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SAFETY CLUTCH WITH BALLS AND SPHERICAL SEATS RADIALLY DISPOSED WITH THRUST SYSTEM BASED ON THRUST DISC

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Abstract: The safety clutches are a reliable solution for the protection of the transmission against the overloads that may interfere in the transmission because of malfunctions or wrong operations executed by the operator. The most used active seats for the safety clutches are trapezoidal, truncated cones or cylindrical shaped and rarely spherical due to the complex necessary technology. This article presents a constructive solution for a safety clutch with balls and spherical seats radial disposed solution that provides a superficial contact in the situation completely engaged and in the process of coupling, respectively a linear contact in the disengaging process.

1. INTRODUCTION

Nowadays in the development of technical and technological processes the trend in the industry is to design and incorporate as much automation as is possible in the manufacturing processes. The machines and the installations become more precise requesting a high quality degree of the processes. They become faster and stronger in order to face the dynamic load necessary for the increase of the productivity capacity of the machine [9] inside an automated process the damage of the machine so the stoppage of the production process and maintenance costs become very expensive. The conclusion of many companies is that a relatively cheap solution against the damage of the machine due to overloads is represented by the integration of reliable safety clutch in the transmission.

The safety clutches integrated in transmissions are able to transmit between the connected elements a controlled torque in order to provide the protection for the transmission and to avoid dangerous overloads determined by malfunctions or by the operator [5].

A safety clutch is more precise and more qualitative as the time elapsed from the overload appearance at the effectors mechanism to the moment of stoppage of the load transmission is shorter. Thus, to the most of the safety clutches meanwhile with the disengaging process are transmitting an electrical signal that shut down the source of the electric engine of the machine.

The safety clutches with balls frequently used in the technical field may have a diversity of shapes of the active seats disposed frontal or radial function of the available gauge. The most used shapes are trapezoidal, cylindrical and spherical. In comparison with the other shapes the spherical active seats have the advantage that in the functioning and engaging process the balls come in contact with this on a surface reducing the shock pressure [1, 2, 3].

The companies in the field [4...9] of safety clutch production are not executing spherical seats because of the technology excepting Walterscheid KG from Germany [6] that is producing this type of safety clutches with the balls with frontal disposure.

In the functioning of a safety clutch with balls there are the different stages: the completely engaged functioning; the disengaging process and the engaging process.

The completely engaged functioning corresponds to the situation when the torque is smaller then the maximum torque that can be transmitted by the clutch in this functioning stage [2, 3], so the safety clutch work like a permanent clutch.

The disengaging process appears when between the semi couplings appears a relative rotational motion because of the torque increase in the transmission, and the torque reaches a value higher then the maximum value of the torque transmitted in the clutch in the completely engaged state. At the end of the disengaging process the safety clutch transmits a torque realized by the friction of the balls with the surface of the ball race called remanent torque.

The engaging process appears when the balls reach the position of the active seats and may continue with the engaged state – if the overload disappear; or with the disengaging process – if the cause of the overload wasn't eliminated.

In this article the authors present a constructive solution for safety clutches with balls and spherical seats radial disposed, seats continued with channels with circular section that follow the entire contour of the semi-coupling and guide the balls in the disengaging process and also in the engaging moments.

2. THE SAFETY CLUTCH DESCRIPTION

the safety clutch with balls and spherical seats radial disposed with thrust system based on thrust disc presented in the fig. 1, in the functioning state engaged, is designed in order to realize the kinematical connection between a shaft, mounted in the boring of the semi-coupling 3 and tooth wheel for belt or chain mounted on the flange 4. The balls 2 are disposed on one hand in the spherical seat from the semi-coupling 3 and on the other hand in the cylindrical hole of the semi-coupling 1. The semi-coupling 1 is assembled with sink-bolts on flange 4. The thrust disk 6 is centered on the flange 4 and the semi-coupling 1 on the cylindrical section with lower diameter both centering being realized by sliding adjustments. The disk 6 is pressed on one side by the disk springs 5 mounted in raw and on the other side acts on the balls in order to maintain them in the spherical seat from the semi-coupling 3.

The thrust disk 6 have on the interior 2 inclined zones at different angles, first zone having the length and the angle smaller and second zone having the length and the angle larger (fig. 2). The disk 4 is designed with a channel where is introduced the inside test indicator that in the moment when the overload appears in the transmission stops the electric engine.

The thrust force developed by the disk springs on the thrust disk 4 is adjusted with the channeled nut 7 that ensures self un-screwing with the safety washer 8.

