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Effect of cryo treatment on s s bearing

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Abstract:

A machine element which support another element and the same time constrains the relative motion of the part with minimum friction is called a bearing. The design of the bearing may provide free linear movement of the moving part or for free rotation or it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts.

Generally 52100 chrome steel is the most common material used to produce the load carrying components in roller bearing tapered, roller bearing & precision ball bearing. Inner rings, outer rings balls & rollers are the components of bearing. The chemical composition of this steel has high carbon and about 1.5% chromium content. For general purpose SAE 52100 is excellent of bearing because of its excellent hardness and wear resistance. Rolling element bearings it has good fatigue life. However because of low chromium content the corrosion resistance of chrome steel is poor. The bearing surface must be protected with a coating of rust inhibitor or oil to stop oxidation.

To make bearing components stainless steel materials are used it is more resistant to surface corrosion due to higher content of chromium (~18%) with the addition of nickel. to creating a passive film the chromium reacts with oxygen to form a layer of chromium oxide on the surface. Miniature bearings made from conventional 440C stainless steel will be slightly noisy because the large carbides that normally concentrate at the grain boundaries are exposed in the raceway finishing process.Researchers have only recently begun to study sub-zero cooling cycles. For many years, sub-zero treatment of metals had the reputation of being a quick fix for poor heat treatment practice. Sub-zero processing technology has not been widely adopted by the metals industry due to a lack of understanding of the fundamental metallurgical mechanisms and due to the wide variation in reported research findings. Research shows that sub-zero processing of steels can improve various properties including: Hardness and strength Wear resistance Dimensional stability.

In this paper we are going to design and analyze the bearings using the commonly used and subzero and cryotrated metals. The design of the bearing will be created using Pro/Engineer and analysis done using Ansys 14.5

1. INTRODUCTION

A machine element which support another element and the same time constrains the relative motion of the part with minimum friction is called a bearing. The design of the bearing may, for example, provide for free rotation around a fixed axis or for free linear movem ent of the moving part; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Bearings are mostly used for minimizing friction. There are different classifications according to type of motion allowed, type of operation or direction of loads applied.

The popular use of ball bearing for general industrial application can generally be associated with the late nineteenth century. In this project an Effort has been put to analyze the deep groove ball bearing using finite element analysis the stress levels or displacement behavior of ball bearing.

The stainless steel bearings can be selected relatively according to different working conditions when the ordinary bearings cannot meet the requirements. The stainless steel bearings have unique characteristics. They can adapt to vast environments and endure acid, alkaline as well as corrosion. They can work in the corrosive mediums such as in seawater, river water, distilled water, dilute nitric acid, maritime climate, vapour etc. They can resist hotness and perform between minus 253 degrees centigrade and 350 degrees centigrade.

Grade 100 AISI316 Stainless steel loose ball bearings hardened to 25-39 Rockwell Scale, similar to the AISI304 stainless steel, it has better resistance to the corrosion under particular circumstances and this is mainly due to the addition of molibdene, AISI316 stainless steel has a very low magnetic permeability which does not change in spite of work-hardening for deformation.

Bearing balls are manufactured to a specific grade, which defines its geometric tolerances. The grades range from 2000 to 3, where the smaller the number the higher the precision. Grades are written "GXXXX", i.e. grade 100 would be "G100". And lack of defects, such as pits, flats, spots, soft and cuts. The surface smoothness is measured in two ways: surface roughness and waviness.

Size refers to how tight the tolerances are on the size, as measured by two parallel plates in contact with the ball surface. The starting size is the nominal ball diameter, which is the nominal, or theoretical, ball diameter. The ball size is then determined by measuring the ball diameter variation, which is the difference between the largest and smallest diameter measurement. For a given lot there is a lot diameter variation, which is the difference between the mean diameter of the largest ball and the smallest ball of the lot.

