School of Mechanical Engineering

Course Code : BTME3025 Course Name:Machine Design

UNIT-5

Topic: Sliding Contact Bearing

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Learning OBJECTIVES:

- Objective and Classification of Lubrication
- Principle of hydrodynamic lubrication
- PETROFF'S Equation for Bearing Friction
- McKee's Investigation
- Thick Film Lubrication
- Nomenclature of a Journal Bearing

Lubrication is the science of reducing friction by application of a suitable substance called lubricant, between the rubbing surfaces of bodies having relative motion. The lubricants are classified into following three groups:

(i) Liquid lubricants like mineral or vegetable oils

(ii) Semi-solid lubricants like grease

(iii) Solid lubricants like graphite or molybdenum disulphide

- The objectives of lubrication are as follows:

(i) to reduce friction (ii) to reduce or prevent wear (iii) to carry away heat generated due to friction (iv) to protect the journal and the bearing from corrosion

- The basic modes of lubrication are thick and thin film lubrication

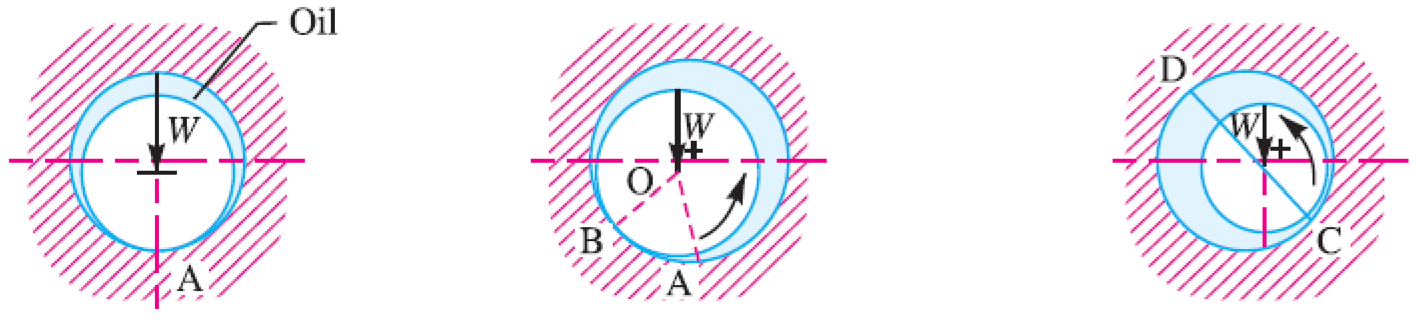
Principle of hydrodynamic lubrication

•Initially, the shaft is at rest (a) and it sinks to the bottom of the clearance space under the action of load *W. The surfaces of the journal and bearing touch during 'rest'.*

•As the journal starts to rotate, it climbs the bearing surface (b).

•As the speed is further increased, it forces the fluid into the wedge-shaped region (c).

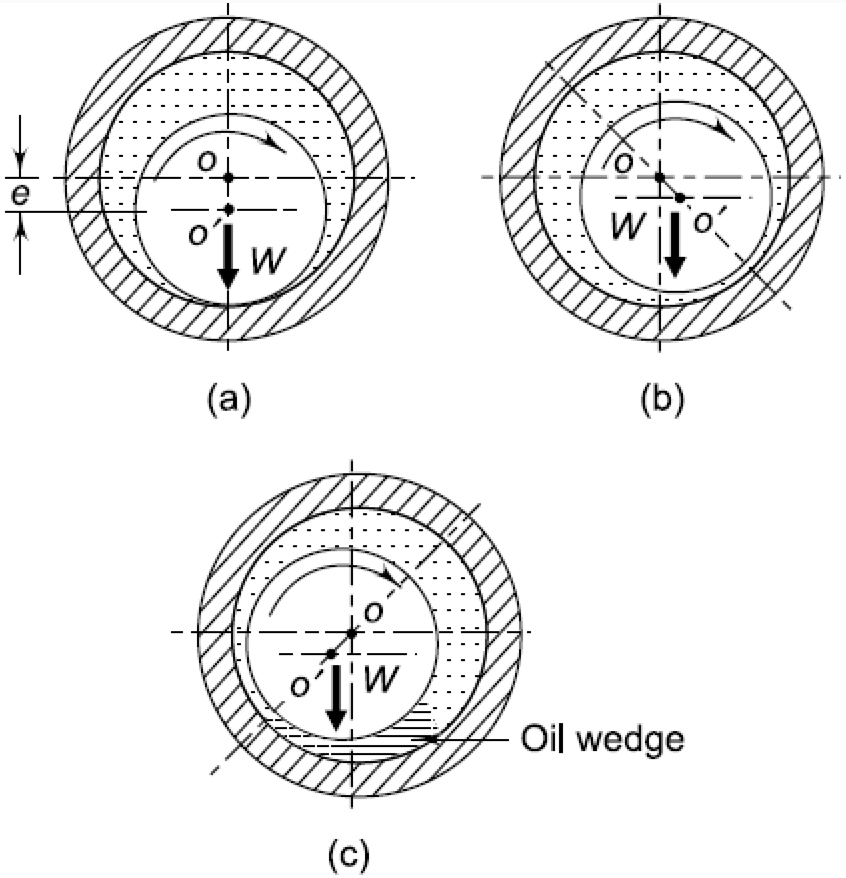
•Since more and more fluid is forced into the wedge-shaped clearance space, pressure is generated within the system.