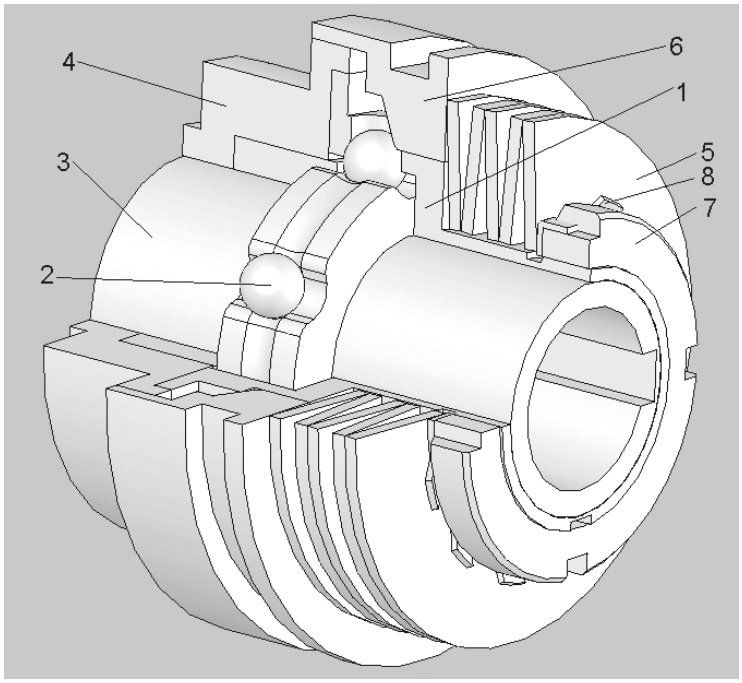

Fig. 1. Safety clutch in the engaged state

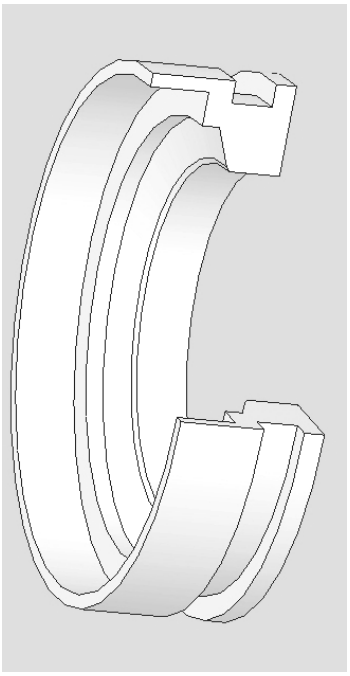

Fig. 2. Thrust disk

The active element from the semi-coupling 3 where are placed the active spherical seats is presented in the figure 3. In the transversal section the profile of the seat is trapezoidal filleted at internally and externally with the cylindrical zones *a* and *b* so that the linear zone *c* have a relatively short length. The active seat *d* is profiled in the previous seat and follows its profile but the generating surface is spherical, on the spherical zone *d,* and cylindrical on the on the filleted zone *e* respectively on the outside diameter of the semi-coupling 3; both profiles have spherical and cylindrical areas of equal radius with the ball radius that is mounted on the seat.

On the appearance of the overloads in the transmission, the ball 2 acts on the thrust disk 4 that moves axially compressing the disk springs 5. In the first phase the ball 2 is moving linear section of the profile of the active seats and corresponding to this section with the small inclination of the disk 4; in second phase the ball 2 is moving on the circular filleting section e and guided on the circular channel reaches at the end of the un-engaged process, on the cylindrical zone of the semi-coupling 3. This position is represented in the fig. 4.

In conclusion the embodiment of this construction for the safety clutch with balls radial disposed, the contact between the ball and the active seat is happening on a spherical surface and in the un-engaged process the contact is happening on a line; in this way the contact between the ball and the active seat is not punctual in any functioning situation.

The main advantages that come from this construction can be synthesized in this way:

- The increase of the precision in the engaging process, by maintaining of the contact surface to the initial state, so the maintaining of this value of the static friction μ_0;
- The increase of sensibility on the disengaging, by maintaining a linear contact and the right guiding between the balls and the circular channel during the entire process of the disengaging;

- The increase of the durability of the coupling by reducing the contact strain between the balls and the active seat in the situation of completely engaged clutch and in the process of the engaging, respectively by replacing of the punctual contact with linear one in the disengaging process;

