Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 4, Issue 11, November-2017

ANALYSIS OF TAPER ROLLER BEARING FOR LIFE IMPROVEMENT

Sorthiya Nirav[1] Prof. Kapil Lakhani[2]

[1] P.G. Student - M.E. Machine Design (09) [Gujarat Technological University - GTU]

[2]Assistant Professor (M.E.)

[Veerayatan Institute of Engineering,Mandvi–Kutch, INDIA]

ABSTRACT

Bearings are greatly engineered, accurately prepared devices that enable different parts to move at very high speeds and carry loads easily and effectively. Bearings must be able to provide stability, consistency, ability and high efficiency to rotate at high speed with very less vibration. They can support radial, axial or combined load properly In current work life improvement is the most important factor. Load carrying capacity of taper roller bearing depends on taper angle of roller. It also depends on various other factors including operating parameters, lubrication during operation in actual situation and applications etc. Individual bearing has its own specialty and restrictions as per load carrying capacity of bearing. In current work life is increased by reducing the stress by the analyzing the bearing of different taper angles with the combination of varying hollowness of roller.

INTRODUCTION

The word "bearing" is made from the verb "to bear". Bearing is a machine element that allows one part to bear i.e. to support another part. A bearing is a machine part that allows relative motion to only the required motion, and reduces friction between different moving parts. The simplest bearings are bearing surfaces, cut or formed into a part, with different degrees of control over the form, size, unevenness and location of the surface. Other bearings are separate elements attached into a machine or machine part. The most complicated bearings for the most challenging applications are very accurate devices, their construction requires some of the chief principles of up to date technology.

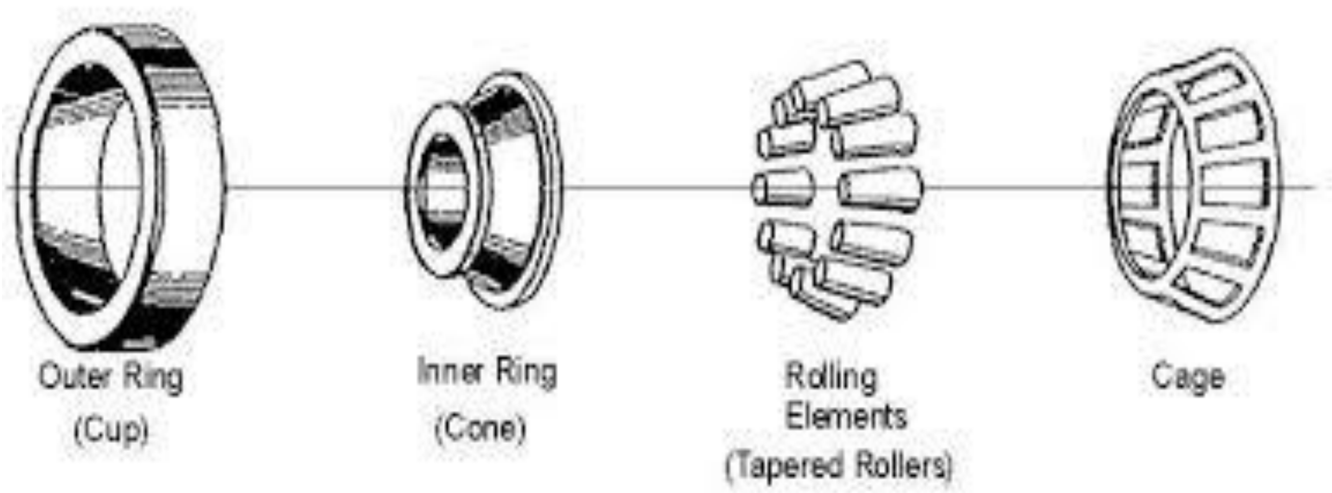
The discovery of the rolling bearing, in the structure of wooden rollers supporting, or bearing, an object being moved is of great significance, and may assume the discovery of the wheel. It is mostly believed that the Egyptians used roller bearings in the form of tree trunks. The first realistic caged-roller bearing was discovered in the mid-1740s by horologist John Harrison. Leonardo da Vinci integrated drawings of ball bearings in his plan for a helicopter around the year 1500. This is the first ever use of bearings in an aerospace design.

