International Journal For Technological Research In Engineering
Volume 1, Issue 10, June-2014 ISSN (Online): 2347 - 4718

FATIGUE LIFE IMPROVEMENT THROUGH REDUCTION OF EDGE PRESSURE IN CYLINDRICAL ROLLER BEARING USING FE ANALYSIS

Shah Maulik J[1], Prof. P.H. Darji[2]
[1]PG Student, [2]Head of Mechanical Engineering Department
C. U. Shah College of Engineering and Technology, Wadhwan City
Gujarat Technological University, Ahmedabad, India.

Abstract: Cylindrical Roller bearings are designed to carry heavy radial loads but due to misalignment and edge loading it is affecting the life of the bearing. So in the design of cylindrical roller bearings the profile of the roller plays important roll. Stress analysis is done based on two dimensional models of the roller and raceways. The Present stress analysis is based on three-dimensional model of the roller and raceways. The flat profile of roller element result in the edge stress concentration. Circular crowning eliminates the edge stress concentration at the low and moderate loads however; it develops edge concentration at heavy loads. The logarithmic profile of the roller result no edge stress concentration at low, medium and high loads and the contact stresses also distributed uniformly along the length of the roller. Result show how logarithmic profile can help in getting a more uniform stress distribution along the roller length and in reducing, the end stress concentration.
Keyword: Cylindrical Roller, bearings

I. INTRODUCTION

Since being originally introduced, cylindrical and taper-roller bearings have been significantly improved, in terms of their performance and working life. This was achieved partially due to the improvement of the properties of the bearing steels, whilst other factors involved design changes, such as the reduction of the stresses of the structures. A major objective has been to decrease the contact stresses at the roller–raceway interfaces, because these are the most heavily stressed areas in a bearing. It has been shown that bearing life is inversely proportional to the stress raised to the ninth power (even higher) . For this reason significant efforts have been made to qualify contact stresses in the bearings. The reduction of the contact stresses has been achieved largely by designing the specific surface geometry of the roller– raceway contacts , because the contact-surface geometry has a direct effect on the distribution of contact stresses, and hence, it prescribes the load-carrying capacity of the bearing.

A. Problem Definition:

When a bearing roller (cylindrical) is in contact with raceways, excessive pressure peaks occur at the ends of the contact rectangles.

II. WORK

Here as per the given data with particular model which will be given by KCI INDUSTRIES (INDIA) LTD, we can easily conclude that due to the small diameter, Length number of rows and other specifications of rollers we can easily say that the cylindrical roller bearings are used. The goal of the dissertation work is to make the analysis of roller profile for cylindrical roller bearings which are used in determining design parameters for the design of logarithmic crowning for roller bearings, by introducing the design parameters into a logarithmic crowning which is given by KCI INDUSTRIES LTD

