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ANALYTICAL MODEL TO CALCULATE THE PRESSURE RING IN COULOMBAIN DAMPER

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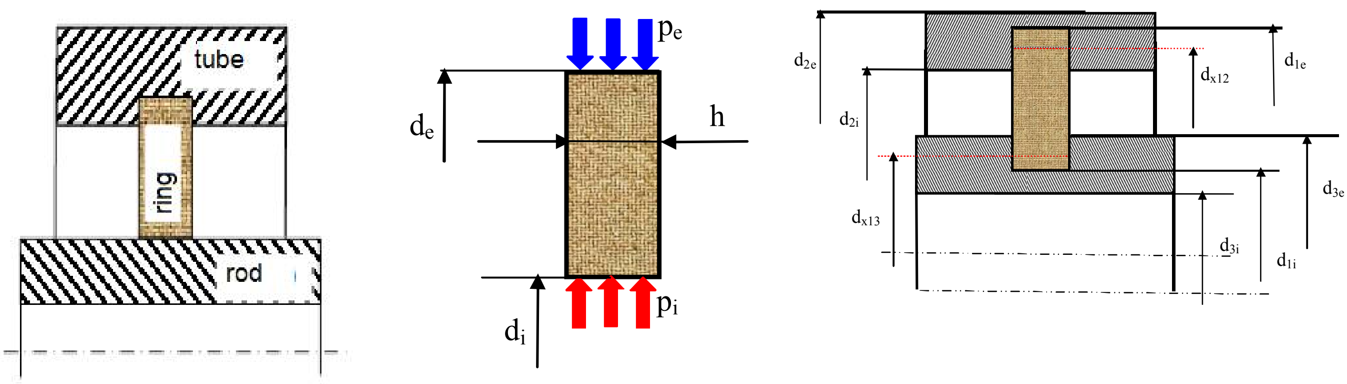
Abstract: *It is considered the case of a pressed assembly of a shaft and a hub in the Coulombian damper. It is used the Lame equation and is defined the maximum contact pressure. The dry friction damper modified the equivalent stres in the working time of damper. The contact pressure defined the design of damper.*
Keywords *Coulomb damper; Rubber ring; Contact pressure; Equivalent stress*

1. INTRODUCTION

The paper presents work as an annular ring is considered cylinder section r_e and r_i length h (Fig. 1). These rays are determined after installation of elastic equilibrium conditions. Limiting the operation of a damper Coulomb is defined by damage rings [1]. This deterioration occurs due to the phenomena of fatigue and aging process at the interface with the rod (damper direct) or to interface with pipe (casing) to damper vice versa. In order to elucidate the mechanism of shutdown of a silencer, considering the stresses and deformations of rings, assembly and operation.



a) *b)*
c)

Fig.1. Functional scheme of direct damper (a), the system forces the ring (gasket) (b) and that seats ring (c).

In this there are two damper assemblies pressed. Thus, a compressed assembly is achieved between the shaft and the ring and the second between the ring and the tube.
It is considered the elastic properties of materials known the three components of the damper modules longitudinal elasticity coefficient E and transverse contraction - Poisson's ratio ν (E_1, ν_1, E_2, ν_2, E_3, ν_3) and geometry of the components before assembly (inner and outer diameters d_{1i}, d_{1e}, d_{2i}, d_{2e}, d_{3i}, d_{3e}). Size representation of fig.1c is exaggerated to suggest the existence of fits clamping ring and ring and rod and the tube [2]. in order to determine the diameters of contact between the ring and the ring and rod and tube, apply Lamé relations of theory of elasticity [2], [3], [4]. In this regard it is considered the case of a pressed assembly of a shaft (a) and a hub (b). It is accepted that the shaft is hollow to give size (outside diameter) and d_1 (the inside diameter) and is made of a material with modulus of elasticity and Poisson's ratio ν_a. Similarly, the hub has dimensions d_2 (outer diameter) and d_a (inner diameter) and E_b and ν_b material. contact conditions are separated from the application studied, by using an envelope system as proposed (contact area specifications) [5]:

$$\Delta_a = p\frac{k_a}{E_a}d;\ \Delta_b = p\frac{k_b}{E_b}d;\ k_a = \frac{d^2+d_1^2}{d^2-d_1^2}-\nu_a;\ k_b = \frac{d_2^2+d^2}{d_2^2-d^2}+\nu_b \tag{1}$$

$$\frac{\dfrac{d^2+d_1^2}{d^2-d_1^2}-\nu_a}{\dfrac{d_2^2+d^2}{d_2^2-d^2}+\nu_b}\cdot\frac{E_b}{E_a}=\frac{d_a-d}{d-d_b} \tag{2}$$

dimenionless are the following

$d_x = d/d_a; d_{1a} = d_1/d_a; d_{2a} = d_2/d_a; d_{ba} = d_b/d_a; E_{ba} = E_b/E_a.$

so, from equation (2) result $d_x(d_{1a}, d_{2a}, d_{ba}, E_{ba}, \nu_a, \nu_b)$.

For example, in fig. 2 presents contact diameter (d_X) for different diameters $d_{ba} = d_b/d_a$

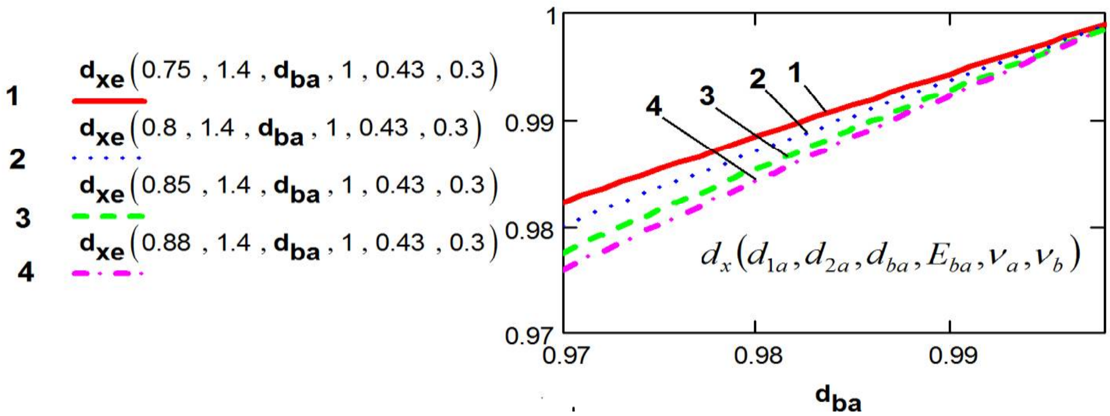


Fig .2 Contact diameters fit of the damper.

coercion shaft is

$$\Delta_{aa} = \Delta_a/d_a = -(1-d_x); \tag{3a}$$

expansion hub

$$\Delta_{ba} = \Delta_b/d_a = -(d_{ba}-d_x) \tag{3b}$$

The contact pressure between shaft and hub, dimensionless to modulus (p= p_a/E_a), is deducted from Lamé equation

$$p_a(d_{1a}, d_{2a}, d_{ba}, E_{ba}, \nu_a, \nu_b) = \frac{\dfrac{1-d_x}{d_x}}{\dfrac{d_x^2+d_{1a}^2}{d_x^2-d_{1a}^2}-\nu_a}. \tag{4}$$

In Fig.3 exemplified contact pressure for different geometric conditions (d_{ba}, d_{1a}) and two different materials of the shaft and hub.