(*a*) At rest. (*b*) Slow speed. (*c*) High speed.

The pressure distribution around the periphery of the journal is shown in Fig. 16.2.

- Since the pressure is created within the system due to rotation of the shaft, this type of bearing is known as *self-acting bearing.*
- The pressure generated in the clearance space supports the external load (*W*).



Petroff's equation is important because it defines the group of dimensionless parameters that govern the frictional properties of the bearing. Petroff published his work on bearing friction based on simplified assumptions.

No eccentricity between bearings and journal and hence there is no "Wedging action" as in Fig. a

Oil film is unable to support load.

No lubricant flow in the axial direction

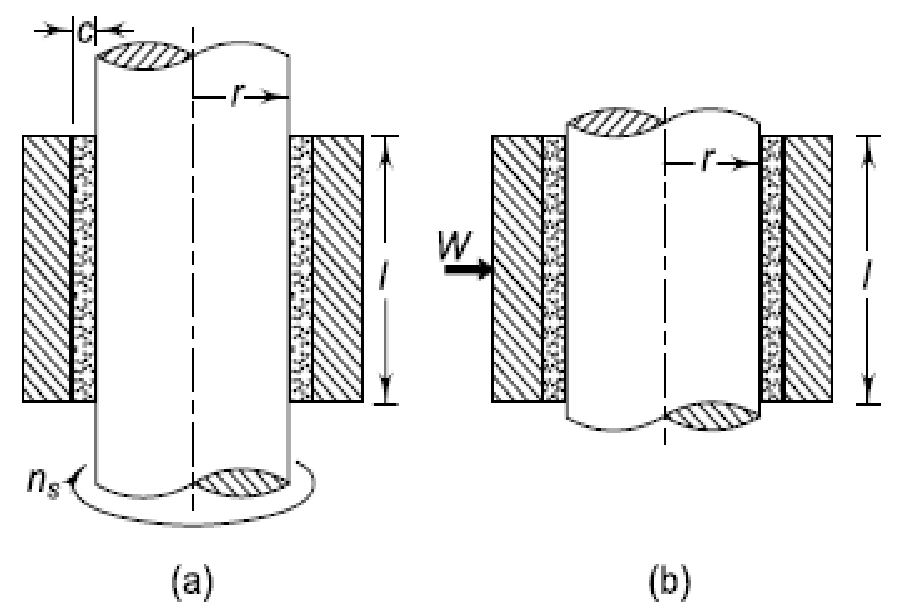
The velocity at the surface of the journal

