



Volume XXI 2018

ISSUE no.1

MBNA Publishing House Constanta 2018



Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

The theoretical model for determining critical rotation speed flexible coupling type SEGE

To cite this article: E Ivanova, S Tenev and T Vasilev, *Scientific Bulletin of Naval Academy*, Vol. XXI 2018, pg. 326-329.

Available online at www.anmb.ro

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-18-I1-050

SBNA© 2018. This work is licensed under the CC BY-NC-SA 4.0 License

The theoretical model for determinig critical rotation speed flexible coupling type SEGE

E Ivanova^{1,1}, S Tenev^{2,2} and T Vasilev^{1,3}

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

2 – Technical University of Varna, Department of Mechanics and Machine Elements 9010, 1 Studentska 1 Street, Varna, Bulgaria

Corresponding author contact: 1 - e.ivanova@naval-acad.bg; 2 - stevo_93@abv.bg,
3 - t.vasilev@naval-acad.bg

Abstract. It this article was studied a flexible coupling with a rubber elastic element. In exploitation period under one direction load, half of all cylinders are working. All of cylinders are made along with a carrying ring. The elastic elements are subjected to compression. On the non-loaded cylinders, a centrifugal force acts to cause their radial displacement. By the slow rubber relaxation of not loaded cylinders, in the case of reverse and impact load it is danger of can be pinched between the metal claws of semi couplings. Radial displacement and critical rotation speeds were determined, for non-loaded cylinders, in the time which is derived pinching the rubber elastic element.

Key words: flexible coupling, rubber element, critical speed, radial displacement

1. Introduction

For determining of radial displacement and critical rotation speed viewed a flexible coupling type SEGE (Acc. to BDS 16420-86). Figure 1 shows the section of semi couplings, for seeing of the rubber elastic element. This type flexible coupling loaded in normal operation conditions, transmit energy between the shafts couplings by half of the all cylinders.

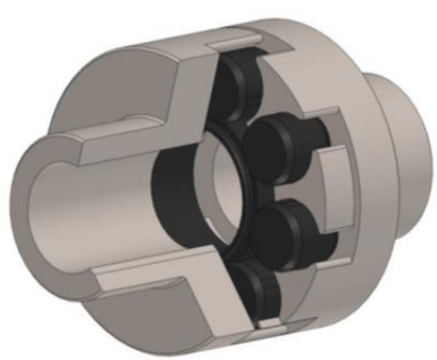


Figure 1. General brief description of coupling type SEGE

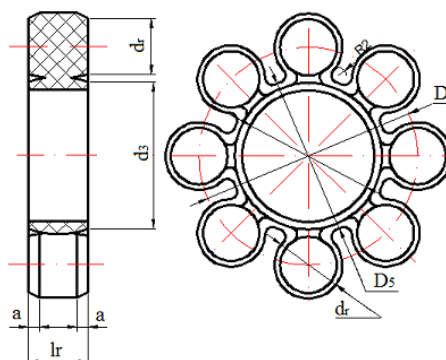


Figure 2. Elastic element

The center of mass on all cylinders are located at a distance r by the center of revolution. The centrifugal force F load them, it can be determined by dependence (1).

$$F = m_c \cdot r \cdot \omega^2, N \quad (1)$$

Where:

- m_c - mass of one cylinder, kg;
- r - circle radius on cylinders mass center are located, m;
- ω - angular speed of the coupling, s^{-1} .

The indication of the elastic element dimensions is shown in Figure 2.

Deformed shape of elastic rubber elements, loaded with torque and centrifugal loads, created by FEM analyse software “Solid Work Simulation” is shown in Figure 3. The study is viewed in [4].