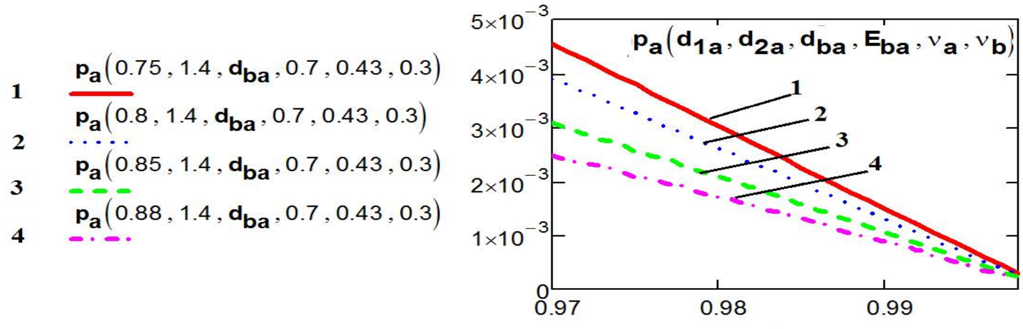


Fig. 3 Contact pressure versus the damper

For dry friction damper (fig.1) is the hub for the contact ring - rod and shaft for contact - tube.the application of the (4) for the contact ring with tube

$$p_{12} = p_a\left(\frac{d_{1i}}{d_{1e}}, \frac{d_{2e}}{d_{1e}}, \frac{d_{2i}}{d_{1e}}, \frac{E_2}{E_1}, \nu_1, \nu_2\right). \tag{5}$$

To contact ring (1) with the rod (3), resulting is

$$p_{13} = p_a\left(\frac{d_{3i}}{d_{3e}}, \frac{d_{1e}}{d_{3e}}, \frac{d_{1i}}{d_{3e}}, \frac{E_2}{E_3}, \nu_3, \nu_1\right). \tag{6}$$

2. ANALYTICAL MODEL TO CALCULATE THE TENSIONS RING AFTER MOUNTING

To determine the tension ring after installation, the support ring as a thick-walled tube with the geometry of fig. 4 subjected to external pressure $p_e = p_{12}$ and an internal pressure $p_i = p_{13}$.

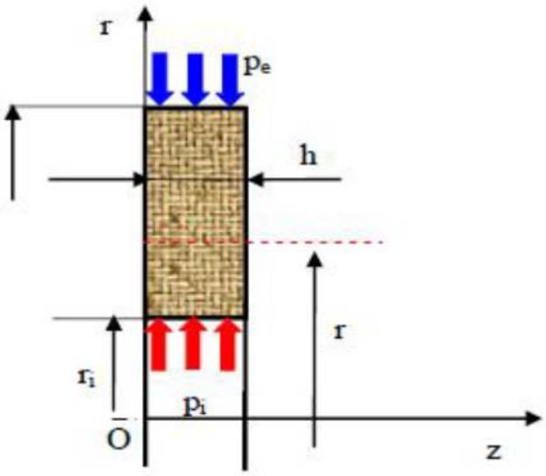


Fig. 4 Pressures on the ring model and damper.

$r_i = \frac{d_{x13}}{2}$ and $r_e = \frac{d_{x12}}{2}$

Choose zOr the cylindrical coordinate system. Based on the theory of elasticity [5], deducted displacements and tensions in the ring as a thick tube using the function of tension type:

$$\phi(z,r) = \left(A_1 \ln r + A_2 r^2\right)z + A_3 z^3, \tag{7}$$

when A_1, A_2 and A_3 are constants of integration. These constants are determined contour following conditions:for $r = r_i$, $\sigma_r = p_i$; $\tau_{r2} = 0$ (interior side contour);

for $r = r_e$, $\sigma_r = -p_e$; $\tau_{rz} = 0$ (the contour of the outer side);
for $z = 0$ and $r = r_i$, $\sigma_z = 0$ (lower contour);
for $z = h$ and $r = r_i$, $w = 0$ (upper contour).

Thus, displacement and tensions expressions: displacement in the radial direction u:

$$u = -\frac{1}{2G\left(r_e^2 - r_i^2\right)}\left[\frac{(p_e - p_i)r_i^2 r_e^2}{r} + \frac{(1-\nu)\left(p_e r_e^2 - p_i r_i^2\right)}{1+\nu} r\right]; \tag{8}$$

where $G = \frac{E}{2(1+\nu)}$ It is the transversal modulus of elasticity;

the axial displacement $w = \frac{\nu\left(p_e r_e^2 - p_i r_i^2\right)}{G(1+\nu)\left(r_e^2 - r_i^2\right)}(z-h);$ (9)