is given by, **U = (2πr) ns**

From Newton's law of viscosity **P = μ AU /h**

Apply above equation for viscous flow through the annula

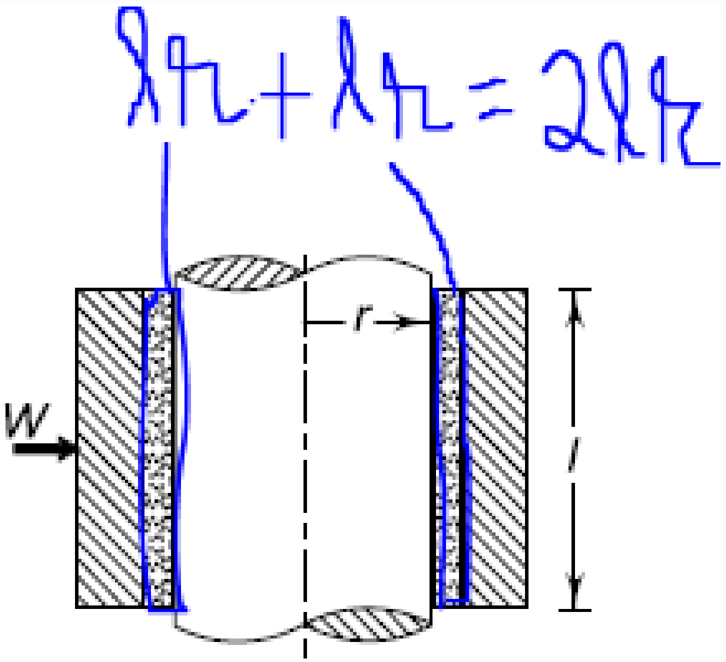
Journal and the bearing in the circumferential direction.



P = tangential frictional force
A = area of journal surface = $(2\pi r)l$
U = surface velocity = $(2\pi r)ns$
h = distance between journal and bearing surfaces = c

Frictional torque is given by

$$P = \mu(2\pi rl)(2\pi rn_s)\left(\frac{1}{c}\right) = \frac{4\pi^2 r^2 \mu l n_s}{c} \quad (1)$$



The unit bearing pressure (p) acting on the bearing is given by W=2prl

The frictional force will be (f W) and frictional torque will be (f Wr).

$$(M_t)_f = Pr = \frac{4\pi^2 r^3 \mu l n_s}{c} \quad (2)$$

From Eq 1 and 2

$$(M_t)_f = fWr = f(2plr)r = f(2plr^2)$$

$$f(2plr^2) = \frac{4\pi^2 r^2 \mu l n_s}{c} \qquad f = (2\pi^2)\left(\frac{r}{c}\right)\left(\frac{\mu n_s}{p}\right)$$

The first quantity in the bracket stands for bearing modulus and second one stands for clearance ratio. Both are dimensionless parameters of the bearing. Clearance ratio normally ranges from 500 to 1000 in bearings.

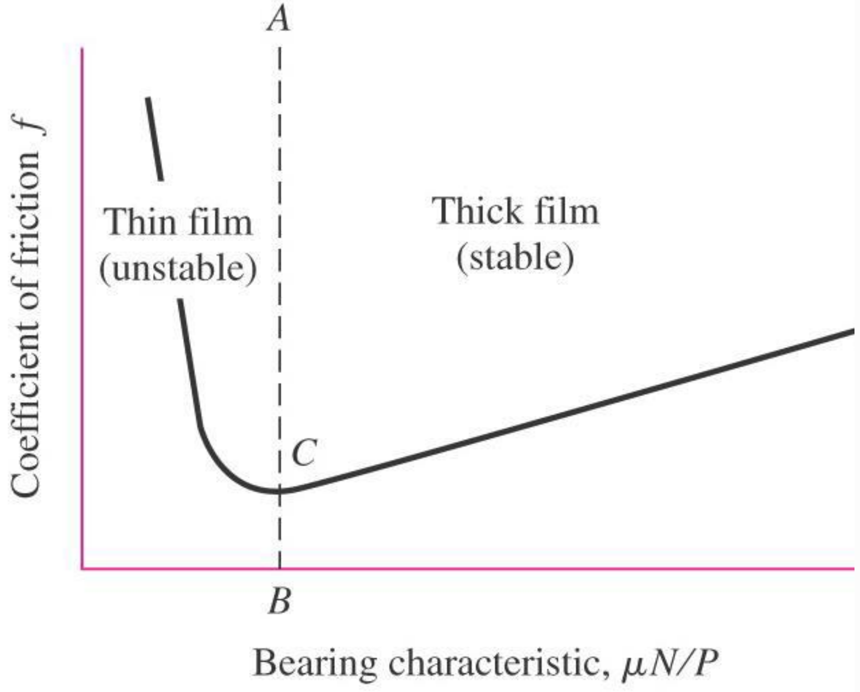
McKee's Investigation

In hydrodynamic bearings, initially the journal is at rest. There is no relative motion and no hydrodynamic film. Therefore, there is metal to metal contact between the surfaces of the journal and the bearing.

