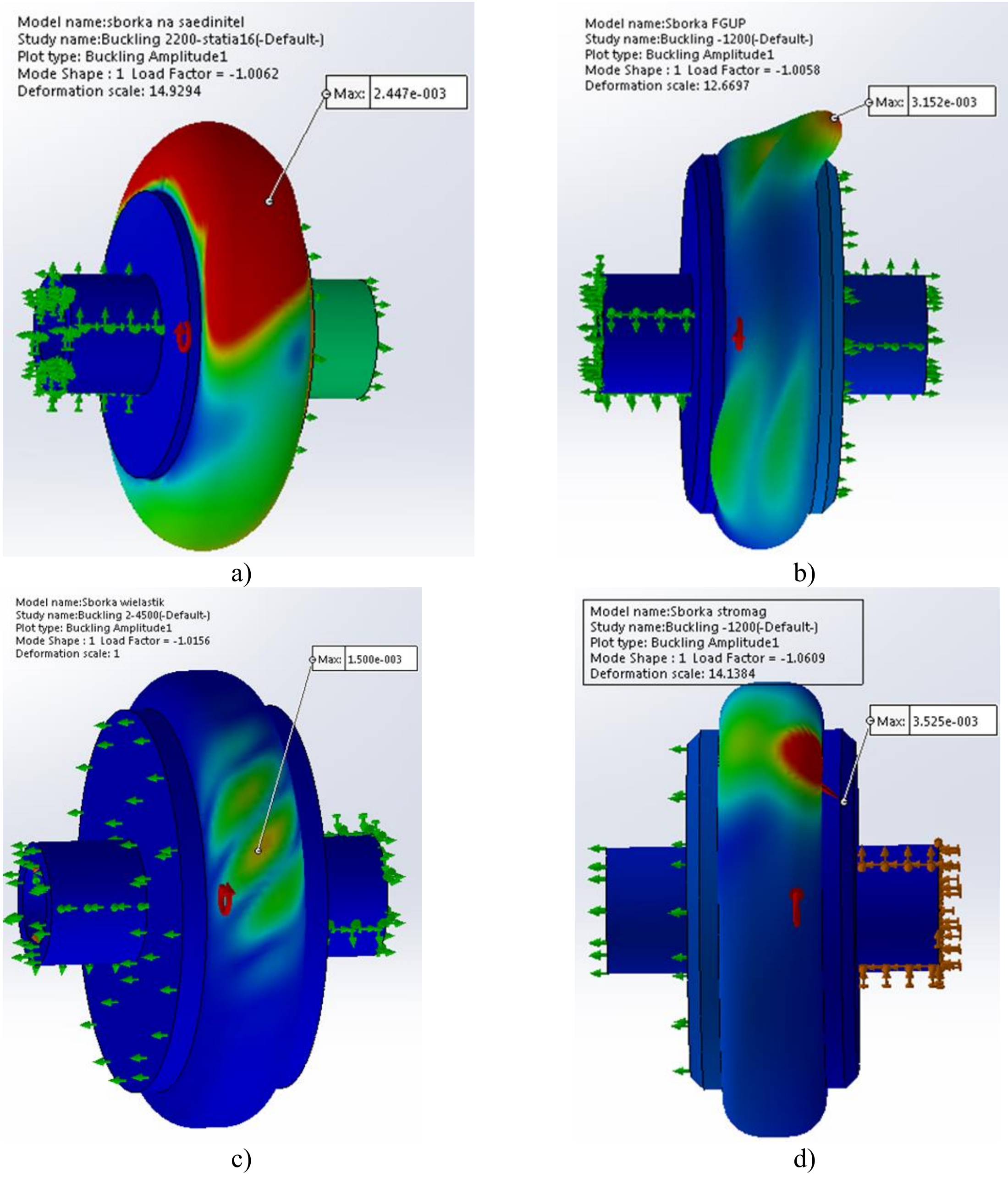


Figure 6. Buckling of different models: a) Standard MN5809-65; b) Patent №RU2325566; c) Vielastic Modul Byala; d) Stromag GKN – Periflex

If we look at the relationship between the geometric parameters characterizing on the elastic coupling element and critical buckling torque we can be represented by the following more dependencies, show in the next graphs (Figure 7, 8, 9 and 10).

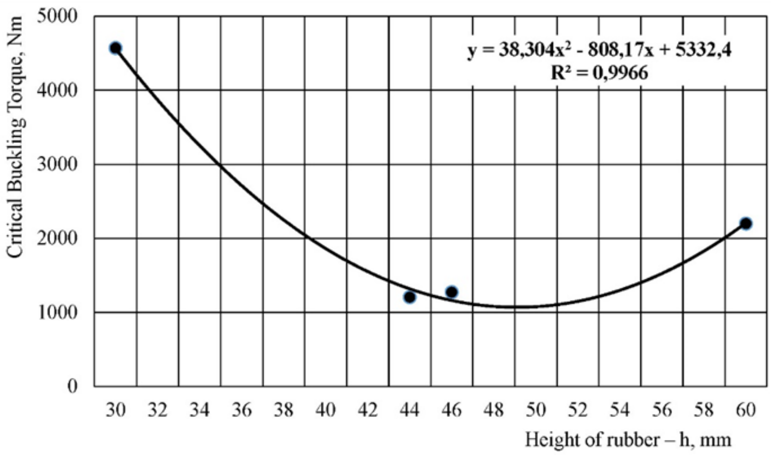


Figure 7. Influence of height of the rubber on critical buckling torque for different coupler design

