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HOMOGENEOUS PLANETARY FOUR POINT CONTACT BALL BEARINGS

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Abstract: *Having as a principal objective the increasing value of the limited speed of the existing four point contact ball bearings, but without a significant change to their known technology, the authors of this paper have began and developed researches concerning the new concept: planetary ball bearings. We illustrate this concept by homogenous planetary four point contact ball bearings. It offers and describes the theoretic obtaining solutions of homogenous planetary four point contact ball bearings by adequate assembling of known and currently used four point contact ball bearings, as well as specific constructive solutions of homogenous planetary four point contact ball bearings. The paper is further supported by a couple of 3D models of homogenous planetary four point contact ball bearings, and also by some of their possible performances.*

Key words: *planetary bearings, homogeneous planetary four point contact ball bearings.*

1. INTRODUCTION

There is a diversity of bearing types, many of them included in certain standards. The most well known and frequently used are the ball bearings. The present paper shows the possibility of obtaining homogeneous planetary bearings by combining themselves four point contact ball bearings, type (symbol) Q and QJ according to Romanian standard STAS 1679-82.

The main objective that leaded to creating these planetary bearings whatever the constructive type was the increase of the limited speed that can be sustained by the bearings. The constructive solutions can be created without any modifications to the present technology of building bearings or with minimal modifications [1].

Before making an experimental research on any type of planetary bearings, some of the performances can be evaluated by comparison to the similar ones on existing bearings that compose the investigated planetary bearing. By using specific mathematical methods, it can be estimated the increasing value of the maximum revolution limit.

2. HOMOGENEOUS PLANETARY FOUR POINT CONTACT BALL BEARINGS, TYPE Q/QJ, OBTAINED BY ASSEMBLING

A homogeneous planetary four point contact ball bearing can be obtained by assembling a type Q bearing over a type QJ one (Fig. 1). The specific constructive solution for four point contact ball bearings with one ring consisting of two identical semi-rings (the external from type Q bearings and the internal one from QJ type bearings) does not allow the achieving of planetary bearings of the combinations Q/Q, QJ/QJ or QJ/Q.

In any case, the achieving of a planetary homogenous four point contact ball bearing by the assembly of two four point contact ball bearings, a type Q one at the exterior and a type QJ one at the interior, is presented in order to provide a reference example necessary for the actual constructive solution of a planetary homogenous four point contact ball bearing, as well as in order to estimate the performance of such a bearing compared to the performance of existing type Q and QJ ones.

Obviously, the inner diameter of the external bearing must be equal to the external diameter of inner bearing. For any combination, there are also some differences between the breadths of the two component bearings and (significant) differences between their static and dynamic radial basic load ratings. These features are determined in Table 1 and Table 2.

Combinations of type Q3xx/2QJxxx are preferable.

Similar bearings by different manufacturers differ by their performance. Tables 1 and 2 highlight the differences of static and dynamic capacity of the respective bearings. While the static capacity of URB manufactured bearings is large, their dynamic capacity is smaller than that of those manufactured by STEYR.

The values in Tables 1 and 2 also bring out the possibility of obtaining, by assembling, planetary four point contact ball bearings by setting up in the inner row two identical bearings (Fig. 2). From this point of view,

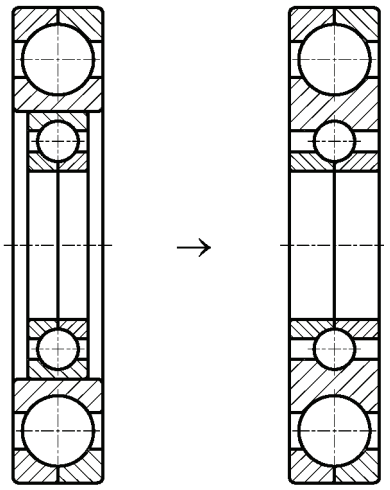

Fig. 1. Planetary four point contact ball bearing, type Q/QJ, obtained by assembling and the correspondent homogenous planetary four point contact ball bearing.

Table 1

Characteristics of some four point contact ball bearings produced by URB [3], that can constitute, by assembling, homogenous planetary four point contact ball bearings, type Q/QJ

Inner bearing, (i)				External bearing, (e)				$(C)_e/(C)_i$	$(C_0)_e/(C_0)_i$
Symbol	B [mm]	Basic load rating [kN]		Symbol	B [mm]	Basic load rating [kN]			
		C	C_0			C	C_0		
QJ208	18	53	43	Q216	26	140	139	2.64	3.23
				Q316N2	39	230	229	4.34	5.33
QJ308	23	72	58.2	Q218N2	30	174	180	2.42	3.09
				Q318N2	43	267	283	3.71	4.86
QJ209	19	58.5	50.5	Q217	28	148	159	2.53	3.15
				Q317N2	41	234	240	4.00	4.75
QJ309	25	93.6	80	Q220N2	34	225	228	2.40	2.85
				Q320N2	47	306	341	3.27	4.26
QJ210	20	61.8	54.2	Q218N2	30	174	180	2.82	3.32
				Q318N2	43	267	283	4.32	5.22
QJ211	21	76.5	74	Q220N2	34	225	228	2.94	3.08
				Q320N2	47	306	341	4.00	4.61

