

# Design and Development of Hydraulically Operated Ball Bearing Radial and Axial Clearance Test Rig

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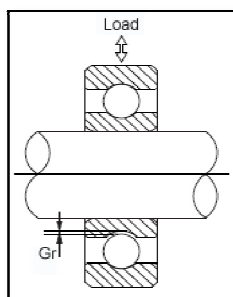
**ABSTRACT:** Bearing is heart of mechanical system which allows relative motion between two mating surface with minimum friction. In ball bearing ball are acting as rolling element which is placed in between inner and outer races. Bearing internal Clearance is amount of internal free movement before mounting. When either inner or outer race is fixed other ring is free to move in Axial or Radial Direction. Depending upon the displacement in radial direction is called “Radial internal Clearance” and Displacement in Axial direction Called “Axial internal Clearance”. Bearing clearance is important indicator of bearing quality .It has impact on bearing vibration, noise and life prediction. This paper mainly focus on measurement of ball bearing radial and axial clearance. For the measurement of internal clearance the test rig is designed and operated by hydraulic pressure. Different size of bearing of ID ranging from 15 mm to 80 mm can be tested on this rig. Test rig is designed using Solidworks.

**KEYWORDS:** Bearing, Ball bearing, Radial clearance, axial clearance, Solidworks.

## I. INTRODUCTION

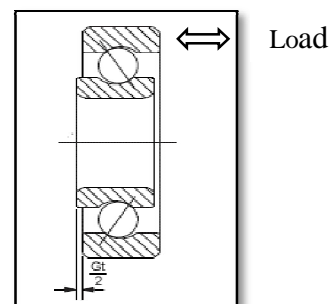
**V.B.Bhandari** [1] Bearing is mechanical element that permits relative motion between two parts, such as shaft and housing, with minimum friction. Bearing ensure free rotation of shaft or axle with minimum friction. Bearing supports the shafts or the axle and holds it in correct position.

**NTN Bearing** [2] Internal clearance is the total distance one ring moves relative to other radially (radial internal clearance) or axially (axial internal clearance).



**Fig No 1 : Radial Clearance**

The displacement generated by moving outer ring in radial direction while securing the inner ring.



**Fig No 2 : Axial Clearance**

The displacement generated by moving outer ring in axial direction while securing the inner ring.

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**NSK Bearing** [3] in bearing it is desirable to provide negative clearance to keep them suppressed called as “Preload”. Preloading helps in,

1. To maintain bearing in exact position both in radially and axially to maintain running accuracy of shaft.
2. To increase bearing rigidity.
3. Vibration and noise is also controlled.

Applying excessive preload results reduction of life, abnormal heating, increase in torque. Hence depending on type of application and objective amount of preload decided.

Bearing internal clearance is defined as the total distance through which one bearing ring can be moved relative to the other in the radial direction (radial internal clearance) or in the axial direction (axial internal clearance). Selection of bearing largely depends on bearing internal clearance hence it is necessary to classify them in categories so that they can be used.

**Table No 1:** Details of class of specification

| Sr no | suffix | Internal clearance  |
|-------|--------|---------------------|
| 1     | C1     | Smaller than C2     |
| 2     | C2     | Smaller than normal |
| 3     | CN     | Normal              |
| 4     | C3     | Greater than normal |
| 5     | C4     | Greater than C3     |
| 6     | C5     | Greater than C4     |

The work in this paper is divided in two stages. 1) Measuring Radial clearance 2) Measuring Axial Clearance. Radial clearance is measured by applying load by cylinder 1 in radial direction at that time dial gauge is set to zero. Then load applied in opposite direction radially by cylinder 2. reading on dial gauge will indicate radial clearance value. Similarly cylinder 3 activated in push mode then dial gauge is set to zero. When cylinder 3 activated in pull mode and corresponding dial gauge reading will indicate axial clearance. Reading are measured on ball and in between ball position.

## II. PROBLEM DEFINITION

This project aims to measure ball bearing radial and axial clearance. The measuring load is applied with the help of hydraulic cylinder. The size of ball bearing ranges from 15mm ID to 80mm ID. To find out probable solution in order to remove the clearance between mandrel and bearing id since it has effects on the clearance that is to be measured.

**Table No 2:-**Specification of Station1

| Sr. no. | Measuring range of Ball bearing | Station 1 |
|---------|---------------------------------|-----------|
| 1       | Inside Diameter                 | 15-80 mm  |
| 2       | Outside Diameter                | 25-130 mm |
| 3       | Width                           | 10-25 mm  |
| 4       | Load                            | 10-100 N  |
| 5       | Hydraulic Pressure              | 30 bar    |

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## III. MODELLING OF VARIOUS COMPONENT OF STATION 1

### 1. 3D Model of Arbor

We use arbor for mounting the mandrel of various sizes. There is locking arrangement is made for holding the mandrel in its position under the action of axial load. Fig no 3 shows 3D Model of arbor.