Martensite Transformation

The martensite transformation occurs only when the austenite is super cooled by rapid cooling (quenching) to low temperature at which diffusion possesses become impossible. In contrast to the pearlite and intermediate transformation, the martensite transformation is of diffusion less nature i.e. it is not accompanied with diffusive displacements of carbon and iron in the rearrangement of the precipitate of carbon from the solution. The transformation is accomplished by a shift, i.e.an ordinary cooperative transfer of atoms from the austenite to martensite. The atoms are not interchanged in re arrangement of the lattice, but, are only displaced by distances not exceeding the inter-atomic ones. The material crystals are shapes like plates narrowed at the edges

Stainless steels are steels with a minimum of 10% chromium. They gain their resistance to corrosion from a thin, tenacious surface layer of chromium oxide. If the oxide layer is physically damaged there is rapid regeneration of the layer, thus preserving the corrosion resistance. However, a chemical environment that can disrupt this layer can initiate corrosion. Consequently, stainless steel is highly resistant to atmospheric corrosion, but not immune to corrosion in all environments.

Cryo Treatment

Over centuries form black art to science the heat transformed has transferred in the development of phase diagrams and heat treatment cycles international reaches had held metallurgists under fans how and why to hat treatment cycle but they understand charging any prossing varin will influence the final properties.At temperature sown to about – 80 ^{0} c or deep cryogenic treatment" at liquid nitrogen temp (-196 ^{0}c) cold treatment so called "sub – zero treatment." Recent evidence shows the virtue of cryogenic treatment at liquid nitrogen temperature is a further enhanced of resistance. There are two mechanisms to improve properties according to researches which as treated cry treatment a process to heat treatment of tool die steel it consists of cooling of conventionally hardened steel specimens to cryogenic temp (-500c to – 1960c) for sufficient long duration of soaking it arrived out at lowest temperature treatment due to this the problem occen in heat treatment where it reduced by controlled transformation of retained austenite into martensite. It proves wear resistance hardness toughness resistance to fatigue cracking micro structure of metal diameter.

For many years subzero treatment of metals had reputation to begin a quick fix for poor heat treatment by the researchers. This has not been widely adopted by the metal industry because of understanding the fundamental metallurgical mechanism and due to wide.

variation in cryogenic treatments can also solve problem from bad glof balls to holes in coomen's hociey have further diminished interest in exploring cryogenics as a credible pros early.

Recently however, researchers have conducted significant research into the fundamental understanding of the mechanisms governing sub-zero processing. Dr. Randall Barron at the University of Louisiana was one of the pioneers in conducting significant research into sub-zero processing. His research shows that sub-zero processing of steels can improve various properties including:

- Hardness and strength
- Wear resistance
- Dimensional stability

BEARING ASSEMBLY

There are different methods of assemble of ball bearings, single and double row. The basic bearings configurations are used in assembly process are slotted and unslotted. Slotted assembly type bearings have filling slots cut axially through the shoulder on one side of each ring, Figure 1.4. This slot allows the introduction of as many balls as permitted by the retainer and the pitch circle.

The radial Load carrying capacity of the bearing can be increased by increasing number of balls. Even though the filling slot may aid in the assembly process, under axial loading the balls will contact the filling slot, causing noise and poor performance. The unspotted, or Conrad, bearing is the bearing assembly type to be addressed in this thesis. Generally the most commonly used bearing is Conrad bearing. The inner and outer races have deep uninterrupted grooves with circular cross sections whose radii are only slightly larger than that of the balls. The inner ring is initially offset inside the outer ring. In most cases, including the double row bearing, the outer ring is slightly distorted to increase the clearance for ball insertion. With the inner ring offset, balls are inserted. After the balls are inserted the inner ring is snapped to a position concentric with the outer ring , the balls are separated uniformly and a cage is inserted to maintain the ball separation. Note that this method limits the number of balls that can be inserted, which limits the bearings radial load carrying capacity.

