4. TAPERED ROLLER BEARINGS

ROLLING BEARINGS

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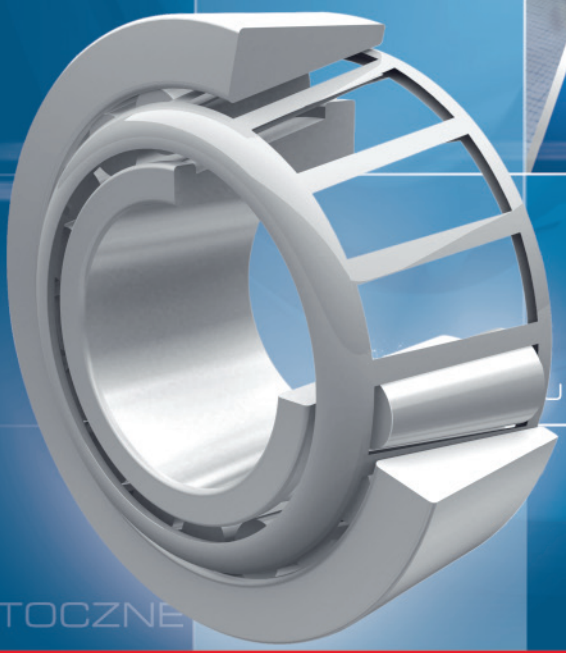

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INTRODUCTION:

4. Single-row tapered roller bearings

4.1. Structure

Tapered roller bearings consist of two inseparable elements: the outer ring, which contains one of the oblique bearing tracks (the outer track) and the inner ring, on the track of which the cage with rolling elements is mounted. Rolling elements in this type of bearing are shaped as cones with truncated vertices. Judging by their appearance they resemble rollers or rolls, for that reason they are commonly called roll bearings or roller bearings. Under normal operation conditions the inner ring, the outer ring and rollers carry the load, whereas the cage separates and holds the rollers.

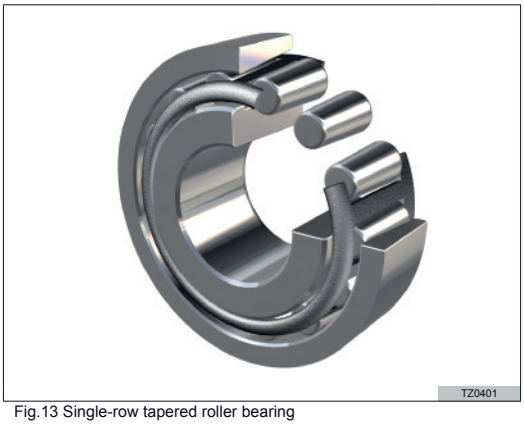

Fig.13 Single-row tapered roller bearing

The inner ring with rollers is often called the inner sub-assembly. Separable design of tapered roller bearings has different advantages during assembly and handling of the bearing. Rolling elements in the tapered roller bearing operate on tracks oblique to the bearing axes. The projection lines of all the tapered surfaces meet at a common point on the bearing axis, what ensures proper rotation of rollers on the tracks.

4.2. Features

Because of tapered tracks the tapered bearing is able to carry all combinations of radial and axial loads. The larger the angle of the outer track the bigger the ratio of the axial load carrying capacity to the radial load carrying capacity of the bearing. The long contact line of the roller with the track allows the tapered roller bearing to carry heavy loads. The tapered roller bearings combine the features of angular-contact radial ball bearings with those of the cylindrical or thrust roller bearings. They can be neither counted among the radial bearings nor among the thrust bearings, because they can operate both as radial and as thrust bearings. The characteristic feature of tapered bearings is their ability to carry axial loads in one direction. For that reason this type of bearings is often assembled in pairs or larger units, as in case of the single-row angular-contact ball bearings. The unit names are similar to the names of units that consist of angular-contact bearings (open, closed, tandem system).
Looking at the structure of the tapered bearing, one can quickly realize that the track angle plays the decisive role in the fact if the bearing is going to carry higher rotational speed or the heavier axial load. The track angles are characteristic for a given dimension series, both according to ISO standards and the AFBMA norms.

4.3. Designation systems of tapered roller bearings

Designations of single-row tapered roller bearings are standardized all over the world, but different designations systems are used for defining tapered bearings with metric and inch dimensions. Generally the bearings with inch dimensions have separate designations for the inner sub-assembly and the outer ring, whereas in case of metric series the ISO provides for only one designation describing the bearing unit (both rings).