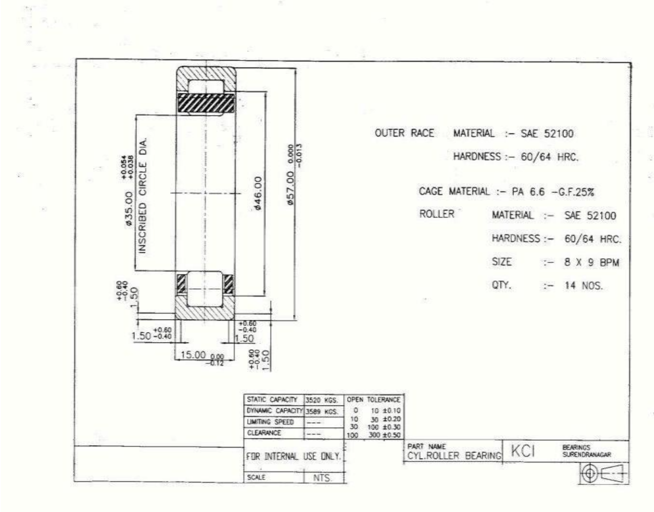

Fig 1

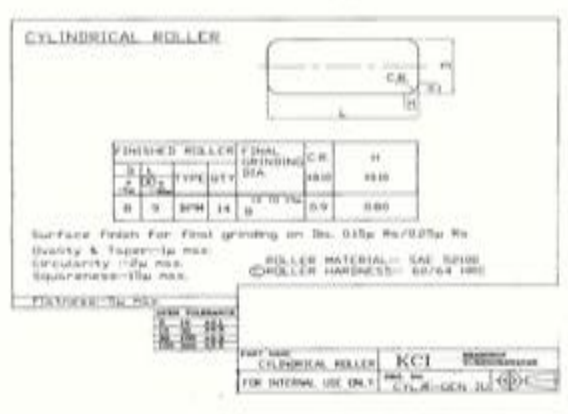

Fig 2

III. LITERATURE REVIEW

A. Introduction

It has been a common practice for many decades to utilize cylindrical shaped roller bearing elements in machinery in order to evenly distribute the bearing load across the line contact between the rollers and race-ways. However, designing a bearing such that a uniform contact stress distribution is resulted along the contact lines of a roller bearing is highly unrealistic. This difficulty stems from the fact that the two ends of a typical roller act as stress-concentration zones, causing the contact stresses to have spikes at the roller end points. The conventional method of rectifying this undesirable condition is to modify the geometric configuration of the ends of the roller in a way that a sharp or abrupt transition from the contact line to the cross- section of the roller is avoided. This geometric modification is called "crowning" of the roller.

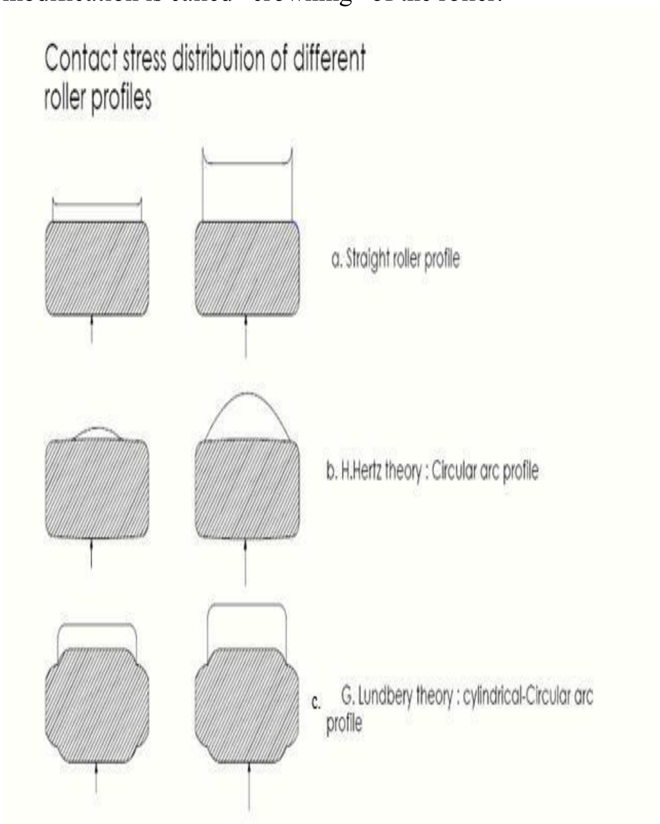

Fig 3

Hiroki Fujiwara, tatsuo Kawase "Logarithmic profiles of rollers in roller bearings and optimization of the profiles."[1] It is known that when a cylindrical surface or conical surface comes in contact, concentrated stress occurs at the end portion of the contact with the resultant Contact pressure becoming excessive. This excessive contact pressure at the end portion is called edge stress. In a common roller bearing the roller rolling surface and/or the raceway surface of the race is crowned to avoid edge stress. Fig. 1 schematically shows a cylindrical roller bearing whose roller is crowned. The amount of decrease in the radius generated by crowning is called the drop.

