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DESIGN METHOD OF ELASTIC COUPLING WITH CYLINDRICAL BOLTS AND NONMETALLIC ELEMENTS FROM RUBBER

Marilena Radu, Emil Chişu, „Transilvania" University Brasov, Eroilor Avenue Nr. 29, Code 500036.

Abstract: In this paper is present design method for new elastic couplings with cylindrical bolts and nonmetallic intermediary elements, which are realized from various rubber qualities. The novelty of this couplings types consist in existence of one disc between those two semi couplings (the disc is not presents centering thresholds), of eight metallic plates and the nonmetallic elements from rubber are mounting on the bolts.

Keywords: elastic coupling, torsion moment, bolts, design method, new constructive forms from various rubber qualities.

1. INTRODUCTION

The couplings are mechanical body which realize relation (permanent or intermittent) between two shafts of one transmission, in scope transmitting torsion moment and of rotation motion, without no modification motion law. These designed couplings are making part from category's mechanic, permanent, mobile, elastic couplings. They have accomplishing the following functions: transmitter of rotation motion and of torsion moment; shocks and vibrations absorption; preload of axial, radial, angular or combinative deviations.

2. FUNCTIONAL PRINCIPLE AND DESIGN METHOD OF THIS COUPLING

The paper presents a design method from this constructive variant (Fig. 1). This variant of designed coupling consist in their component one disc *7* between those two semi-couplings *1*, respective *2*, the nonmetallic elements *3* from various rubber qualities are fixed between metallic plates *10* and mounting on the bolts. The bolts *4* are cylindrical – their number being of 4. The fastening of bolts for each semi-coupling is realize by Grower washers *5* and hexagonal nuts *6*. The fastening of metallic plates *10* for intermediary disc *7* is realize through cylindrical screws and hexagonal groove *11*, and the fastening of intermediary disc *7* by the semi-coupling *2* is realize by cylindrical screws and hexagonal groove *8* and for intermediary disc centering is follow cylindrical pin *9*.

At the this constructive variant of coupling, the torsion moment is transmit from the driver semi-coupling *1* on the nonmetallic elements *3*, by diverse forms, through all four cylindrical bolts *4*, fixated rigid for semi-coupling *1*, and through intermediary disc *7* by driven semi-coupling *2*. For this constructive variant of coupling it is propose a design method, this method being presents in the Table 1.

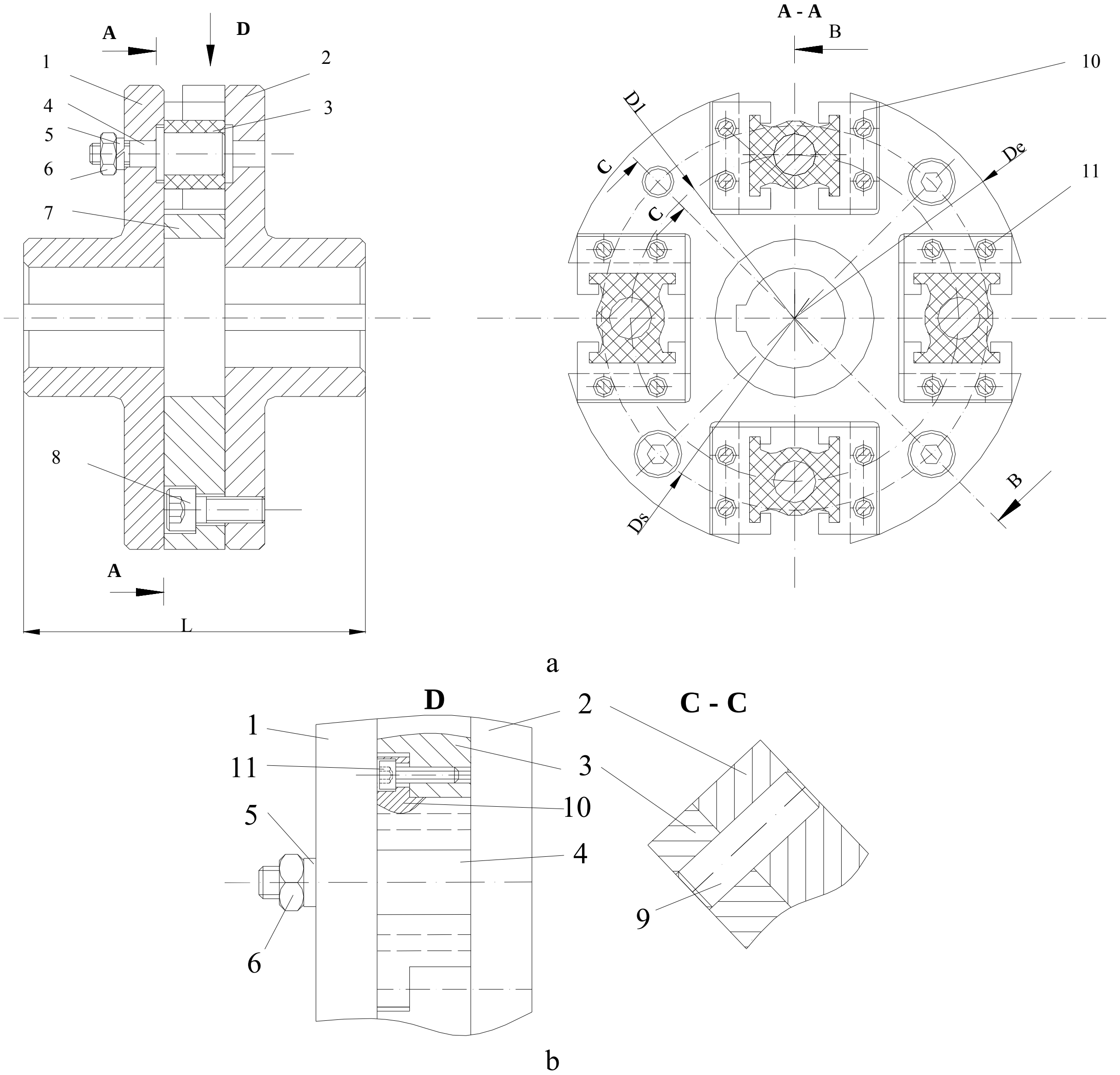
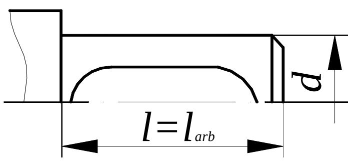
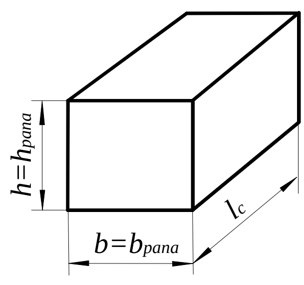