4.3.1. Tapered roller bearings with metric dimensions (DESIGNATION SYSTEM ACCORDING TO ISO STANDARDS)

4.3.1.a. Dimension series

- **329.. 320.. 330.. 331.. 302.. 322.. 332.. 303.. 313.. 323..**

Five-digit designation, always beginning with the digit 3. The next digit means the bearing width series beginning with the smallest one (0,1,2,3). The third digit means the outer diameter series from the smallest up (9,0,2,3). The last two digits are kept in reserve for marking the inner diameter of a bearing – multiplied by 5 determine the inner diameter in mm, e.g. the 32005 bearing has the inner diameter of 25 mm (05 x 5).

The ISO 355 standard for metric tapered bearings sets the designation system, in which every bearing is defined by the combination of three symbols. The first symbol determines the series of angles of contact. The second symbol is the letter-symbol of the outer diameter series and contains

Contact angle range		
angle series	Angle range	
	from	to
1	reserve	
2	10°	13°52'
3	13°52'	15°59'
4	15°59'	18°55'
5	18°55'	23°
6	23°	27°
7	27°	30°

Letter designation of the tapered roller bearing

Bore diameter of a bearing in mm

Ratio of the outer diameter to the bore diameter		
diameter series	$\frac{D}{d^{0,77}}$	
	from	to
A	reserve	
B	3,40	3,80
C	3,80	4,40
D	4,40	4,70
E	4,70	5,00
F	5,00	5,60
G	5,60	7,00

Ratio of the bearing width to the thickness of its cross-section		
width series	$\frac{T}{(D-d)^{0,95}}$	
	from	to
A	reserve	
B	0,50	0,68
C	0,68	0,80
D	0,80	0,88
E	0,88	1,00

the range of numerical values of the outer diameter in the function of the bore diameter. The third symbol is the letter designation of the width series, which contains the range of numerical values of the width in the function of the bearing size. When all regular metric bearings get new designation according to the ISO 355 standard, the old designations will be still valid.

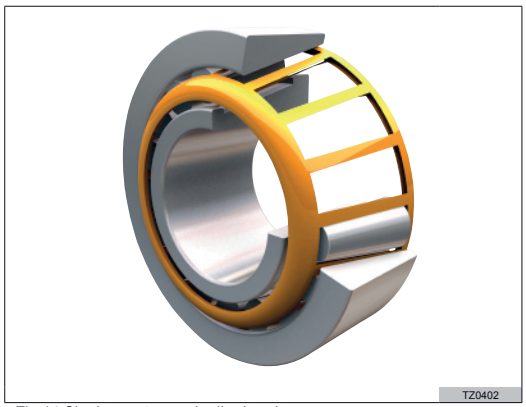

Fig.14 Single-row tapered roller bearing

4.3.2. Inch-dimensioned tapered roller bearings

4.3.2.a. Designation system of original inch bearings

According to this system the bearings are grouped on the ground of their shape and the size of the rolling element – the roller. Through differentiation of, e.g., the number of rollers or the track angle, one can match the bearing to the different load. Each group is represented by a given series number, which most often consists of three up to six digits. Let's take a look at the 795-series: our exemplary bearing is called 797/792. "797" means the inner sub-assembly and "792" the outer ring. The designation of the inner sub-assembly is most often higher than the series number, and the designation of the outer ring is lower. But there are some exceptions, e.g. the 15000-series bearing: 15123/15245.

4.3.2.b. Designation system according to AFBMA (Anti-Friction Bearing Manufacturers Association Inc)

Nowadays this designation system has become the international standard for marking inch-dimensioned bearings, but it relates to new series only. Former designations of bearings' elements in conformity with the original system, new designations added to the existing series and patented markings of elements of special bearings are still valid.

The AFBMA designation differs mainly in the fact that it treats separately the inner sub-assembly and the outer ring. The symbols of both parts differ from each other and both parts can be combined in various systems. This fact gives us new opportunities for engineering solutions and increases decisively the number of available types of bearings.
This system separates the inner ring designations from the ones regarding the outer ring, whereas the symbol of the inner sub-assembly is always provided first, followed by the "/"-sign and the symbol of the outer ring.