As the journal starts to rotate, it takes some time for the hydrodynamic film to build sufficient pressure in the clearance space. During this period, there is partial metal to metal contact and a partial lubricant film. This is thin film lubrication.

As the speed is increased, more and more lubricant is forced into the wedge-shaped clearance space and sufficient pressure is built up, separating the surfaces of the journal and the bearing. This is thick film lubrication. Therefore, there is a transition from thin film lubrication to thick film lubrication as the speed increases.

The transition from thin film lubrication to thick film hydrodynamic lubrication can be better visualized by means of a curve called *μN/p curve.*

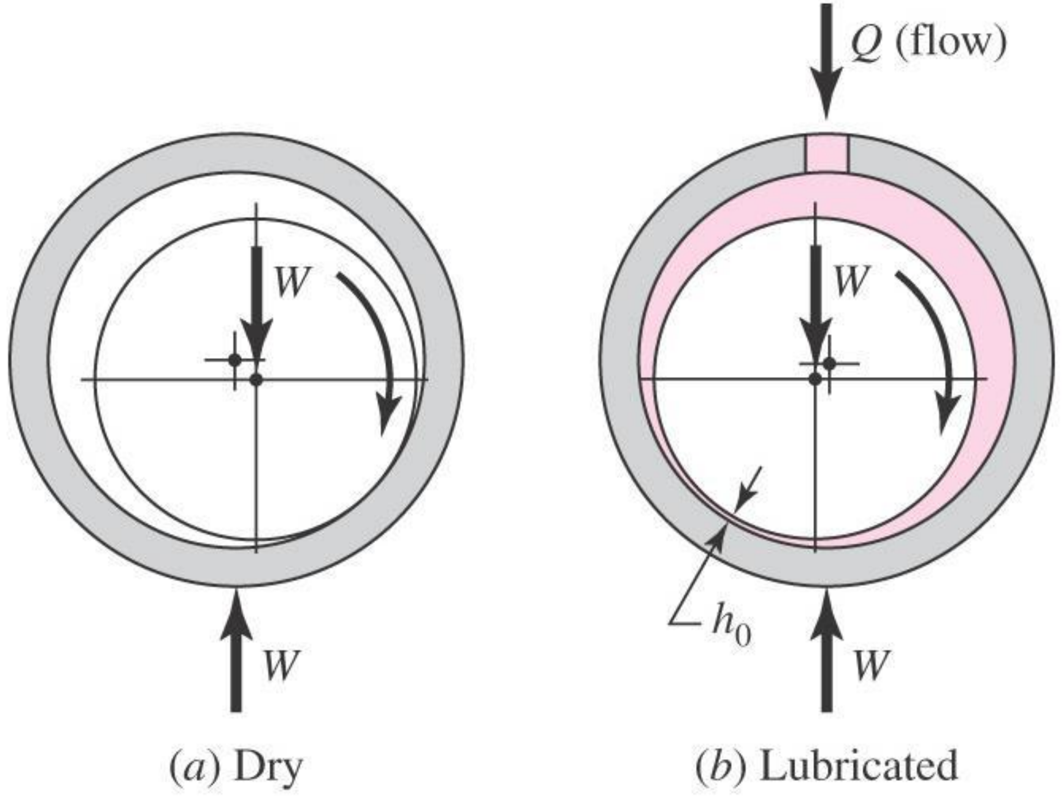


Stable Lubrication

- To the right of *AB, changes in conditions are self-correcting and results in stable lubrication*
- To the left of *AB, changes in conditions tend to get worse and results in unstable lubrication*
- Point *C represents the approximate transition between metal-to-metal contact and thick film separation of the parts*
- Common design constraint for point *B,* $\frac{\mu N}{P} \geq 1.7(10^{-6})$

Thick Film Lubrication

- Thick film lubrication describes a condition of lubrication, where two surfaces of the bearing in relative motion are completely separated by a film of fluid.