radial tension $\sigma_r = \frac{r_i^2 r_e^2}{r_e^2 - r_i^2} \cdot \frac{p_e - p_i}{r^2} - \frac{p_e r_e^2 - p_i r_i^2}{r_e^2 - r_i^2};$ (10)

angular tension $\sigma_\theta = -\frac{r_i^2 r_e^2}{r_e^2 - r_i^2} \cdot \frac{p_e - p_i}{r^2} - \frac{p_e r_e^2 - p_i r_i^2}{r_e^2 - r_i^2};$ (11)

tangential and axial $\tau_{rz} = \sigma_z = 0.$

Von Mises equivalent stress ring $\sigma_e = \frac{\sqrt{2}}{2}\sqrt{(\sigma_e - \sigma_\theta)^2 + (\sigma_\theta - \sigma_z)^2 + (\sigma_r - \sigma_z)^2}$. (12)

For damper geometry is considered as defining the outer diameter of the ring *(d_e)* and thickness (h), so proposes dimensionless other geometric elements to diametrul d_e and *thickness h.*
The tension ring is dimensionless to its longitudinal modulus E.

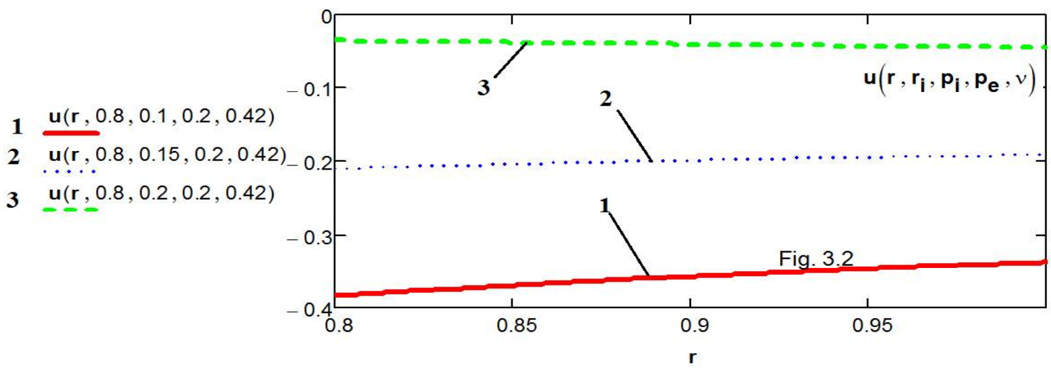


Fig. 5 Dimensionless radial displacements versus dimensionless radius.

It is exemplified in Fig. 5 the dependencies dimensionless radial $u_{ra} = u_r / r_e$ and displacement and axial displacement $w_a = w / h$ for different dimensionless pressure applied $\left(p_{ai} = p_i / E\right)$ to the rod inside the ring silencer for an external pressure $p_{ae} = 2 \cdot 10^{-4}$. The material of the ring is characterized by Poisson's ratio $\nu = 0.42$.

Radial tensions, angular and dimensionless equivalent of Coulomb damper ring are illustrated in Fig. 6, 7 as a function of radial position, for various internal pressures generated by the damper rod dimensions

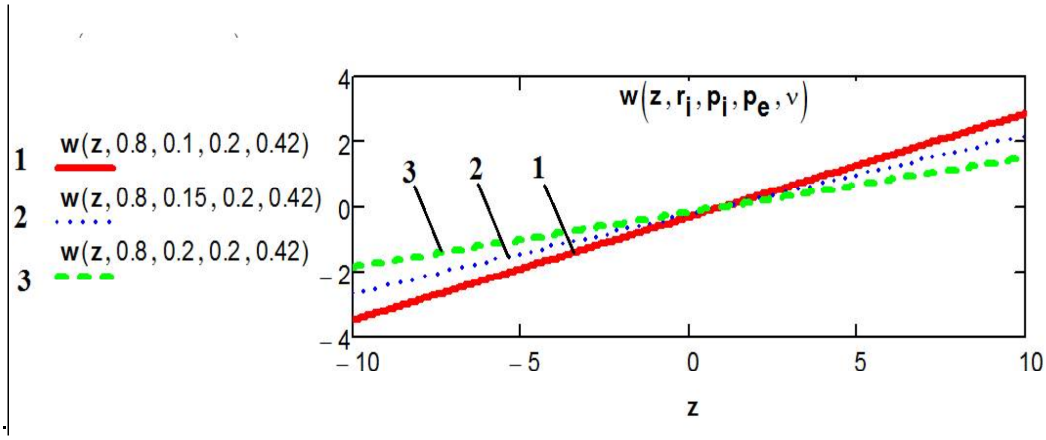


Fig. 6 Dimensionless axial displacement versus dimensionless axial position.