Fig. 1. *First constructive variant of elastic coupling (a), and (b) section C-C and view D.*

Table 1. The design method of elastic couplings with bolts and nonmetallic intermediary elements.

Crt. nr.	**Elements of calculus**	**Symbol, unit of measure**	**Relations of calculus. Recommenders**
0	1	2	3
1.	***Date of designing***		
1.1.	*Power of transmit*	***P*** [kW]	-

0	1	2	3
1.2.	*Shafts speed*	***n*** [rot/min]	-
1.3.	*Functionary conditions*	-	Driving machine, under driven machine, size of overloads.
2.	***Thermic treatment and materials choosing***		
2.1.	*Material of semi-couplings*	-	It will choose: OLC 45 STAS 880, improved; OL 50 STAS 500.
2.2.	*Material of intermediary disc*	-	It will choose: OLC 45 STAS 880.
2.3.	*Material of metallic plates*	-	It will choose: OLC 45 STAS 880, improved.
2.4.	*Material of bolts*	-	It will choose for: OL 60 STAS 500; OLC 45 STAS 880, improved.
2.5.	*Material of nonmetallic elements*	-	It will choose: Natural Rubber, NR; Butadiene – acril-nitrile rubber, NBR; Ethylene – propylene diene rubber, EPDM.
3.	***Stages of designing***		
3.1.	*Nominal moment of torsion*	M_{tn} [Nmm]	$M_{tn} = 9{,}55 * 10^6 \frac{P}{n}$.
3.2.	*Choosing of safety coefficient*	K_s	-
3.3.	*Torsion moment of calcul*	M_{tc} [Nmm]	$M_{tc} = K_s * M_{tn}$.
3.4.	*Diameter and length of shat end*  **Fig. 2.** *The shaft end*	*d [mm]* *l [mm]*	If isn't indicated through design theme, the shaft's diameter is determine with relation: $d = \sqrt[3]{\frac{M_{tn}}{0{,}2 * \tau_{at}}}$, it's choosed from STAS 8724/2 standard values for *d* and $l = l_{arb}$. It's recomande the admissible resistance to torsion $\tau_{at} = (15...45) MPa$.
3.5.	*Dimensions of wedge*  **Fig. 3.** *Wedge Types*	*b, h,* l_p [mm]	- *b, h* are choose in function of shaft's diameter *d* from STAS 1004. - l_c is determine in function of admissible resistance to crushing of wedge $\sigma_{aspanna} = 120\ MPa$ - for wedge material OL 60, conform STAS 1004, for other materials it is recommends $\sigma_{aspanna} = (0{,}25...0{,}35)\sigma_{02}$. - In function by wedge type (A, B, C) it is determine real length of wedge $l = l_{pana}$, follows as: • wedge of type A: $l = l_c + b$; • wedge of type B: $l = l_{pana} = l_c$; • wedge of type C: $l = l_c + (b/2)$.