APPLICATION

Because of their universal features, construction is very simple, mounting and dismounting are easy and low cost. Radial contact deep groove ball bearings have many applications in branches of industry. With advanced technology makes to possible to produce a ball bearing with outside diameter of only 1 mm

2. DESIGN
Pro-E AND ANSYS

2.1 Introduction to Pro-E

Pro-E is also known as production Engineer and it is software programming package that has been developed by the French company called by as Dassult Systems.
Pro-E is a suit having a process-centric computer-aided design/computer-assisted manufacturing/computer-aided engineering (CAD/CAM/CAE) system that utilizes next generation objective technologies and leading edge industrial standard. Pro-E is integrated

with in the Dassult Systems Product Lifecycle Management (PLM) solution. It allows the users to easily simulate their industrial designing processes from initially at a concept to product designing, analyze, assemble and also for maintenance. In this software package, it is included mechanical, and shape design, styling, product synthesis, equipment and systems engineering, Numerical Control manufacturing, analyzing and simulating, and industrially plant design. It is very much user friendly software as because Pro-E Knowledge ware allows boarded communities of user in easily capturing and sharing knowing -how, rules, and other intellectual property asset.

2.2 Engineering Design

Pro-E 5.0 is offering a wider range of tools by enabling the generation in a complete digital Representative of the product which is being designed. In addition to the general geometrical tools there in also the ability of generating of geometry in other integrated designing disciplines such by industrial and standard pipe working and complete wiring dimensions. Tools are also available in supportive collaborative of development.

A numerous type of concept designing tools that provide it up-front Industrial Designing concept can then be of used in a downstream process of engineering of that product. These are ranging from conceptual Industrial designing sketches, reverse engineering with a point of cloud data and comprehensive free forming of surface tools.

2.3 Different Modules in Pro-E 5.0

- ✓ Sketcher
- ✓ Part Modeling
- ✓ Surfacing
- ✓ Sheet Metal
- ✓ Drafting
- ✓ Manufacturing
- ✓ Shape designs

2.4 ANALYSIS

After designing the component, finite element analysis is to be carried out and this method is very important for those involved in engineering design. This finite element method used to solve several problems in these areas of structural analysis, thermal analysis, buckling analysis etc.,

The analysis software programmed was first developed by swason analysis systems Inc. and in this present project the control system component was analyses and type of analysis done was structural analysis by using finite element method.

The organization of ansys programmer was done by two levels. At beginning level used for programme controls such as copying binary files etc., and at processor level the entire analysis is carried out to obtain the results to check whether the component has designed properly or not. At processor level the analysis is carried in three different levels. each processor stage has its separate characteristics for doing analysis.

- Preprocessor: In this stage, initially element type was assigned which belongs to component and geometry definitions was given and using material whether aluminum or S2 glass material properties was given(young's modulus, poissions ratio, density etc.,)

Type of analysis was to given whether structural analysis or thermal analysis or buckling analysis etc., in this project structural analysis of component was done.

Mesh generation: it is carried in preprocessor stage and before meshing ,type of meshing is to select whether free mesh or mapped mesh both are having different method of meshing characteristics. Free mesh having no restrictions in terms of element shapes and has no specified

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pattern applied to it. But mapped mesh having specified restrictions in terms of their element shapes and mapped area mesh have quadrilateral or only triangular elements and mapped volume mesh have hexahedron elements.

Material Date:
Density 7800 kg m^-3
Coeff of Thermal Expansion 1.2X10 $^{-5}$ C^{-1}
Specific Heat 460 J kg^{-1} C^{-1}
Thermal Conductivity 24.2 W m^{-1} C^{-1}
Resistivity 1.7e-007 ohm m
Young's Modulus 2E+11
Poisson's ratio 0.3

- Solution processor: In this stage,the main analysis is carried out that is applying the loads and obtaining the solutions and in this solution processor the entire using data definitions has to given that are type of solution whether static, modal or transient etc., and defining loads whether point loads or surface loads etc., are the basic using data definitions necessary in solution processor.
- Post processor: In the general post processor, already obtained solution in solution processor is analysed with help of graphs and comparing with other parameters to view results.