The first modern recorded copyright on ball bearings was in the name of Philip Vaughan, a British inventor and ironmaster who made the first design for a ball bearing in Carmarthen in 1794.

Definitely, the most general bearing is the plain bearing which uses surfaces in rubbing contact, having a lubricant such as oil or graphite. It is a bearing surface having hole with a shaft passing through it, or of a planar surface that supports other or it may be layers of bearing metal either merged to the substrate or in the form of a divisible sleeve. With proper lubrication, plain bearings often give correctness, life, and friction at low cost. So they are very extensively used.

CONCEPT OF TAPER ROLLER BEARING

DIFFERENT PARTS OF TAPER ROLLER BEARING



- **Cup or outer ring**

Made of chrome steel **SAE 52100** or **EN 31** steel

- **Cone or inner ring**

Made of same material **SAE 52100** or **EN 31**

- **Tapered rollers :**

Made of same material **SAE 52100** or **EN 31**

- **Cage**

Made of mostly polymers or non ferrous metals.

SAE 52100 CHEMICAL COMPOSITION

Elements	**Wt%(mass fraction)**
Carbon	0.98 - 1.1
Chromium	1.3 - 1.6
Iron	Balance
Manganese	0.25 - 0.45
Phosphorus	0.025 max
Silicon	0.15 – 0.35
Sulphur	0.025 max