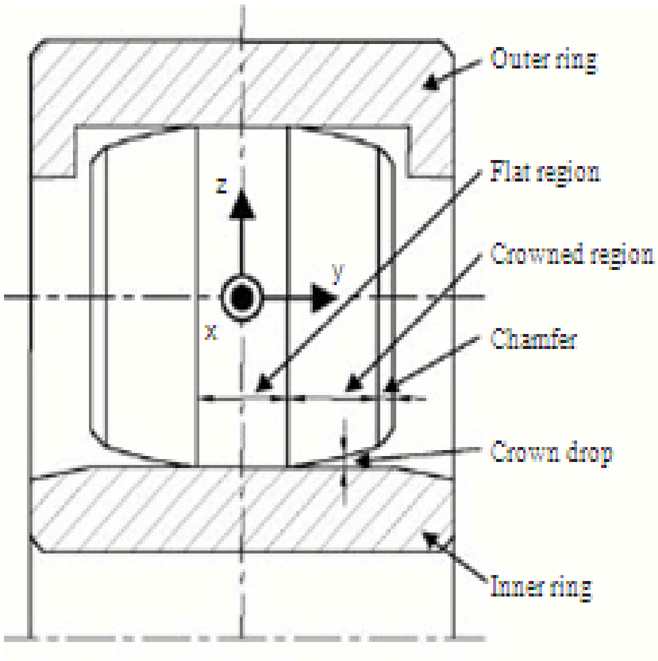

Fig 4

Hiroki Fujiwara, tatsuo Kawase "Logarithmic profiles of rollers in roller bearings and optimization of the profiles."[1] It is known that when a cylindrical surface or conical surface comes in contact, concentrated stress occurs at the end portion of the contact with the resultant contact pressure becoming excessive. This excessive contact pressure at the end portion is called edge stress. In a common roller bearing the roller rolling surface and/or the raceway surface of the race is crowned to avoid edge stress. Fig. 1 schematically shows a cylindrical roller bearing whose roller is crowned. The amount of decrease in the radius generated by crowning is called the drop.

A logarithmic profile is essentially optimal crowning geometry for rolling machine elements such as bearing rollers and raceways. - 10 - Although some design methods of the profile have been proposed, they do not refer to the tolerance of the geometry required in engineering applications and in y production. When a cylindrical roller bearing is subjected to a load, the rollers of finite length contact the mating raceways of greater length, and compressive stresses at the roller ends tend to be substantially higher than those at the center of the contact. This phenomenon of stress concentration is referred to as edge loading. In roller bearings, the radii of the rollers and/or the raceways are reduced on the order of micrometers to avoid edge loading. This modified geometry is called crowning. Typical crowning profiles include a single straight line, circular curve, their combination, and so on. In some cases, crowning extends over the full length of the rollers and/or raceways (full crowning), while in other cases crowning is processed only near both ends (partial crowning). Contact stress is correlated with rolling contact fatigue life, and lower stress yields longer life.

 ISSN (Online): 2347 - 4718

Roller radius	4.5 mm
Roller width	10 mm
Roller chamfer width	0.5 mm
Straight part length	5 mm
Inner race radius	13.5 mm
Roller load	3.2 kN
Bearing misalignment	2/1000