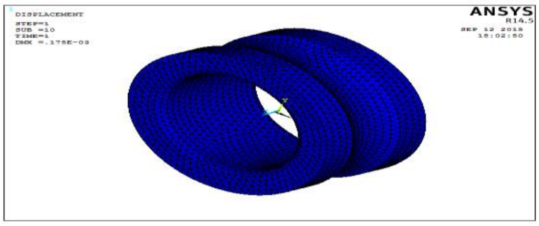
2.5 Specific Capabilities of ANSYS:

- Structural analysis
- Thermal analysis
- Acoustics / Vibration
- Coupled Fields
- Modal Analysis
- Harmonic Analysis

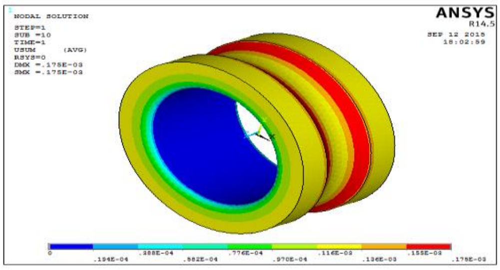
3. ANALYSIS IN ANSYS

3.1 STATIC ANALYSIS OF INNER RACE
Using steel

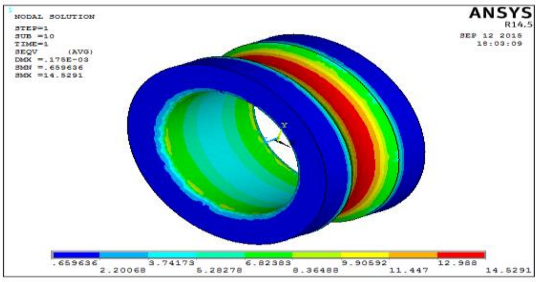
Deformed shape



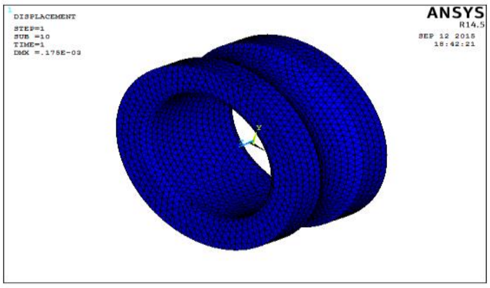
Displacement vector sum



Von Mises stress



Using cryotreated steel
Deformed shape



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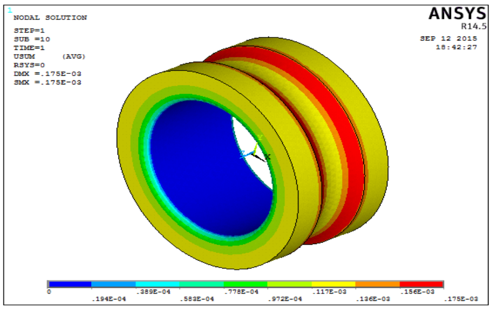
Displacement vector sum



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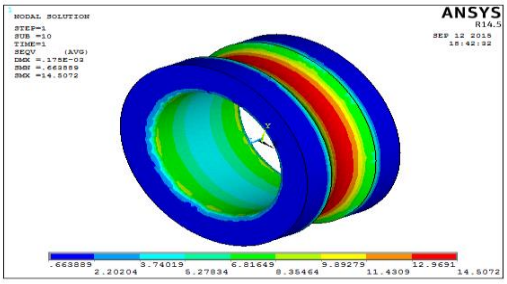
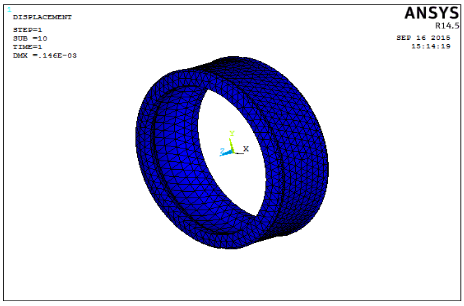


3.2 STATIC ANALYSIS OF OUTER RACE

Using steel

Deformed shape



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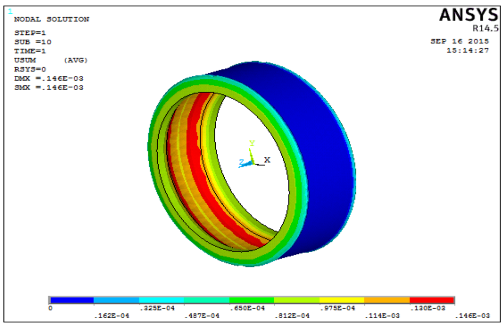