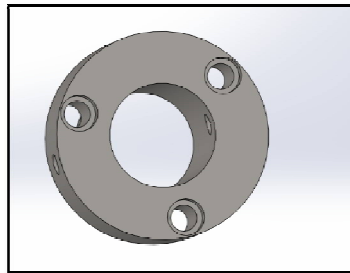


Fig No 3: 3D model of arbor

### 2. 3D Model of mandrel

We use mandrel for holding the bearing in correct place by means of spacer ring. V groove is provided on the bottom of mandrel that can be act as seat which is used for locking in arbor by means of Allen bolt.

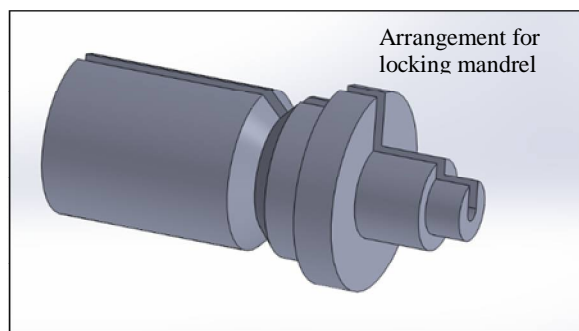


Fig No 4: 3D model of mandrel

### 3. Mechanism for accommodating varying ID bearings

This mechanism consist of assembly of slider, sliding, bolt and knob. Sliding is one which is fixed to main plate by means of 5mm bolts. Slider is one which slide on sliding for accommodating various size of bearing & also act as support for mounting of lever & hydraulic cylinder. After adjusting the slider depending upon the OD of bearing it is locked in its place by means of bolt and knob. Fig no 5 shows assembly of Sliding, Slider, bolt & knob respectively.

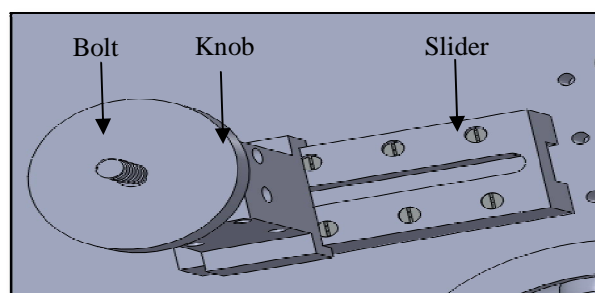


Fig No 5: Mechanism for accommodating varying size of bearing

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## 4. Tapered locking arrangement

This arrangement consist of  $\varnothing 10$  bolt which pass through the mandrel and tapered plate is bolted to threaded bolt by means of knob. This arrangement removes clearance between mandrel and bearing ID. Fig no 6 shows tapered locking arrangement.