Tip: A Tip: B Tip: C

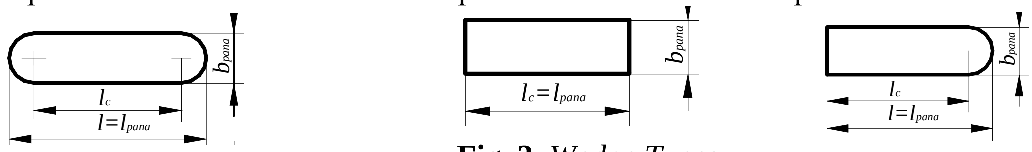


Fig. 3. *Wedge Types*

3.6	*Diameter's circle of arrangement of bolts choosing, respective coupling's exterior diameter*	D_1, D_e [mm]	It's recommends (see Fig. 3): • $D_1=(3...5)d$; $De=D_1+3{,}25d_b$.
3.7.	*Determination of bolt diameter, of bolts number and of length of contact between bolt and nonmetallic element.*	d_b, l_2 [mm] *z*	It's recommends (see Fig. 3): • $d_b=0{,}13D_1$; $l_2=(0{,}9...1{,}4)d_b$ • $z=4$.

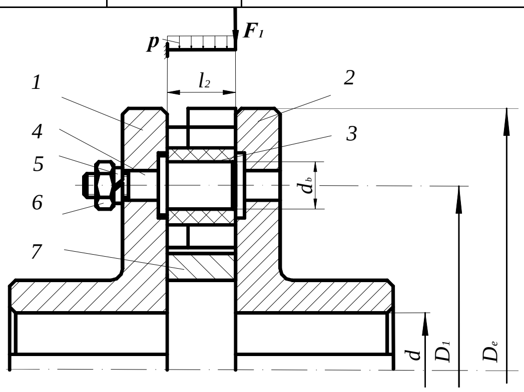


Fig. 4. *Calculus scheme*

3.8.	*Determination of hub length, respective of coupling's length*	L_1, L $[mm]$	It's recommend (v. fig. 4): • $L_1=1{,}4d$; $L=(1{,}5...3{,}4)d$.
3.9.	*Determination of nonmetallic elements dimensions*	[mm]	• $h=h_1+6=1{,}94d_b$; • $l_1=1{,}625d_b$; $l=l_1+d_b/2$; b is adopts constructive.

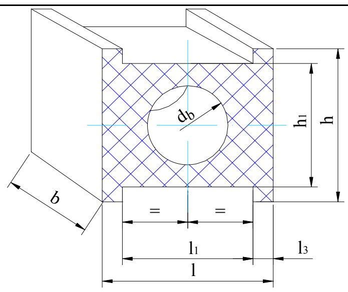


Fig. 5. *Form 1*

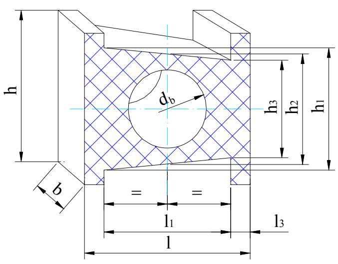


Fig. 6. *Form 2*

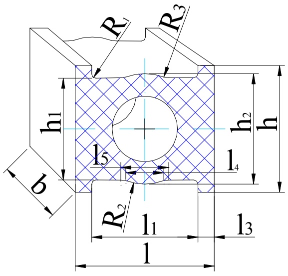


Fig. 7. *Form 3*

3.9.1.	*Form 1*	[mm]	• $h_1=d_b+9$; $l_3=d_b/4=0{,}25d_b$.
3.9.2.	*Form 2*	[mm]	• $h_1=d_b+9$; • $h_2=d_b+6{,}5$; • $h_3=h_1-5$; • $h_1=d_b+9$ • $h_2=d_b+6{,}5$; • $h_3=h_1-5$; • $l_3=d_b/4=0{,}25d_b$.
3.9.3.	*Form 3*	[mm]	• $h_1=d_b+9$; • $h_2=h_1+2$; • $l_1=1{,}625d_b$; • $l_3=0{,}25d_b$; • $l_4=(d_b/4)+1$ • $l_5=0{,}75d_b$ • $R_2=0{,}844d_b$; • $R_3=0{,}1563d_b$. • $R_1=0{,}0625d_b$;

			;