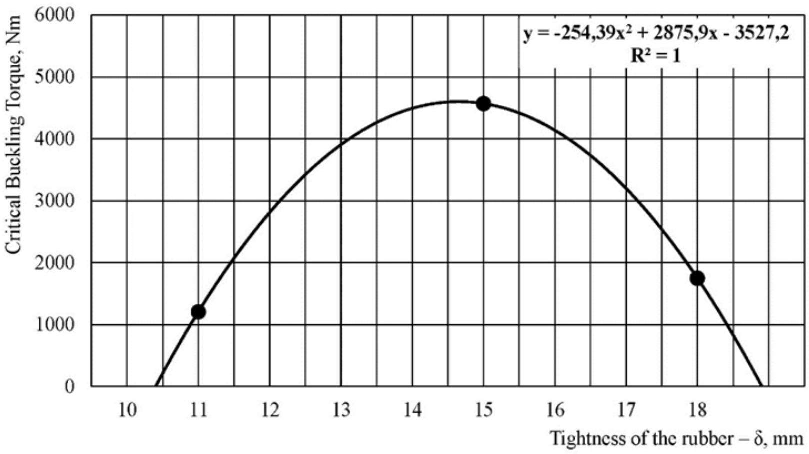


Figure 8. Influence of tightness of the rubber δ, mm on critical buckling torque for different coupling design

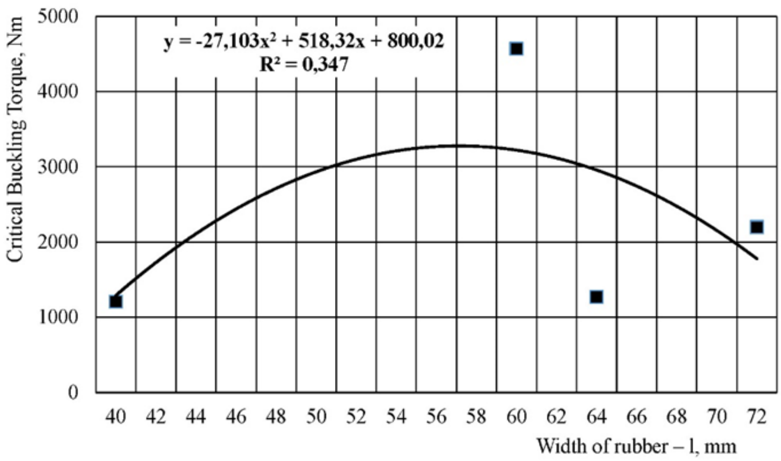


Figure 9. Influence of width of the rubber l, mm on critical buckling torque for different coupling design

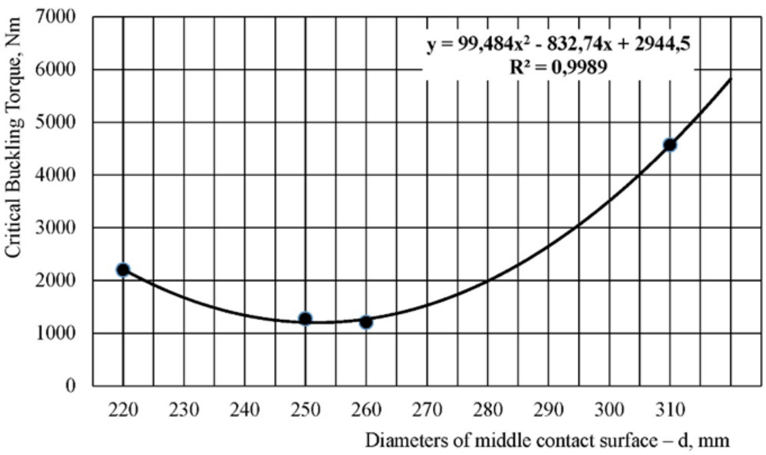


Figure 10. Influence of diameters of middle contact surface – d, mm on critical buckling torque for different coupling design

4. Conclusion:

From the research carried out, can be made the following important conclusions:

1. Increasing of the height of the rubber leads to lowering of maximal working torque showing on the Figure 7;
2. Increasing of the tightness of the rubber leads to increasing of maximal working torque showing on the Figure 8;
3. The width of the elastic elements has no significant influence on the change in the critical buckling moment, showing on the Figure 9
4. Increasing of diameters of middle contact surface on the rubber leads to increasing of maximal working torque showing on the Figure 10;
5. Studies carried out on the indicate that the design of rubber elastic elements “Vielastic” of Modul Byala may transmission the largest torque under the same conditions with other designs, showing in Table. 4;

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