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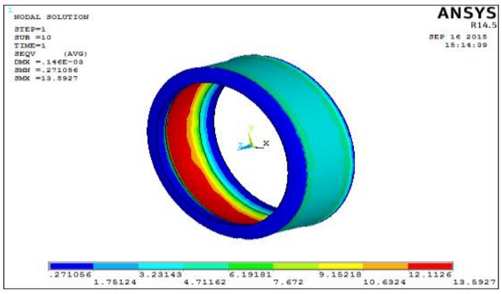
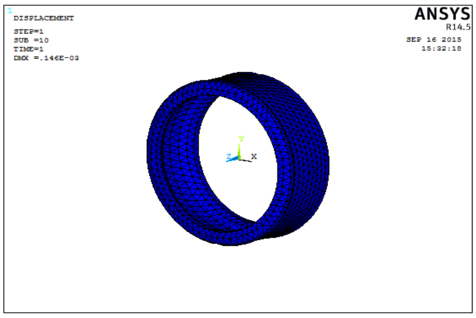
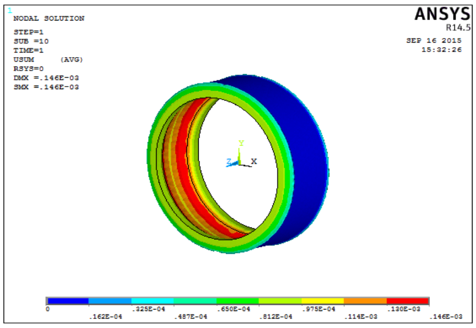


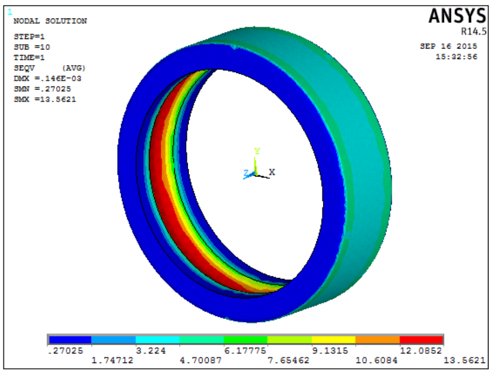
Using cryotreated steel



Displacement vector sum



Von Mises stress



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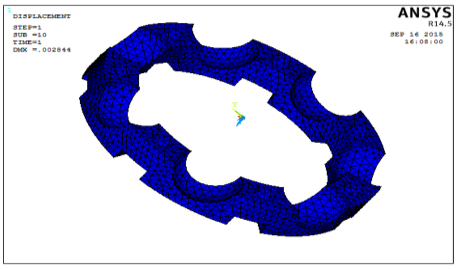
3.3 STATIC ANALYSIS OF RETAINER

Using steel

Deformed shape



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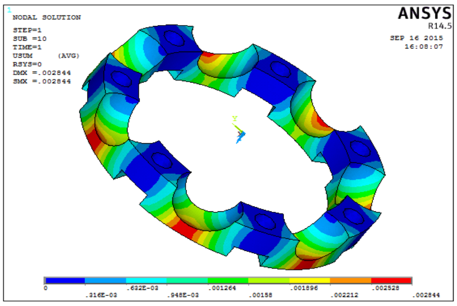
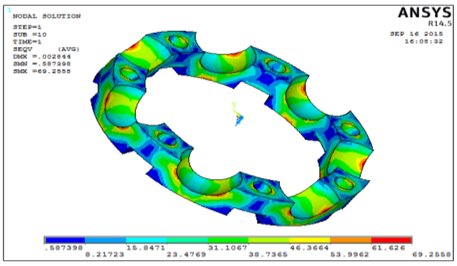
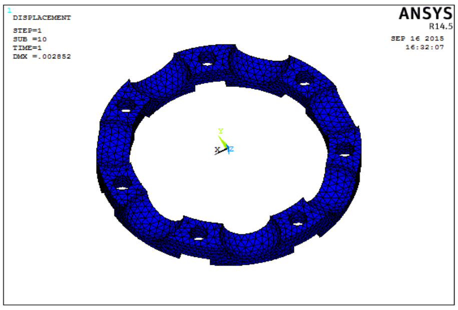