Fig 5

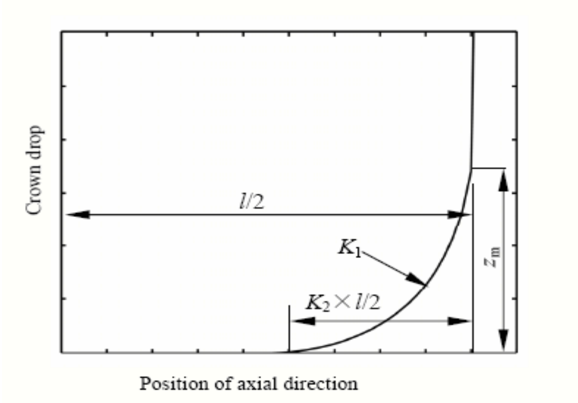

Fig 6

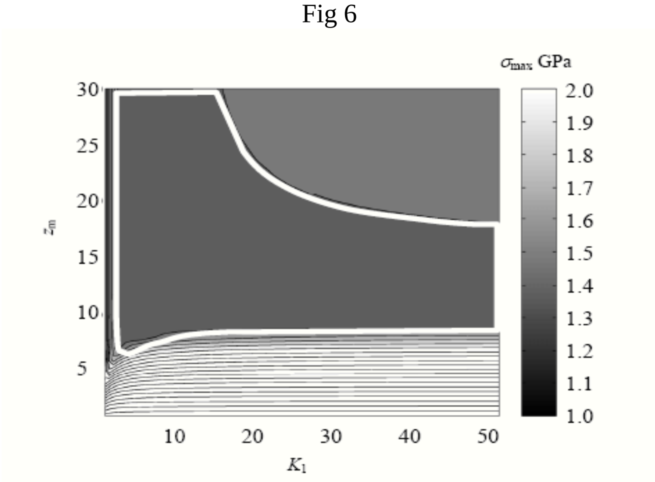

Fig 7

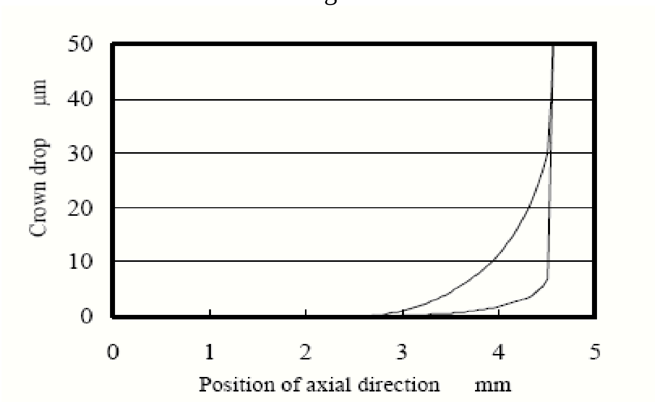

Fig 8

Spiridon S. Cretu, Marcelin i. Benchea “An Elastic-Plastic analysis of Profile Evolution in cylindrical roller bearings.”[3] A NJ2232 roller bearing has been selected for this study: - inner ring raceway diameter d =228 mm, i - outer ring raceway diameter d =308 mm, e - roller diameter D =40 mm, w - total roller length L =65 mm, w - roller’s end chamfer R2=1.2 mm, - 14 - number of cylindrical roller Z=17, - internal clearance S=0.15 mm. Two roller profile designs were involved: - straight line profile with end chamfer, Fig. a, and - cylindrical-crowned profile with end chamfer, Fig. b. Class I discontinuities exist at the intersection points of roller profile: points A and B in Fig.2.10 a and Fig.2.10 b, respectively.