SAE5 2100 PROPERTIES

Young's modulus: 200000 Mpa

Tensile strength: 650 – 880 Mpa

Elongation: 8 – 25 %

Fatigue: 275 Mpa

Yield strength: 350 – 550 Mpa

Thermal expansion: 10e-6 K

Thermal conductivity: 25 W/mK

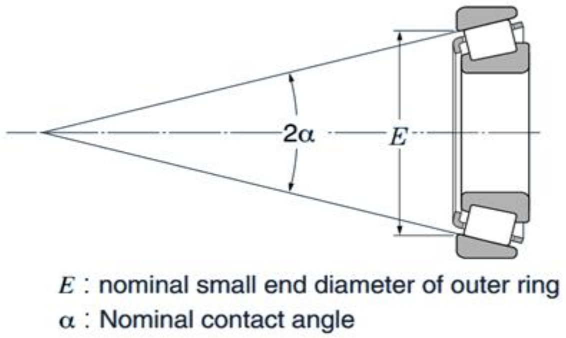
Specific heat: J/Kg.K

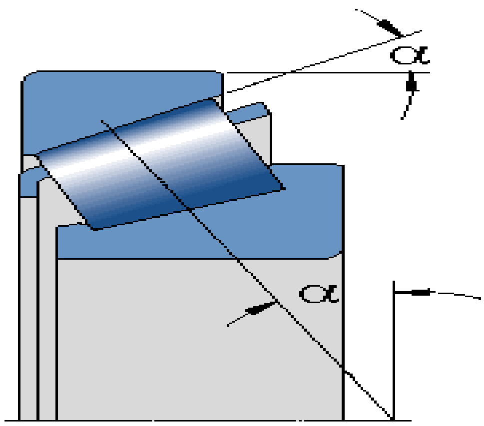
Melting temperature: 1450 – 1510˚C

Density: 7700 Kg/m3

Resistivity: 0.55 ohm.mm2/m

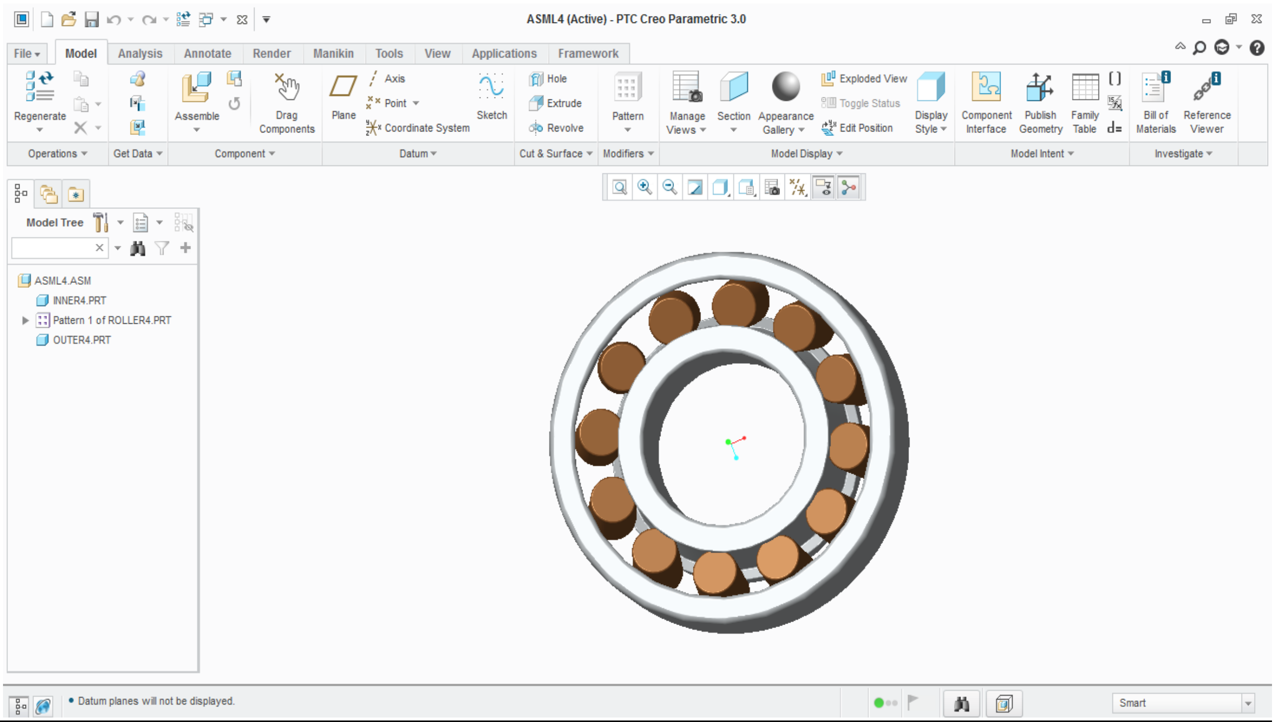
TAPER ANGLE

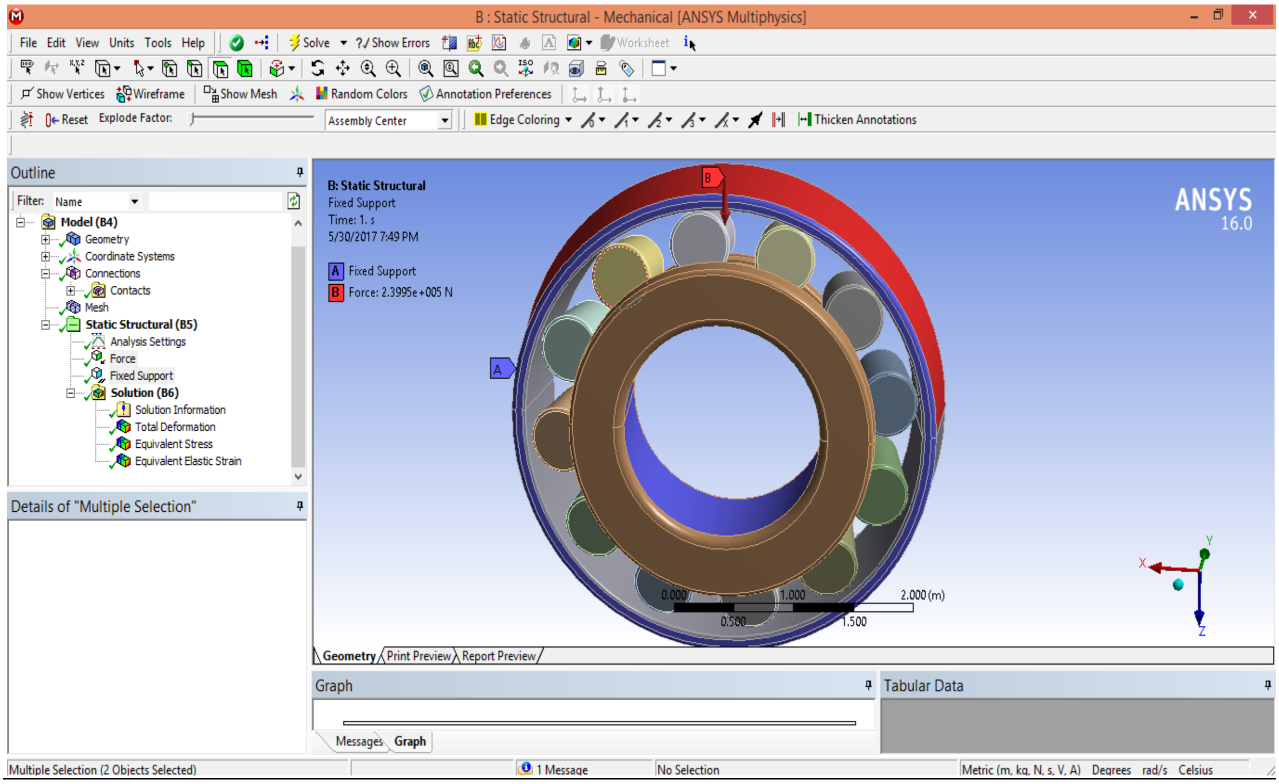




The axial load carrying capacity of **tapered roller bearings** increases with increasing contact **angle α.**

MODEL OF TAPER ROLLER BEARING





LITERATURE REVIEW

G. D. Bassan D. P. Vakharia [1] increased the fatigue life by reducing contact stress by selecting the proper hollowness in the taper roller bearing. Finite Element Analysis has been used to check about the contact stress, contact pressure and total deformation. Analysis have been made for different hollowness percentage from 0% to 90% of the outer diameter of roller. It is concluded that the approximately 65 % hollowness of the roller gives the lowest contact stress which finally gives the maximum fatigue life of the bearing.

Prachi Prajapati, Digvijay Jadeja[2] worked for optimization of the geometry of the bearing. By optimizing the measurement of the pocket corner radius of bearing, the total mass of the bearing assembly reduces. By reducing the weight of the bearing element finally total efficiency as well as total cost of the bearing also decreases. The optimization has been carried out by keeping the outcomes of the existing bearing same .By increasing the pocket corner radius, the stress value decreases and the bearing life increases.

Yusuf Kayah,Ismail Ucun,Kubilay Aslantas [3] carried out the failure analysis of a tapered roller bearing which used in a lorry wheel hub. Different studies and analysis including visual examination, optical microscopy, and scanning electron microscopy were performed. In addition two-dimensional (2D) finite element analysis was performed to calculate the stress distribution on inner ring surface. On the basis of the results of visual examination and microstructure and fracture surface analysis, it was determined that the tapered roller bearing failed by contact fatigue that was caused by overloading of the bearing. So to increase the fatigue life of bearing decrease the load on lorry and increase the hardness of the bearing.

Siyuan Ai, Wenzhong Wang, Yunlong Wang, Ziqiang Zhao [4] describes the Thermal Network Model (TNM) based on generalized Ohm's law for double-row tapered roller bearing which is lubricated with grease, which is commonly used in high-speed railway. Quasi-static model is used to find the load distribution and kinematic parameters in bearing. The temperature of bearing is calculated for different speeds; different grease filling ratios and roller large end radius are checked. The results are that high rotating speed and filling grease ratio gives in high temperature rise, particularly at roller large end and flange contacts. Also, the best roller large end radius i.e. 400 mm is offered and its mechanism has been discovered.