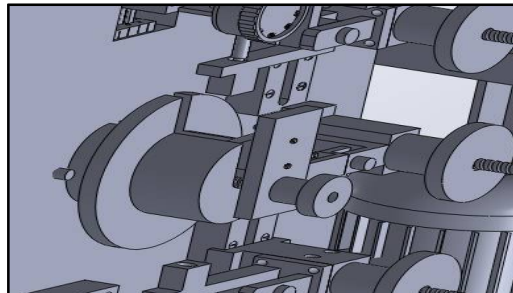


Fig No 6: Tapered locking arrangement

## IV. HYDRAULIC CIRCUIT WITH SEQUENCE OF OPERATION FOR STATION 1

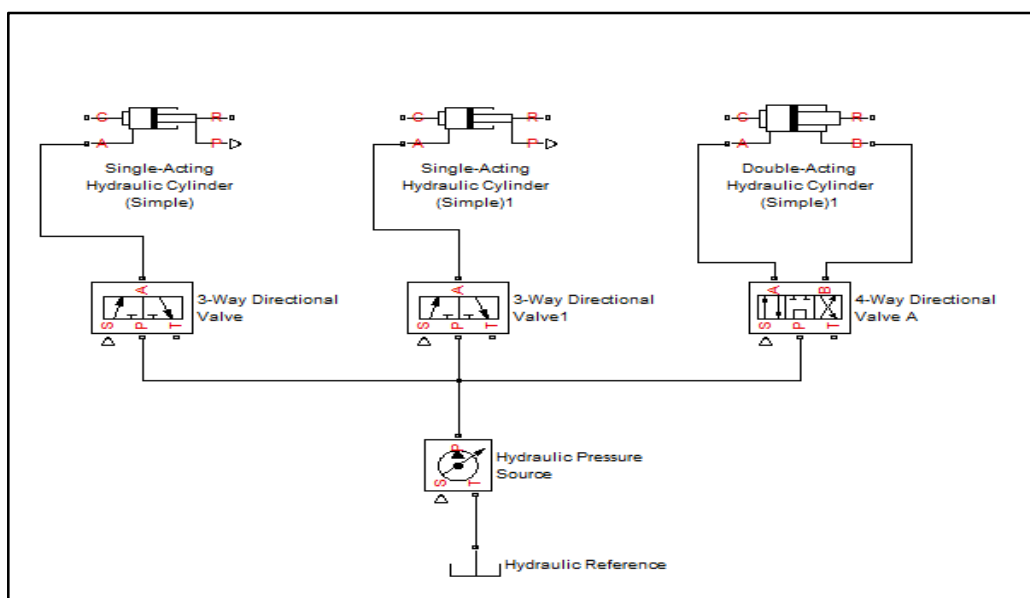
### 1. Nomenclature

- |                                  |            |
|----------------------------------|------------|
| 1. Cylinder for Radial clearance | Cylinder 1 |
| 2. Cylinder for Radial clearance | Cylinder 2 |
| 3. Cylinder for Axial clearance  | Cylinder 3 |

### 2. Sequence of operation:-

1. Actuating cylinder 1 until dial gauge is set to zero.
2. Releasing cylinder 1.
3. Actuating cylinder 2 until dial gauge reading is noted down.
4. Actuating cylinder 3 (in push mode) until dial gauge is set to zero.
5. Actuating cylinder 3 (in pull mode) until dial gauge reading noted down.

Fig No 7: Hydraulic circuit for Station 1



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## V. SELECTION OF HYDRAULIC CYLINDER

### 1. Hydraulic cylinder design for station 1:-

Design calculation for hydraulic piston

Known

Force: - 100 N

Fluid pressure: - 30 bar = 3 N/mm<sup>2</sup>

#### Step 1

Finding area of cross-section required

$$A = \frac{F}{P} = \frac{100}{3} = 33.33 \text{ mm}^2$$

#### Step 2

Calculation of piston diameter

$$D_p = \sqrt{\frac{4A}{\pi}} = 6.51 \text{ mm}$$

Internal diameter of cylinder is equal to piston diameter.

Available cylinder from Hypower clamps Product catalogue is 8mm bore diameter.  
Hence the selected cylinder is Manifold mounting cylinder part no 1703500.



Fig No 8: Manifold Mounting Cylinder

### 2. Hydraulic cylinder 2 design for station 1:-

Design calculation for hydraulic piston

Known

Force: - 500 N

Fluid pressure: - 30 bar = 3 N/mm<sup>2</sup>

#### Step 1

Finding area of cross-section required

$$A = \frac{F}{P} = \frac{500}{3} = 166.66 \text{ mm}^2$$

#### Step 2

Calculation of piston diameter

$$D_p = \sqrt{\frac{4A}{\pi}} = 14.56 \text{ mm}$$

Internal diameter of cylinder is equal to piston diameter.

Available cylinder from Hypower clamps Product catalogue is 8mm bore diameter.  
Hence the selected cylinder is Manifold mounting cylinder part no 2710200



Fig No 9: Compact cylinder

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## VI. VIRTUAL AND ACTUAL TEST RIG



**Fig No 10:** Virtual design Station 1



**Fig No 11:** Actual design Station 1

## VII. RESULTS AND DISCUSSION

1. Size of bearing (ID):- 80 mm
2. Manufacture Name :- NTN bearing

**Table No 3:**Radial & Axial Clearance for Station 1(On Ball & In between Ball)

| Sr no | Radial Clearance On Ball | Radial clearance In between ball | Axial clearance On ball | Axial clearance In between ball |
|-------|--------------------------|----------------------------------|-------------------------|---------------------------------|
| 1     | 7                        | 9                                | 50                      | 52                              |
| 2     | 6                        | 10                               | 52                      | 55                              |
| 3     | 6                        | 10                               | 51                      | 51                              |

\*\*\* All units are in  $\mu\text{m}$

**Table No 4:**Radial & Axial Clearance for Station 1(Removing & Without Removing)

| Sr no | Radial clearance Without removing | Radial clearance After removing | Axial clearance Without removing | Axial clearance After removing |
|-------|-----------------------------------|---------------------------------|----------------------------------|--------------------------------|
| 1     | 7                                 | 7                               | 50                               | 52                             |
| 2     | 6                                 | 5                               | 49                               | 49                             |
| 3     | 6                                 | 7                               | 51                               | 50                             |

\*\*\* All units are in  $\mu\text{m}$

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## **VIII. CONCLUSION**

1. From table No 3 it is clear that Clearance of bearing on ball is less than Clearance of the bearing in between ball.
2. From table No 4 it is clear that axial clearance is 8 to 10 time's radial clearance.

## **IX. FUTURE SCOPE**

The future work of this paper is to design machine that can measure the Radial and Axial Clearance of bearing size varying from ID 85 mm to 200 mm.

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