Table 2

Characteristics of some four point contact ball bearings produced by STEYR [2], that can constitute, by assembling, homogenous planetary four point contact ball bearings, type Q/QJ

Inner bearing, (i)				External bearing, (e)				$(C)_e/(C)_i$	$(C_0)_e/(C_0)_i$
Symbol	B [mm]	Basic load rating [kN]		Symbol	B [mm]	Basic load rating [kN]			
		C	C_0			C	C_0		
QJ208	18	45	51	Q216	26	121	161	2.69	3.16
				Q316	39	196	245	4.36	4.80
QJ308	23	69	72	Q218	30	154	210	2.23	2.92
				Q318	43	228	303	3.30	4.21
QJ209	19	52	61	Q217	28	135	182	2.60	2.98
				Q317	41	212	273	4.08	4.48
QJ309	25	84	89	Q220	34	195	272	2.32	3.06
				Q320	47	260	363	3.10	4.08
QJ210	20	60	72	Q218	30	154	210	2.57	2.92
				Q318	43	228	303	3.80	4.21
QJ211	21	68	85	Q220	34	195	272	2.87	3.20
				Q320	47	260	363	3.82	4.27

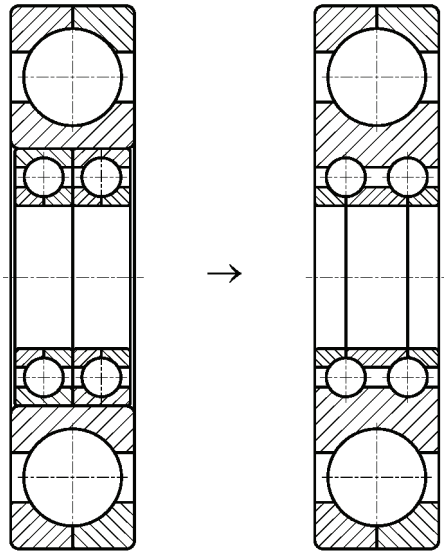

Fig. 2. Planetary four point contact ball bearing, type Q/2QJ, obtained by assembling and the correspondent homogenous planetary four point contact ball bearing.

advantageous are the combinations where the values of the fractions $(C)_e/(C)_i$ and $(C_0)_e/(C_0)_i$ are approximately 2. It's even better if also $B_e/B_i \approx 2$.

Planetary four point contact ball bearings, homogenous, type Q/QJ and Q/2QJ, obtained by assembling, can't tolerate axial loads, given the potential axial displacing between the two bearings of the assembly.

3. PLANETARY FOUR POINT CONTACT BALL BEARINGS, HOMOGENEOUS, TYPE Q/QJ

A planetary four point contact ball bearing, homogenous, type Q/QJ, is different from a similar type four point contact planetary ball bearing obtained by assembling two four point contact ball bearings by the fact that external race of the inner bearing and the inner race of the external bearing represent a common body, the intermediary race of the planetary bearing (Fig. 3).

It is to be studied whether the widths of the (internal, intermediary and external) rings of a planetary bearing should have the same value.

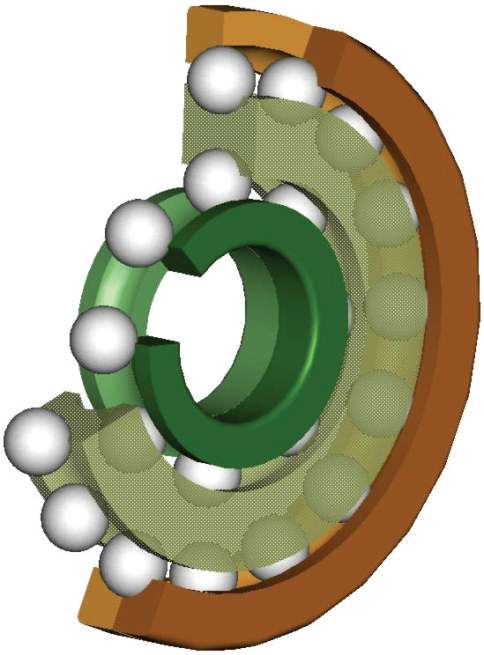

Fig. 3. Planetary four point contact ball bearing, homogenous, type Q/QJ, with equal radius balls on both rows.