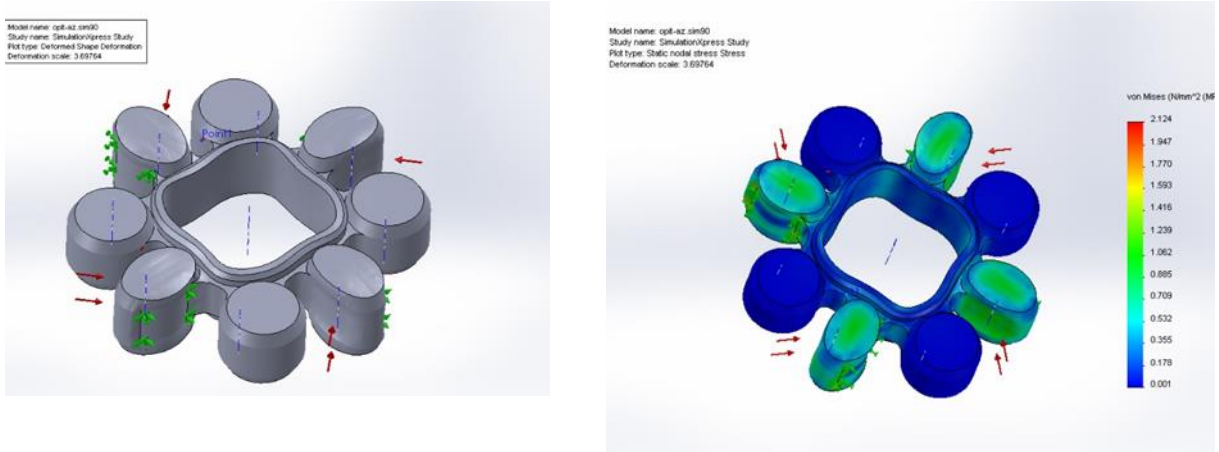


Figure 3. Deformation of the elastic element [4]

Schematic representation of the load on the ring holding the working cylinders is shown in Figure 4.

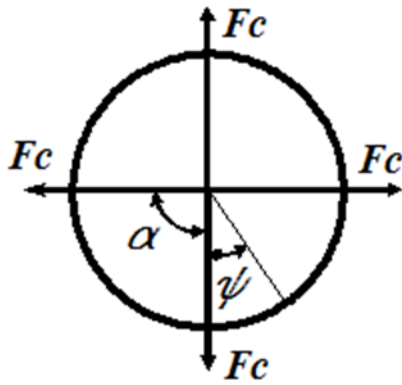


Figure 4. Load diagram of centrifugal force

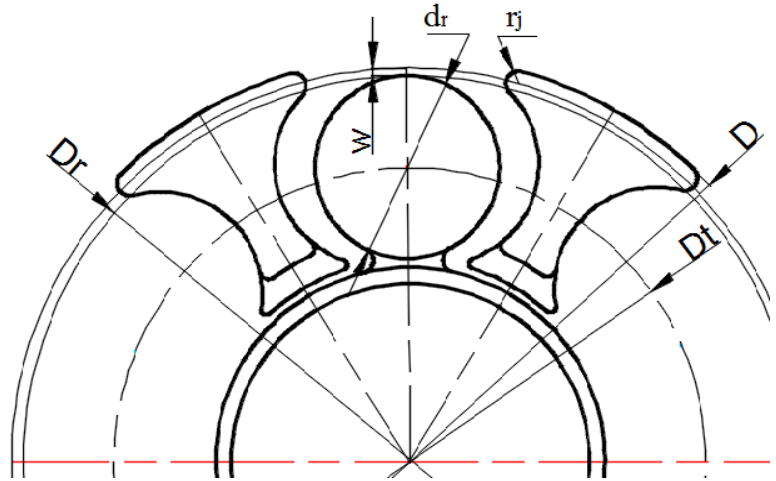


Figure 5. Hang down the free cylinder

Slope under operating force in a radial direction from the centre according to [2] is determined by formula (2).

$$w(\psi) = \frac{F \cdot r^3}{E \cdot J} \cdot \frac{1}{2 \cdot \sin^2\left(\frac{\alpha}{2}\right)} \left(\frac{\alpha}{4} + \frac{1}{4} \cdot \sin \alpha \cdot \frac{2 \cdot \sin^2\left(\frac{\alpha}{2}\right)}{\alpha} \right) + \frac{F \cdot r}{E \cdot A} \cdot \frac{1}{2 \sin^2\left(\frac{\alpha}{2}\right)} \left(\frac{\alpha}{4} + \frac{\sin \alpha}{4} \right), \quad (2)$$

Where:

- $\psi = k.\pi/2$ - current angle, $k \in [1; 2]$, rad;
- z - the number of non-loaded cylinders, pcs;
- $\alpha = 2\pi/z$ - angle between the non-loaded cylinders, rad;
- F - the centrifugal force acting on the non-loaded cylinders, N;
- $E = 4,5 \div 5,5$ - modulus of elasticity of the rubber, MPa;
- J - moment of inertia of the ring section, m^4 ;
- A - area of the cross-section of the ring, m^2 .