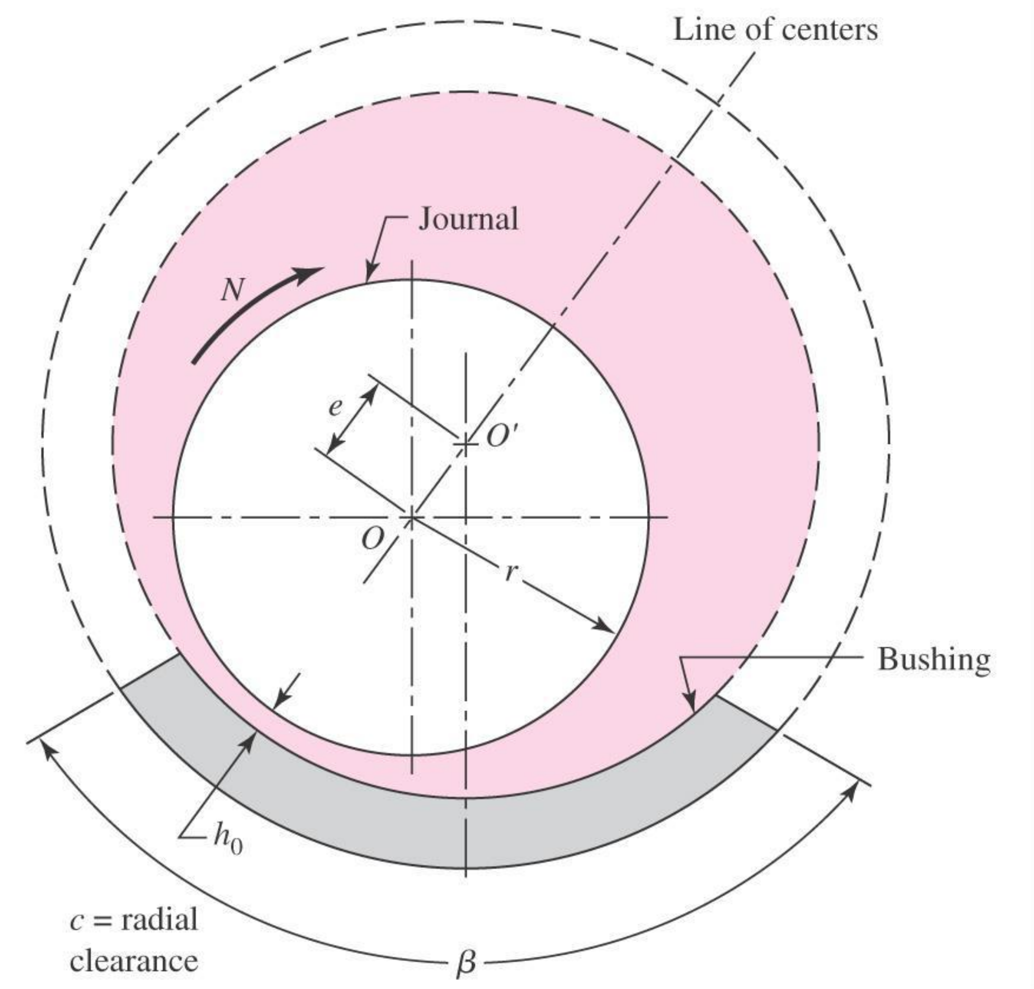


- *A journal bearing is a sliding contact bearing working on hydrodynamic lubrication and which supports the load in radial direction. The portion of the shaft inside the bearing is called journal and hence the name 'journal' bearing.*

Nomenclature of a Journal Bearing

Center of journal at *O*

- Center of bearing at *O'*
- *Eccentricity e*
- *Minimum film thickness h0occurs at line of centers*
- Film thickness anywhere is *h*
- *Eccentricity ratio*
- *Partial bearinghas b< 360*
- *Full bearing has b= 360*
- *Fitted bearing has equal radii of bushing and journal*



Questions for Practice

- In case of partial bearing, the angle of contact of the bushing with the journal is …
- A thick film bearing is a bearing
  - (I)where the surfaces of journal and the bearing are completely separated by a film of lubricant
  - (II)where the surfaces of journal and the bearing are partially separated by a film of lubricant and there is partial metal to metal contact
  - (III)where there is no lubricant
  - (IV)where the surfaces of journal and the bearing are separated by a film created by elastic deflection of parts
- Give two applications of hydrodynamic journal bearings.
- What is bearing characteristic number as applied to the journal bearing?

References

1. https://nptel.ac.in/content/storage2/courses/112105125/pdf/mod10les4.pdf
2. V.B. Bhandari (2010), Design of Machine elements, 3rd Edition, Tata McGraw Hill.ISBN: 978-0-070-68179-8.
3. Richard G. Budynas, J. Keith Nisbet(2011) Shigley's Mechanical Engineering Design ,Ninth Edition, McGRAW-HILL, ISBN: 978-0-07-352928-8

Thank you