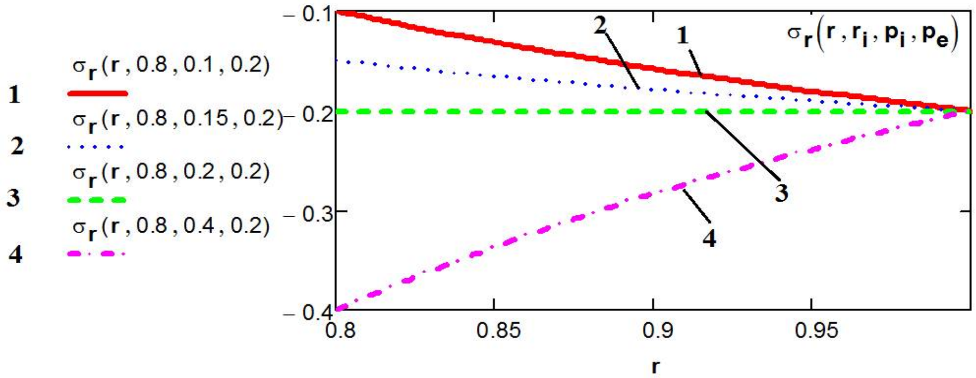


Fig.7 Dimensionless radial tension versus dimensionless radial position.

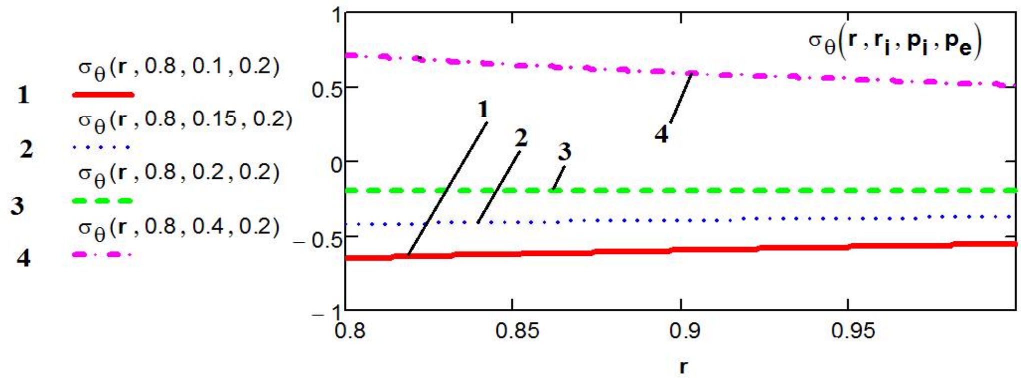


Fig. 8 Dimensionless angular tension versus dimensionless radial position.

It is noted that when the ring constraints pressures created by rod and outer tube are equal tensions radial, angular and radial position equivalent to not depend on the point considered. However, it is noted that the tension is equivalent to the minimum when the ring is required to equal pressure on the two cylindrical surfaces.

3. CONCLUSION

- From a functional perspective damper friction conventional dry, old or mixed can be considered as an application tube with thick with an inner surface (silencer directly) or external (silencer vice versa) subjected to pressure radial assembly and tangential variables.
- Radial pressures on the two surfaces of the ring (inner and outer) are determinable from Lame's equations, the geometry of the rod ring and housing and elastic characteristics of the material. In this sense, one can use a spreadsheet program achieved 14.0 Matchad utility.
- Based on knowledge radial pressures on the two surfaces of the ring, determine the state of stress and strain from anywhere in the ring, being able to optimize constructive solution

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