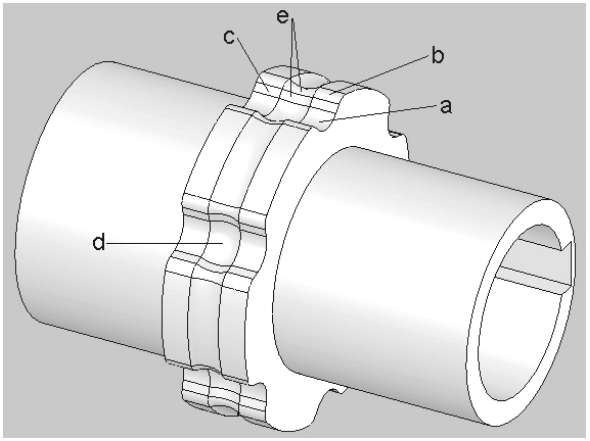

Fig. 3. The semi-coupling with active seats

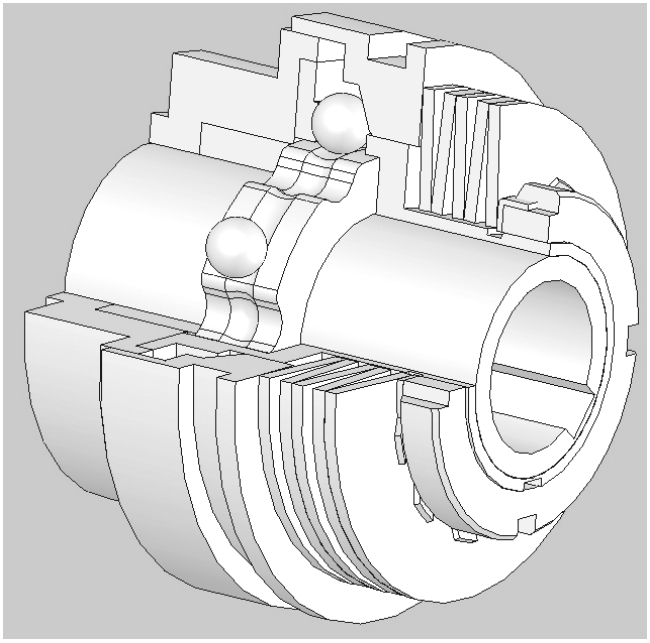

Fig. 4. The safety clutch at the end of the disengaging process

- Reducing the number of the disengaging and engaging repeated actions by stopping the electrical source of the motor that drives the thrust disk. This entire advantages lad to the obtaining of the constructive solutions of more reliable safety clutches with balls so there can be provided a better functioning of the mechanical transmission equipped with such clutches.

3. GEOMETRICAL ELEMENTS

In fig. 5 and fig 6 are presented a frontal section, respectively a longitudinal section on the safety balls radial disposed with thrust disk, where are described the main geometrical elements that characterize the coupling. These geometrical elements of the clutch are:

- Ball diameter d_b;
- Balls number z;
- Disposure diameter of the balls D_0;
- The angular step for the ball disposure γ;
- Filleting radius of the profile of the active seats to the external channel of the internal semi-coupling r ;
- The angle of the active seat where the balls are mounted α_0;
- The length of the linear zone of the active profile from the internal semi-coupling a;
- The central angle of the active profile on the internal semi-coupling γ_3;
- The linear step for the ball disposure p, corresponds with the diameter D_0;
- Distance between 2 neighboring seats or 2 neighboring cylindrical holes g;
- The thrust angles of the balls executed in the thrust disk α_1 and α_2;
- The sink depth of the ball in the active seat h;

- The depth of the guiding channel of the ball in the circular seat h_2;
- The inner diameter off the channel of the central surface of the internal semi-coupling D_3;
- Bore diameter for the shaft d.

The calculus relations of the main geometrical elements of the active seats of the safety clutch and of the diameters of the semi-coupling 1 and 3 are presented in the table 1. There are presented also the calculus schemes from fig. 7.