The symbol itself can be divided into five parts:
- load
- contact angle
- basic series designation (based on inner diameters)
- descriptor of the element (the unit or the ring)
- supplementary designation of the construction variant

Load

Introductory designation, which can consist of one or two letters – determines the type of load the bearing supports.
- **EL** extremely light
- **LL** less than light
- **L** light
- **LM** medium light
- **M** medium
- **HM** medium heavy
- **H** heavy
- **HH** very heavy
- **EH** extremely heavy
- **T** only axial

Contact angle

The first digit behind the introductory designation describes the code of the half of the tapered angle of the outer ring
- **1, 2, 3, 4, 5, 6, 7, 8, 9, 0** whereas the "1" means the smallest angle, other follow in the increasing order.

Basic series designation (based on inner diameters)

The three subsequent digits are kept in reserve for marking the basic bearing's series, which is in turn directly connected with the inner diameter of the bearing.
- from **00** to **999** it is a digital code for the bore in inches from the smallest up to the largest.

Descriptor of the element (the unit or the ring)

The two last digits of the ring's symbol
- from **10** to **19** for outer rings from the smallest to the largest
- from **30** to **49** for outer rings from the smallest to the largest.

If the number of rings in a given series exceeds the range, one applies additional numbers from 20 to 29.

Supplementary designation

Supplementary designation of the construction variant
It consists of one, two or three letters and means modifications of the outside shape or the inner geometry.
The most commonly encountered are:
- **A** differences of diameters, mounting truncation and width
- **AX** as above
- **B** outer ring with the flange
- **B** inner ring – sizes are kept but construction changed
- **F** polyamide cage
- **V** ring made of special steel.

4.3.2.c AFBMA Designation system – for inch-dimensioned bearings transferred into metric dimensions

The system is identical to the standard AFBMA system, but it regards bearings, which in spite of inch designations have metric size. To differentiate them a "J" letter is put before the typical ring designation. e.g. JL69349/JL69310, JLM506849/JLM506810, JHM720249/JHM720210, JL68145/JL68111
Characteristic feature of the AFBMA system is the frequent usage of designations' abbreviations, consisting in omitting the repeated elements of the designation, e.g. LM11749/LM11710 = LM11749/10

4.4. Application

Because of their universal features the tapered roller bearings are widely applied and it is difficult to indicate the field, in which they are not used. We can encounter them just everywhere beginning with the light industry, textile industry and food industry through to automobile industry and agriculture not to mention the heavy industry, iron and steel industry, mining, aircraft industry and shipyards. The units of tapered precision bearings successfully substitute angular-contact and cylindrical bearings in the machine tools' spindles. Thrust tapered bearings (not mentioned here) in many cases demonstrate their superiority when compared to thrust ball bearings and even in comparison with thrust spherical roller bearings. The most durable solutions for car wheel hubs are based on double-row tapered bearings, combined integrally and sharing the same outer ring. Such a construction allows an extremely easy and proper assembly. In this field the tapered bearings compete with double-row angular-compact ball bearings, but are decisively more reliable and durable than their competitors.
Besides it is worth noting, that the most part of hubs of the cars currently running on our roads base on the units of two single-row tapered roller bearings.

4.5. Notes

- Tapered roller bearings produced currently (it regards metric bearings) feature modernized construction in relation to their original versions and are characterized by higher load carrying capacity and better rotational parameters. It results from the increased size and number of rollers, whilst the main dimensions are kept. These bearings have been temporarily marked with the **A**-letter or the **E**-letter behind the main symbol, but in the meantime this way of designation is being abandoned, because the latest production of these bearings is no more based on original standards.

- It is often the case that the **X**-marking can be found behind the symbol – it means the main dimensions of such bearing have been changed and it often cannot be substituted with the version without this marking.
  The X-marking most often tells us about:
  - the change in the inner ring height
  - the change in the outer ring height
  - larger mounting truncation of the ring or rings
  - the change in the cage construction
  - the change in the rollers' angle displacement.
- Many companies place the **K**-letter before the ring/bearing symbol to draw attention to inch dimensions of bearings. This letter does not introduce any changes, it's only about the difference in the symbol system.

- In case of inch-dimensioned tapered bearings the symbol of one the rings does not give all information about the second one. That is why it is useful to know the symbol system for both rings or their dimensions.