S.ShevchenkaA.Mukhovata, O. Krolb [5] developed geometric modification of single row tapered roller bearing.The radius of these generators is the same, which makes linear contact between the rollers and raceways of the rings. Arc shape forming from the rollers and raceways reduces the reduced curvature of the contacting bodies and increases their contact length. As a result, the contact stresses in a modified roller bearing are 6% less than in the standard roller bearing, which accordingly leads to increased bearing life of this type.

Zhiwei Wang,Lingqin Meng,Wensi Hao,E Zhang [6] developed a mathematical model to optimize the design of Tapered Roller Bearing. On the basis of comparison of the result from optimized design and the conventional design of the Four Column Tapered Roller Bearing 3811/750/HC, the dynamic load increases by 22% and the working life expectation increases 85% by using our design. It fully shows the reasonable meaning of the optimization design, and it provides a practical method for the optimization design in future

Kwan Ho Kwim,Jae Sueng Lee,Duk Lak Lee [7] presented the study on a new through-hardening heat treatment, quenching and partitioning (Q&P), which has been selected in place of the normal quenching and tempering. One of the discrete differences between tempering and partitioning is no fine carbide precipitation during partitioning, leading to the stability of austenite due to the diffusion of carbon atoms from martensite, which can be understood by increasing silicon content. A new high carbon chromium bearing steel by Q&P process showed better rolling contact fatigue life characteristics than conventional steel

Daisuke Yonekura, Richard J. Chittenden, Peter A. Dearnley [8] shows the development of new low friction coatings for automotive engine. 100Cr6 steel rollers were coated with three different materials: (i) Cr2N; (ii) CrN + nC (where nC refers to nano-/micrometer-sized carbon particles embedded in the CrN matrix) and (iii) Cr + W–C: H were compared to uncoated 100Cr6 steel. Two oils FVA-3 and SAE10W40 were used. Six modes of failure means were seen for the coated rollers. Only two of these resulted in the early pitting of the bearing due to rolling contact fatigue. In the FVA-3 oil, the stability is Cr2N > Cr + W–C:H > CrN + nC coatings, and in the SAE10W40 oil, the stability is Cr + W–C:H > Cr2N > CrN + nC coatings. The CrN + nC coatings was the least durable and Cr + W–C: H gave the best overall coating durability

Xia Yang, Qingxue Huang, Chuang Yan [9] shows Boundary Element Method(BEM) to analyze the roller contact bearing problem. The plate units are used for simulation of the rollers, the bearing boundary elements are used to show the alternating nature of the grip on the contact area, and the Hertz contact theory is used to improve contact widths between rollers and the inner and outer race. The shaft block direct measure method is used to measure the load distribution of the four- row tapered roller bearing. The experimental data and the result of simulation are compared, which proves the authority and usefulness of the bearing. It was observed that pressure was more on small end than large end of bearing. Also pressure is maximum on the second row rollers in four row taper roller bearing.

Zhang Yongqi,Tan Qingchang,Zhang Kuo,Li Jiangang [10] made finite element model of roller bearings is developed with the help of Reynolds equation and bearing in mind the surface roughness. Then stress fields in the roller and the raceway are calculated by adding load and solving problem, obtaining the highest stress and strain of the bearings. After that, effect of the pre-tightening on the work property of the bearings is analyzed by the obtained maximum stress and strain. In this work, 8μm of axial displacement are applied to the inner ring, 3923.3N of radial support force are exerted on inner ring; the axial force exerted is 45972N. Rotation speed of 2000 r/min is exerted on the inner ring.