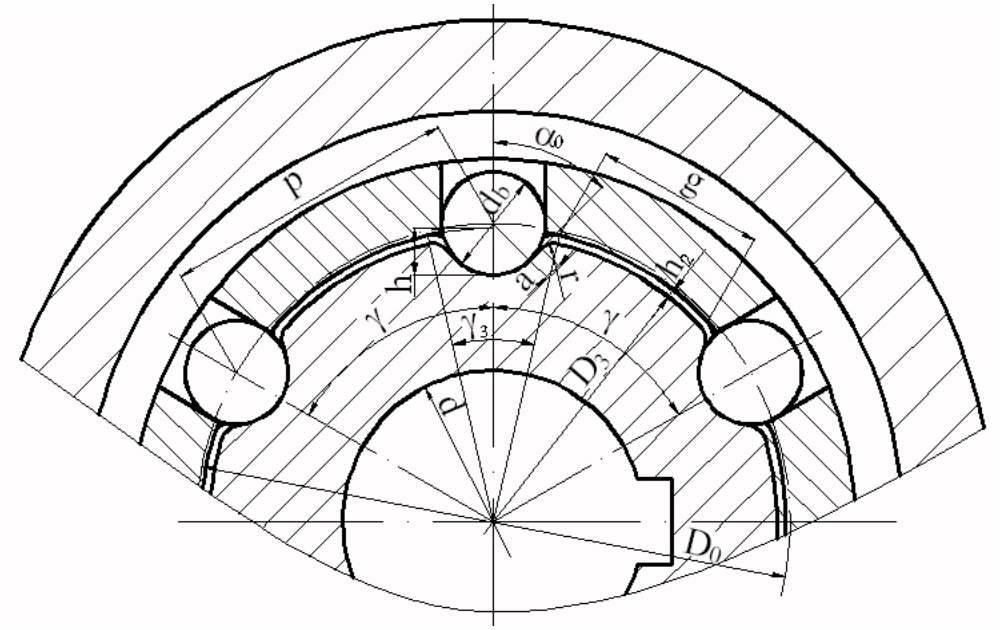

Fig. 5.Transversal section

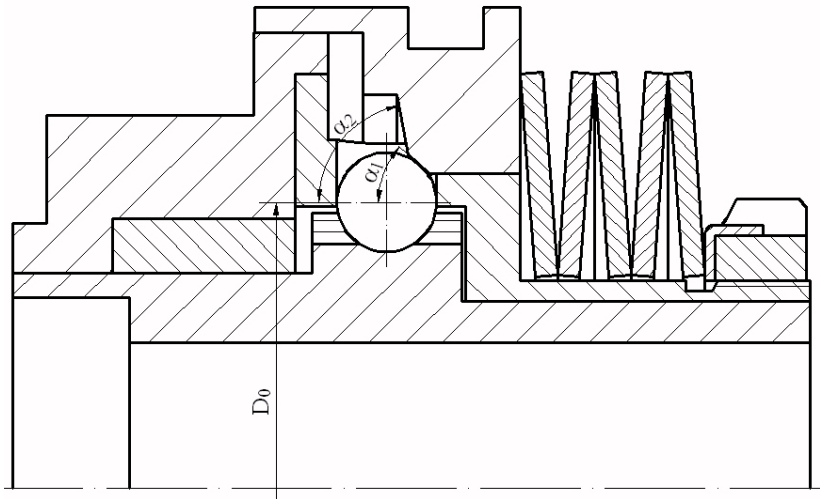

Fig. 6. longitudinal section

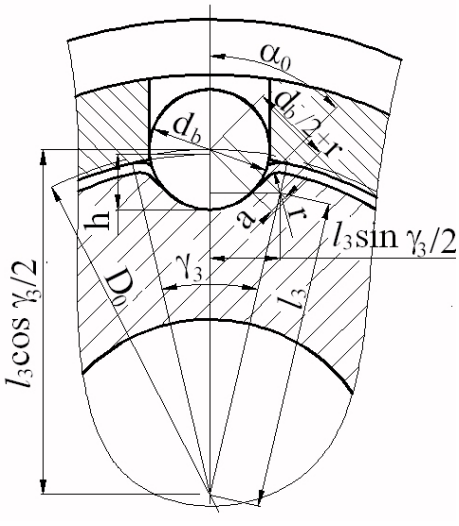

Fig. 7. detail of the profile of the seat.

Table 1

Table 1. The calculus relation for the geometrical elements of safety clutch

geometrical elements	calculus relation
Diametric d_b	$d_b = 6...14$ mm
Diametric D_0	$D_0 = (3...5)d$

Table 1 (continuation)

Angular step γ	$\gamma = 2\pi / z$
Thickness g	g = 8….12 mm
Fillet radius r	r = 2...5 mm
angle α_0	α_0= 30º...70º
lengt a	a=2...5 mm
angle γ_3	$\gamma_3 = 2\,\text{arctg}\dfrac{(d_b + 2r)\cos\alpha_0 + 2a\sin\alpha_0}{D_0 - (d_b + 2r)\sin\alpha_0 + 2a\cos\alpha_0}$
angle α_1	α_1=30º... 45º
angle α_2	α_2=50º... 70º
Linear step p	$p = D_0 \sin\dfrac{\gamma}{2}$
Depth h_2	h_2 =1.5 ... 3 mm
depth h	$h \le d_b/2$
Linear zone a	a = 3 … 5 mm
diameter D_{3int}	$D_3 = D_0$-(2...4) mm
diameter d	Determined by stress conditions

Calculus relation shown in the table 1 will be used in the design of the safety clutches with balls and spherical seats radial disposed with thrust disk and also in the analysis of the functioning state, of the engaging process and disengaging, analysis that are subject of further developments.

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