Experiments were carried out to capture the static characteristics of different types of type couplings. It was found that at full unloading the two semi couplings had a relative rotation of the order $7-13.10^{-3}$ rad. However, at least 8 seconds are required for complete relaxation of the elastic element, including those with high stiffness [3, 4].

Under severe vibration and impact loads, the initially free (unloaded) cylinders may be pinched in the peripheral part of the metal claws of the semi-couplings. This necessitates a limitation of the radial deformation of the ring and the displacement of the cylinder according to the overall diameter of the metal claws and their radii of roundness as shown in figure 5.

The radial deflection should be limited by the metal claws according to the standard coupling sizes as follows:

$$\omega_{\max} = \frac{D - D_r}{2} - r_j, \quad (3)$$

Where:

- D – outer diameter of the claws of the metal semi coupling, m;
- D_r – outer diameter of the elastic element, m;
- r_j – radius of curvature of the claws, m.

Given that the radial deformation is obtained from the centrifugal force, solving together (1), (2) and (3), we obtain the dependence on the angular speed at which the maximum deformation in the species is reached

$$\omega_{cr} = \sqrt{\frac{(D - D_r - 2r_j)}{\left(r^3 \cdot \frac{C_1}{E.J} + r \cdot \frac{C_2}{E.A}\right) m_c \cdot D_t}}, \quad (4)$$

Here the constants are respectively

$$C_1 = \frac{1}{2 \cdot \sin^2\left(\frac{\alpha}{2}\right)} \left(\frac{\alpha}{4} + \frac{1}{4} \cdot \sin \alpha \cdot \frac{2 \cdot \sin^2\left(\frac{\alpha}{2}\right)}{\alpha} \right) \text{ and } C_2 = \frac{1}{2 \cdot \sin^2\left(\frac{\alpha}{2}\right)} \cdot \left(\frac{\alpha}{4} + \frac{\sin \alpha}{4} \right)$$

From the calculations made for the coupler with a nominal torque of 80 Nm, a critical speed of rotation of $n_{cr} = 1189 \text{ min}^{-1}$ is obtained. In the Table1 shows data for a part of a type of couplings in which the maximum revolutions are taken from the standard and are determined by the strength condition of the loaded cylinders and the critical revolutions are determined at reversal and impact loads by the critical angular speed of formula (4).

Table 1 Maximum and critical revolutions.

Torque T , [Nm]	Number of cylinders z	Max. Revolutions n_{max} [min ⁻¹]	Critical revolutions n_{cr} [min ⁻¹]
80	8	4500	1189
125	8	4000	1040
200	8	3500	1264
315	10	3000	662
400	10	2700	652

Since the stressed and strain state of the loaded cylinders was examined in detail in [5], the effect of centrifugal forces on them was not studied in the present work.

2. Conclusion:

1. The standard, BDS 16420-86 has determined the permissible speed of rotation of the coupling based on the strength of loaded cylinders at nominal torque;
2. In heavier working modes associated with reverse or strong impacts, account shall be taken of the permissible critical speed after which there is a risk of pinching the cylinders between the metal claws.
3. Increasing the critical rotational speed can be obtained by increasing the thickness and the axial size of the ring holding the cylinders.

References:

- [1] БДС 16420-86, *Съединител еластичен с гумен елемент*
- [2] Биргер ИА, Шор БФ, Йосилевич ГБ 1979, *Расчет на прочность деталей машин*, М. Машиностроение.
- [3] Христов Х, Тенев С, Стоянов С 2012, *Изследване възможността за линеаризация на характеристиката на еластичен съединител тип СЕГЕ*, ЮНК 50 год. ТУ-Варна, **том IV**, стр.74-77
- [4] Тенев С, Христов Х, Иванова Е 2014, *Относно динамичните характеристики на еластичен съединител тип СЕГЕ при променливо натоварване*, сп. „Машиностроителна техника и технологии“, ISSN 1312-0859, **кн. 2**, стр. 75-78
- [5] Иванова Е 2016, *Изследване влиянието на вида на деформационния процес върху експлоатационните характеристики на еластичния съединител с неметален елемент*, Дисертация за ОНС „доктор“, ТУ-Варна
- [6] Иванова Е, Василев Т, Христов Х, 2018, *Влияние на физико - механичните свойства на еластичния елемент върху деформационния процес на съединител СЕГЕ*, сп. Машиностроене и Машинознание, ISSN1312-8612, **кн.28**