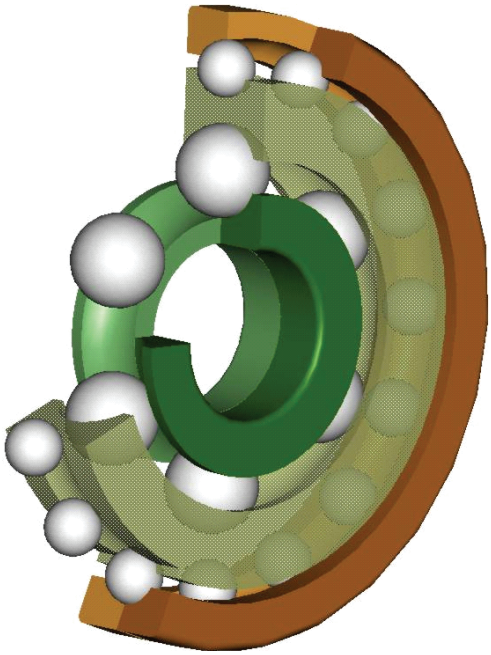

Fig. 4. Planetary four point contact ball bearing, homogenous, type Q/QJ, with the balls' radius on the inner layer bigger than the one on the external layer.

In homogenous planetary four point contact ball bearings the inner and external rings consist each of two (or even three) semi-rings.

For the homogenous planetary four point contact ball bearings it's important that the basic load rating – both, dynamic and static – ensured by the two rows of the bearing have close values. The basic load rating of the planetary bearing is determined by the minimal correspondent values ensured by its two layers, so that any unbalance is economically inefficient. The capacity surplus can't be effectively used.

The equalization of C and C_0 values can be accomplished by adequate determination of the number and radius of the balls on the two levels of the planetary bearing.

In this case, it must be said that, for the one-row four point contact ball bearings, the increment of the overall size determines an increment on the balls radius, the races width and basic load rating.

For the homogenous planetary four point contact ball bearings, types Q/QJ, if on both layers are used balls with the same radius value as shown in Fig. 3, the amount of balls in the external layer will be larger than on the inner layer. This concludes to the fact that the basic load rating corresponding to the external layer is (considerably) higher than those corresponding to the inner layer. In order to equalize these values, the balls on the inner layer must have a bigger radius, even if their number decreases. Such a bearing is presented in Fig. 4.

After increasing the balls' radius on the inner layer a decrement of the balls' radius on the external layer can also be decided upon, with (preferably) or without modifying the number of balls.

The opposite case – planetary four point contact ball bearing, homogenous, type Q/QJ, with decreased radius of the balls on the inner layer and increased radius on the external layer, bearing presented in Fig. 5 – is also possible, but not recommended. For this kind of structure, the unbalances previously mentioned are significantly amplified.

4. FOUR POINT CONTACT PLANETARY BALL BEARINGS, TYPE Q/2QJ AND 2Q/QJ

In accordance with the assertions above illustrated in Fig. 2, another way of balancing the static and dynamic load capacities of planetary bearings is the implementation of two rows of rollers into the interior layer, between the internal and the intermediary rings.

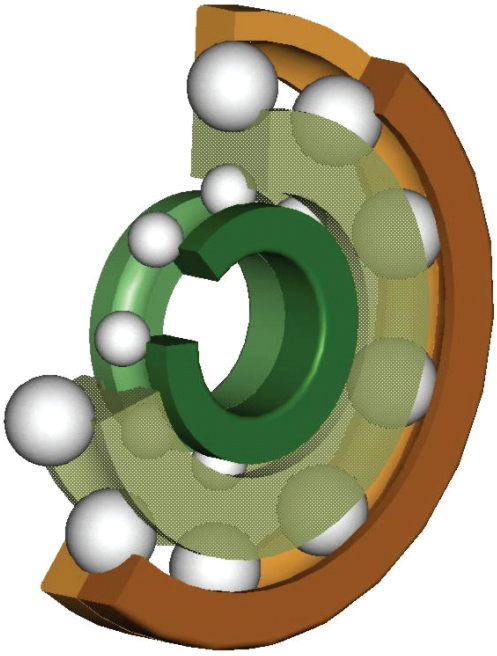

Fig. 5. Planetary four point contact ball bearing, homogenous, type Q/QJ, with the balls' radius on the inner layer smaller than the one on the external layer.