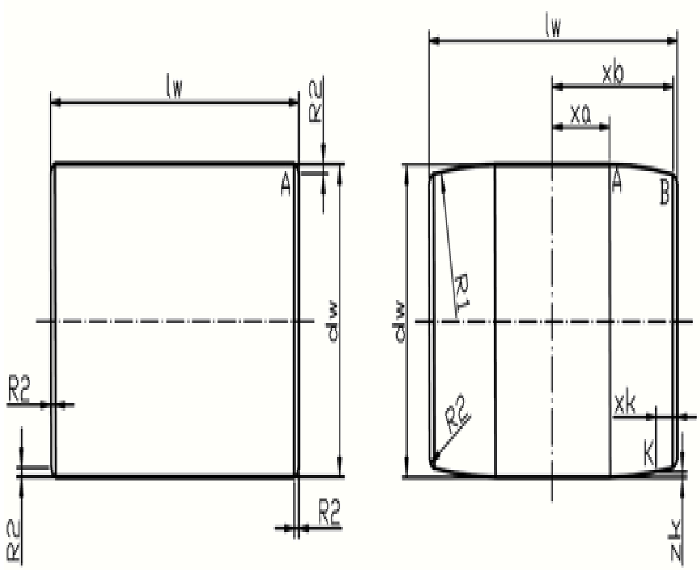

Fig 9

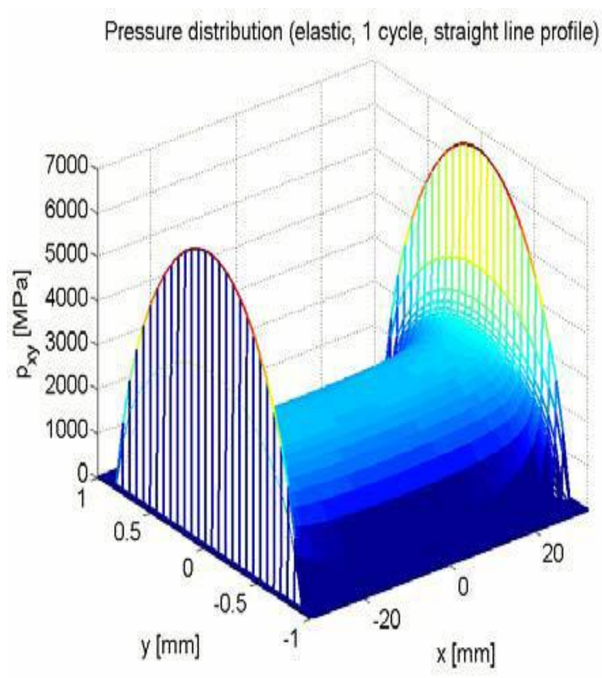

Fig 10

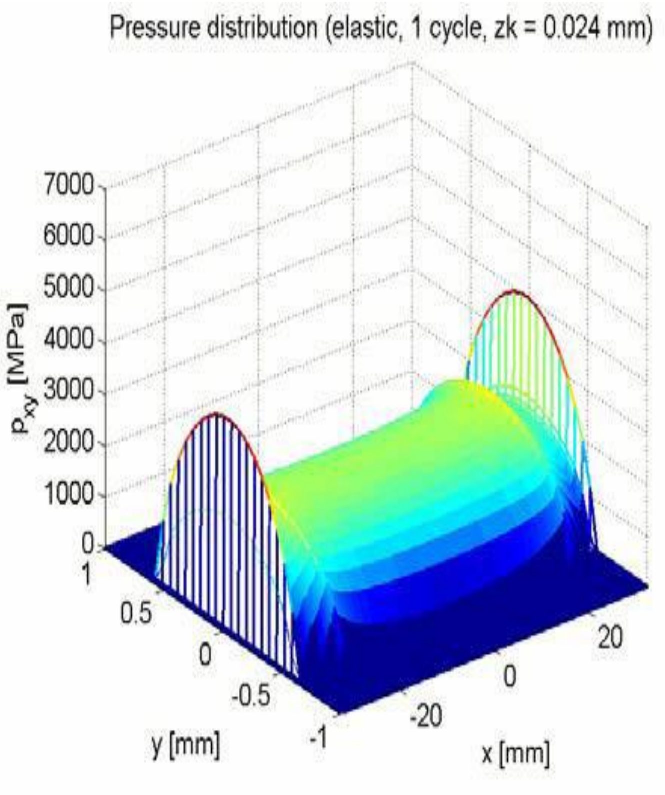

Fig 11

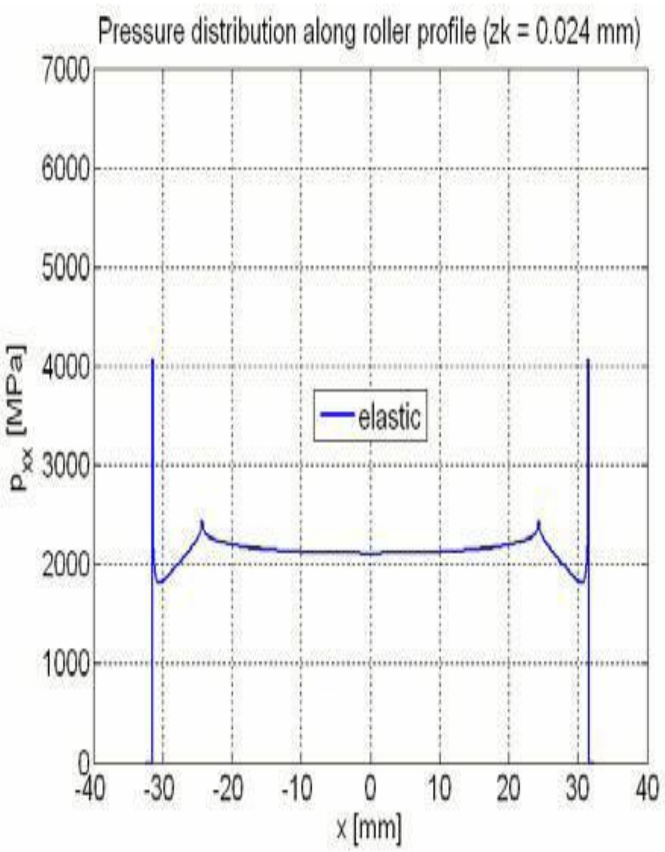

Fig 12

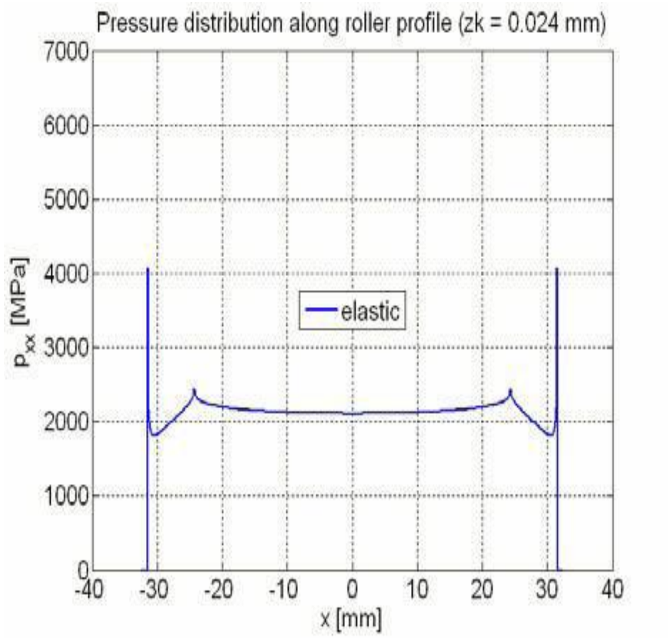

Fig 13

About FE Analysis and ANSYS

About FEA The physical problem is idealized as a mathematical model using certain assumptions, which together leads to differential equations governing the Mathematical model. The finite element analysis solves this mathematical model. In brief the basis of finite element analysis is the representation of the body or structure by an assembly of subdivisions called finite elements. These elements are considered as interconnected at the joints, which are called nodes or nodal points. A typical finite element model is comprised of nodes, degrees of freedom, elements material properties, externally applied loads and analysis type. The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide range of engineering problems.

Steps in Finite Element Analysis

Step 1:

First the domain is represented as finite elements. This is called discretization of domain. Mesh generation programs called processors, help in dividing the structure.

Step 2:

Formulate the properties of each element in stress analysis. It means determining the nodal loads associated with all element deformation stress that is allowed.

Step 3:

Assemble elements to obtain the finite element model of the structure.

Step 4:

Apply the known loads, nodal forces in stress analysis. In stress analysis the support of the structure has to be specified.

Step 5:
Solve simultaneous line algebraic equations to determine nodal displacements in the stress analysis.

Step 6:
Post processors help the user to sort the output and display in the graphical output.

About Analysis
The software ANSYS was developed by ANSYS Inc. USA. The ANSYS product family offers the following capabilities linear stress, structural non-linear, dynamic analysis, buckling analysis, buckling, sub structuring, heat transfer, transient, thermal, thermal non-linear, electrostatics, acoustics, electromagnetic and coupled field.

Assumption in
FEA The four primary assumptions, which must be considered in any Finite element based solution, are as below.

(1) Geometry
Geometry must be in its proper context. An FEA solver only understands nodes, and the connectivity of nodes, which are elements. The smaller the element size or the higher the element order, the better the mesh will represent the geometry template it was based on. The inherent assumption when a model is sent is to solve is that the mesh represents the geometry adequately for the study goals.

(2) Material Properties
Specifying a single set of material properties for a part in an FEA study makes the significant assumption that all parts in the production run intended to be represented by the analysis have the same properties. It is also typical to assume that most parts will be isotropic and homogenous.