CONCLUSION

Model	Nodes	Element	Von-Mises stress Max.(MPa)	Total deformation Max.(mm)
Standard 4 degree solid model	104389	39702	3.1411	0.006418
3 degree solid model	126850	63068	3.887	0.007177
5 degree solid model	104298	39617	2.7639	0.0055685
3 degree 60% hollowness	410032	230594	2.1177	0.0048107
4 degree 60% hollowness	161162	87898	1.1729	0.0041522
5 degree 60% hollowness	79315	43237	1.6554	0.0068299
3 degree 62% hollowness	105371	49169	2.6865	0.0058193
4 degree 62% hollowness	104121	48819	1.9963	0.0059824
5 degree 62% hollowness	104084	48810	1.4213	0.0059821
3 degree 65% hollowness	208968	97008	1.3128	0.0051059

4 degree 65% hollowness	103296	48110	1.3022	0.0058979
5 degree 65% hollowness	104401	48726	2.0765	0.0061189
3 degree 68% hollowness	103296	48110	1.7565	0.0053431
4 degree 68% hollowness	102849	47865	1.7567	0.0057921
5 degree 68% hollowness	103594	48199	1.6342	0.0057624
3 degree 70% hollowness	79683	43460	1.5695	**0.0032849**
4 degree 70% hollowness	80610	43683	1.6827	0.005433
5 degree 70% hollowness	78612	42848	**0.84681**	0.006846

- **5 degree model with 70 % hollowness of roller has the least deformation.**
- **3 degree model with 70% hollowness has the least stress.**
- **Hollow rollers have comparatively less stress and less value of deformation compared to solid models.**
- **So we have to select the bearing as per application and loading conditions. It will improve the performance and life of taper roller bearing.**

REFERENCE

1) G. D. Bassan D. P. Vakharia, "Determination of optimum hollowness in tapered roller bearing using finite element analysis to increase the fatigue life" International Journal of Innovation and Scientific Research, **ISSN 2351-8014,Vol. 17 No. 2 Aug. 2015.**

2) Prachi Prajapati, Digvijay Jadeja, "Bearing Life Optimization of Taper Roller Bearing" International Journal for Scientific Research and Development, **Vol 2,Issue 7,ISSN 2321-0613,2014.**

3) Yusuf Kayah,Ismail Ucun,Kubilay Aslantas, " Contact Fatigue Failure of a Tapered Roller Bearing Used in a Lorry Wheel" Journal of Failure Analysis and Prevention,**2009**.

4) Siyuan Ai, Wenzhong Wang, Yunlong Wang, Ziqiang Zhao, "Temperature rise of double-row tapered roller bearings analyze with the thermal network method" Tribology International 87,**2015.**

5) S.ShevchenkaA.Mukhovata, O. Krolb, " Geometric Aspects of Modifications of Tapered Roller Bearings" Procedia Engineering 150,**1107 – 1112,2016.**

6) Zhiwei Wang,Lingqin Meng,Wensi Hao,E Zhang, "Optimal Design of Parameters for Four Column Tapered Roller Bearing" Applied Mechanics and Materials,**Vols .63-64 (2011) pp 201-204**,**2011.**

7) Kwan Ho Kwim,Jae Sueng Lee,Duk Lak Lee, "Improvement of rolling contact fatigue life of bearing steel by quenching and partitioning process" Materials Science Forum,**Vols.706-709 pp 2152-2157,2012.**

8) Daisuke Yonekura, Richard J. Chittenden, Peter A. Dearnley, "Wear mechanisms of steel roller bearings protected by thin, hard and low friction coatings" Wear 259,**779 –788,2004.**

9) Xia Yang, QingxueHuang, ChuangYan, "Analyzing the load distribution of four-row tapered roller bearing with Boundary Element Method" Engineering Analysis with Boundary Elements 56,**20–29,2015.**

10) Zhang Yongqi,Tan Qingchang,Zhang Kuo,Li Jiangang, "Analysis of Stress and Strain of the Rolling Bearing by FEA method" Physics Procedia 24,**19 – 24,2011.**