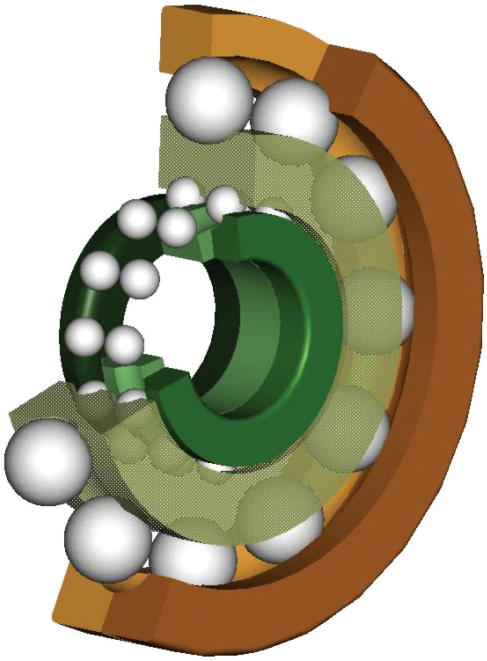

Fig. 6. Planetary four point contact ball bearing, homogenous, type Q/2QJ, with the balls' radius on the inner layer smaller than the one on the external layer.

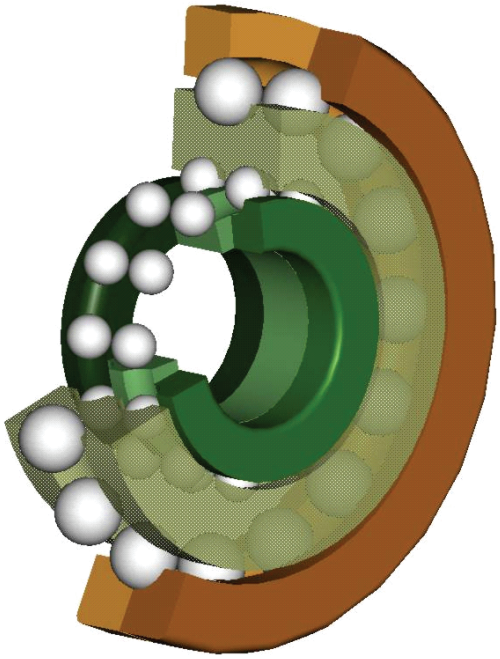

Fig. 7. Planetary four point contact ball bearing, homogenous, type Q/2QJ, with internal layer ball radius slightly smaller than the external layer one.

Type Q/2QJ bearings are obtained by applying this concept to planetary four point contact ball bearings. However, in Q/2QJ type planetary four point contact ball bearings large differences persist between the static and dynamic load capacities of the two layers, if the balls used will be of the same size as those of the corresponding Q and QJ type bearings as shown in Fig. 6 and emphasized by the data in Tables 1 and 2.

The static and dynamic load capacities of the two layers of balls can be balanced to minimum differences by an adequate modification of the diameters of the used balls. Fig. 7 presents the image of a possible planetary bearing of this design.

The construction of planetary four point contact ball bearing of type 2Q/QJ is not justified, even if the ball diameter of the external layer is (significantly) smaller than the diameter of the internal layer balls.

5. CONCLUSIONS

The planetary bearings are specially designed for high rotative speed machines. The planetary bearings can be differentiated constructions, but can also be obtained by adequate assembling of already existing bearings. In the first case, the establishing of the value of the maximum limited speed is determined on certain mathematical models. In the second case, the maximum rotative speed limit is the sum of the maximum limited speeds of the bearings on both layers that compose the planetary bearing.

The diversity of bearing types creates the possibility to design, by different combinations [4], a high number of different planetary bearings types that can be either homogenous or mixed [5]. Their conception must also take into consideration the equalization of static and dynamic basic load rating of the two component bearings. This objective can be achieved by adequate establishing the radius value and the number of balls used in the two layers.

Planetary bearings represent an original concept for which the authors have applied for official recognition [6].

REFERENCES

[1] Cioară, R., Mărăscu-Klein, Vl., Pisarciuc, C. (2005). *Unconventional Construction of Radial Planetary Ball Bearings, Type 6/6*, Nonconventional Technologies Review, no. 1, pp. 77–80, ISSN 1454-3087.

[2] *** (1980). *STEYR Walzlager. Technisches Handbuch 280 D.*

[3] *** (1993). *URB. Catalog General de Rulmenți.*

[4] Belous, V. (1992). *Inventica*, Edit. Gh. Asachi, Iași.

[5] Cioară, R., Mărăscu-Klein, Vl., Pisarciuc, C. (2005). *Mixed planetary ball bearings, type 6/4 and 4/6*, Proceedings of TMCR 2005 International Scientific Conference, Editors Sergiu Mazuru & Gavril Muscă, pp. 192–195, ISBN 9975-9875-6-7, Chișinău, 19–21 May 2005, Editura U.T.M., Chișinău.

[6] Cioară, R., Mărăscu-Klein, Vl., Pisarciuc, C. Limbășan, G., Cioară, Rx. (2006), *Rulment planetar radial-axial, cu bile*, Romanian patent claim no. A/00173, 16.03.2006.

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