(3) Mesh
The mesh is our way of communicating the geometry to the FEA solver. The accuracy of the solution depends entirely on the quantity of the mesh. The quality of the mesh is best characterized by the convergence of the problem. The global displacements should converge to a stable value and other results of the interest should converge locally. A less tangible, more subjective measure of the quality of mesh is its appearance and ability to visually convey the geometry it represents.

(4) Boundary Condition
The boundary conditions are those conditions that are placed on the model to represent everything about the system that is not been modeled.

IV. CONCLUSION

The goal of this presented work was to minimize Edge stress of the roller by developing logarithmic profile on the roller of the roller bearing.

- In the flat profile as the load increases the edge loading increases. The logarithmic profile is the remedy foe the edge loading at high-applied loads.
- In logarithmic profile roller as the load increases the length of the contact increases.
- As we known that if the edge stress will reduce the fatigue life of the roller as well as roller bearing increased because it is inversely proportional to the Fatigue life.

Table 1 Von-mises stress result Comparisons

Load (N)	Flat_Profile Roller (Cylindrical Roller)		Logarithmically profile roller (Crowning Roller)	
	Von-mises Stress N/mm^2		Von-mises Stress N/mm^2	
	Analytical	FEM	Analytical	FEM
5000	824.426	823.55	1165.57	1161.5
8000	1024.36	1041.9	1474.3	1470.5
10000	1165.844	1160.2	1648.41	1647.1

Table 2 – Edge Stress Result

Sr.no	Edge stress N/mm^2		**% Reduction in Edge Stress**
	Flat profile roller	Logarithmic profile roller	
Case01 (At load 1000)	6850	4490	34
Case02 (At load 8000)	4750	3658	22
Case03 (At load 5000)	2995	2344	21

Table 3 Comparison between calculated stress and stress generated through FE analysis

Description of Load	**Load (N)**	**Generated Stresses (Mpa)**		**% Difference**
		Analytical	**FE Analysis**	
Max. load on o' position	11259.67	1153.8	1152	0.156
Max. load on logarithmic profile roller	10000	1648.416	1647.1	0.08

REFERENCES

[1] Hiroki Fujiwara, tatsuo Kawase "Logarithmic profiles of rollers in roller bearing and optimization of the profiles" Japan society of Mechanical Engineers Part C, Vol.72(2006), pp.3022-3029 Elemental Technological R & D Center. Part: 1 Model Development".

[2] Hiroki Fujiwara, Kazuto Yamauch "Tolerance Design of Logarithmic Roller Profiles in Cylindrical Roller Bearings", Journal of Advanced Design, Systems and manufacturing.
[3] Spiridon S. Cretu, Marcelin I. Benchea " An Elastic-Plastic Analysis of profile Evolution in Cylindrical Roller bearing" Proceeding of the ASME 2012 11th biennial Conference on Engineering System Design And Analysis.
[4] Xintao Xia, Shichao Zhu, Chenhui Jia, Rongjun Niu "Study of Interval of Arc Modification Length of Cylindrical Roller Using ANSYS" International Journal of Engineering and Science, ISSN: 2278-4721, Vol.1 Issue (Aug 2012), PP 8-13.
[5] Yangang Wei, Yi Qinb, Raj Balendra, Qingyu Jiang " FE analysis of a novel roller form: a deep end-cavity roller for roller-type bearing" Journal of Materials Processing Technology 145(2004) 233-241
[6] Thin-Lin HORANG, "A Numerical Algorithm for Determining the Contact Stress of Circular Crowned Roller Compressed between Two Flat Plates" Journal of System Design And Dynamics, Vol. 3, No.2, 2009
[7] ENESCU IOAN, ENESCUDANIELA, "Finite element methods for contact problems in rolling bearing elements" Advances in Remote Sensing, Finite Differences and Information Security ISBN: 978-1-61804-127-2
[8] Haruo NAGATANI, "Improved Method of Rolling Bearing fatigue Life Prediction under Edge Loading Conditions" NTN TECHNICAL REVIEW NO. 78 (2010)
[9] B. Ramu, V.V.R.Murthy, "Contact Analysis of Cylindrical Roller Bearing using Different Roller Profiles" IJMET Vol.3, Issue 1, Nov-April 2013ISSN : 2249-5762 (Online) | ISSN : 2249-5770