Von Mises stress



Using cryotreated steel

Deformed shape



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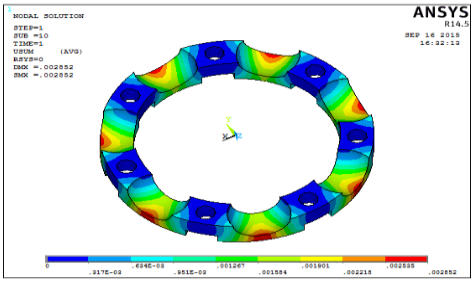
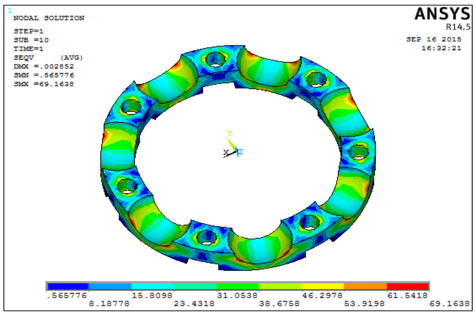


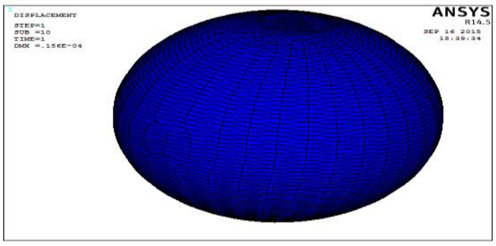
Von Mises stress



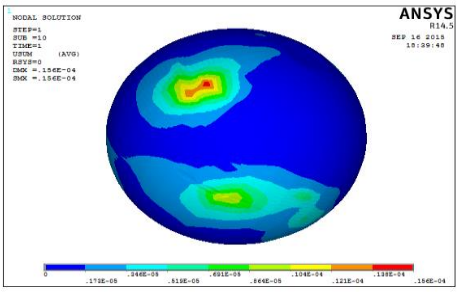
3.4 STATIC ANALYSIS OF BALL

Using steel

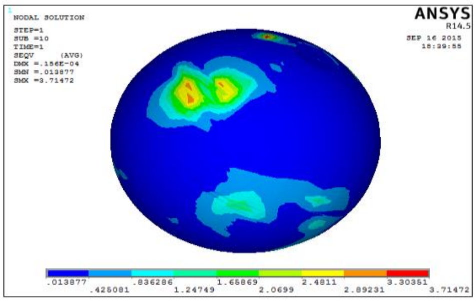
Deformed shape



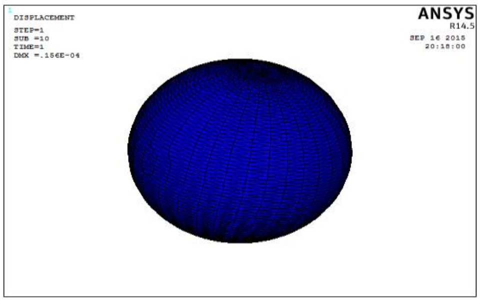
Displacement vector sum



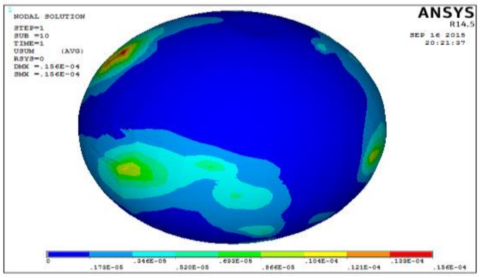
Von Mises stress



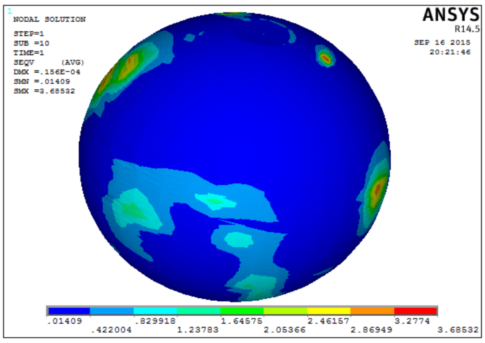
For cryo treated steel
Deformed shape



Displacement vector sum



Von Mises stress



4. COMPARISION TABLES FOR STATIC ANAL YSIS

Steel Inner Race

	Deformation	Stress	
		Max	Min
Load 1	0.175 e-3	0.6596	14.529
Load 2	0.175 e-3	0.6596	14.529
Load 3	0.873 e-4	0.3298	7.2645
Load 4	0.873 e-4	0.3298	7.2645

CRYOTREATED inner:

	Deformation	Stress	
		Max	Min
Load 1	0.175 e-3	0.6639	14.507
Load 2	0.175 e-3	0.6639	14.507
Load 3	0.875 e-4	0.3319	7.2536
Load 4	0.875 e-4	0.3319	7.2536

Steelouter race:

	Deformation	Stress	
		Max	Min
Load 1	0.146 e-3	0.2711	13.593
Load 2	0.146 e-3	0.2711	13.593
Load 3	0.731 e-4	0.1355	6.7964
Load 4	0.731 e-4	0.1355	6.7964

CRYOTREATED outlet race:

	Deformation	Stress	
		Max	Min
Load 1	0.146 e-3	0.2703	13.562
Load 2	0.146 e-3	0.2703	13.562
Load 3	0.731 e-4	0.1351	6.7811
Load 4	0.731 e-4	0.1351	6.7811

Steel retainer:

	Deformation	Stress	
		Max	Min
Load 1	0.002844	0.5874	69.254
Load 2	0.002844	0.5874	69.254
Load 3	0.001422	0.2937	34.628
Load 4	0.001422	0.2937	34.628

CRYOTREATED Retainer:

	Deformation	Stress	
		Max	Min
Load 1	0.002852	0.5658	69.164
Load 2	0.002852	0.5658	69.163
Load 3	0.001426	0.2829	34.582
Load 4	0.001426	0.2829	34.582

Steel Ball:

	Deformation	Stress	
		Max	Min
Load 1	0.156 e-4	0.1388	3.7147
Load 2	0.156 e-4	0.1388	3.7147
Load 3	0.778 e-5	0.0069	1.8574
Load 4	0.778 e-5	0.0069	1.8574

CRYOTREATED Ball:

	Deformation	Stress	
		Max	Min
Load 1	0.156 e-4	0.0141	3.6852
Load 2	0.156 e-4	0.0141	3.6852
Load 3	0.780 e-5	0.007	1.8427
Load 4	0.780 e-5	0.007	1.8427

COMPARISSION TABLES FOR FATIGUE ANALYSIS

Inner race:

	Fixed		Middle	
	event 1 load1	event 2 load1	event 1 load1	event 2 load1
Steel	9.4226	4.7113	1.8069	0.9034
CRYOTREATED	9.4856	4.7428	1.8241	0.9121

Outer race:

	Fixed		Middle	
	event1 load1	event2 load1	event1 load1	event2 load1
Steel	13.641	6.8205	6.2858	3.1429
CRYOTREATED	13.667	6.8336	6.2065	3.1032

Retainer:

	Fixed		Middle	
	event1 load1	event2 load1	event1 load1	event2 load1
Steel	74.174	37.082	42.885	21.442
CRYOTREATED	74.046	37.023	42.815	21.407

Ball:

	Fixed		Middle	
	event1 load1	event2 load1	event1 load1	event2 load1
Steel	4.3618	2.1809	0.5651	0.2575
CRYOTREATED	4.3245	2.1623	0.5202	0.2601

5. CONCLUSION

By Finite Element Analysis, the cryogenic treated ball bearing withstands maximum stress when compared to normal ball bearing and also hardness increases for cryotreated as compared to normal. This shows that cryogenic treated ball bearing can withstand heavy loads when compared to normal ball bearing. Because of improvement in maximum stress values, the life of the bearing will be longer.

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