0	1	2	3
3.10.	*Calculus of force which loaded one bolt.*	F_1 [N]	$F_1 = \frac{2M_{tc}}{zD_1}$.
3.11.	*Verification of nonmetallic element to those two solicitations.*	σ_t, σ_s [MPa]	$\sigma_t = \frac{F_t}{A_t} = \frac{2M_{tc}}{zD_1A_t} \le \sigma_{at}$; $\sigma_s = \frac{F_s}{A_s} = \frac{2M_{tc}}{zD_1A_s} \le \sigma_{as}$ $\sigma_{at} = 0{,}5 MPa$; $\sigma_{as} = (5...7) MPa$;
3.11.1.	*Form 1*	σ_{tF1} σ_{sF1}	$\sigma_{tF1} = \frac{2M_{tc}}{zD_1(h_1 - d_b)b} \le \sigma_{at}$; $\sigma_{sF1} = \frac{2M_{tc}}{zD_1d_bb} \le \sigma_{as}$;
3.11.2.	*Form 2*	σ_{tF2} σ_{sF2}	$\sigma_{tF2} = \frac{2M_{tc}}{zD_1(h_3 - d_b)b} \le \sigma_{at}$; $\sigma_{sF2} = \frac{2M_{tc}}{zD_1d_bb} \le \sigma_{as}$;
3.11.3.	*Form 3*	σ_{tF3} σ_{sF3}	$\sigma_{tF3} = \frac{2M_{tc}}{zD_1(h_2 - d_b)b} \le \sigma_{at}$; $\sigma_{sF3} = \frac{2M_{tc}}{zD_1d_bb} \le \sigma_{as}$;
3.12.	*Capable torsion moment calculus for those two solicitations of nonmetallic element.*	M_{tcapt} M_{tcaps} [Nmm]	$M_{tcapt} = \frac{zD_1A_t\sigma_{at}}{2}$; $M_{tcaps} == \frac{zD_1A_s\sigma_{as}}{2}$.
3.12.1.	*Form 1*	$M_{tcaptF1}$ $M_{tcapsF1}$	$M_{tcaptF1} = \frac{zD_1(h_1 - d_b)b\sigma_{at}}{2}$; $M_{tcapsF1} = \frac{zD_1d_bb\sigma_{as}}{2}$.
3.12.2.	*Form 2*	$M_{tcaptF2}$ $M_{tcapsF2}$	$M_{tcaptF2} = \frac{zD_1(h_3 - d_b)b\sigma_{at}}{2}$; $M_{tcapsF2} = \frac{zD_1d_bb\sigma_{as}}{2}$.
3.12.3.	*Form 3*	$M_{tcaptF3}$ $M_{tcapsF3}$	$M_{tcaptF3} = \frac{zD_1(h_2 - d_b)b\sigma_{at}}{2}$; $M_{tcapsF3} = \frac{zD_1d_bb\sigma_{as}}{2}$.
3.13.	*Determination of ratio of capable moments*	K [-]	
3.13.1.	*Form 1*	K_{F1}	$K_{F1} = \left(\frac{h_1}{d_b} - 1\right)\frac{\sigma_{at}}{\sigma_{as}} = (0{,}1...0{,}07)\left(\frac{h_1}{d_b} - 1\right)$;
3.13.2.	*Form 2*	K_{F2}	$K_{F2} = \left(\frac{h_2}{d_b} - 1\right)\frac{\sigma_{at}}{\sigma_{as}} = (0{,}1...0{,}07)\left(\frac{h_3}{d_b} - 1\right)$;
3.13.3.	*Form 3*	K_{F3}	$K_{F3} = \left(\frac{h_3}{d_b} - 1\right)\frac{\sigma_{at}}{\sigma_{as}} = (0{,}1...0{,}07)\left(\frac{h_2}{d_b} - 1\right)$;
3.14.	*Verification to bending of bolt.*	σ_i [MPa]	$\sigma_i = \frac{M_i}{W_z} = \frac{F_1l_2}{\frac{\pi d_b^3}{32}} = \frac{64M_{tc}l_2}{\pi d_b^3D_1z} \le \sigma_{ai}$, $\sigma_{ai} = (0{,}25...0{,}4)\sigma_{02}, \sigma_{02} = 320\ MPa$ -for OL

0	1	2	3
			60 bolt; $\sigma_{02} = 360\ MPa$ - for OLC 45 bolt improved, N; $\sigma_{02} = 400\ MPa$ - for OLC 45 bolt improved, I;
3.15.	*Angle of relative rotation of semi-couplings.*	φ [rad]	$\varphi(M_t)$.
3.16.	*Rigidities of coupling.*	k [Nmm/rad]	$k=M_t/\varphi$.

3. CONCLUSION

From the presented in paper, it may be formulate the following conclusions:

- the coupling transmits the torsion moment in any direction, he being an elastic coupling, which realized damping vibrations and shocks and may take over radial deviations;
- the nonmetallic element may be confectioned from various materials with different hardness.
- with this design method, any user may determine dimensions for desired couplings.

4. REFERENCES

* E-mail address: marilenaradu@unitbv.ro.

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