HYDRODYNAMIC LUBRICATION:

Journal bearings – Analytical solutions

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1. Introduction

Journal bearings are used to support shafts and to carry radial loads with minimum power loss and minimum wear. The journal bearing can be represented by a plain cylindrical sleeve wrapped around the shaft (journal), but the bearings can adopt a variety of forms. The lubricant is supplied at some convenient point in the bearing through a hole or a groove. If the bearing extends around the full 360° of the journal, it is described as a "full journal bearing". If the angle of wrap is less than 360°, the term "partial journal bearing" is used.

Journal bearings rely on shaft motion to generate the load-supporting pressures in the lubricant film. The geometry of the journal bearing is shown in *figure 1*. The shaft does not normally run concentric with the bearing. The displacement of the shaft center relative to the bearing center is known as the 'eccentricity'. The shaft's eccentric position within the bearing clearance is influenced by the load that is carries. The amount of eccentricity adjusts itself until the load is balanced by the pressure generated in the converging lubricating film. The line drawn through the shaft center and the bearing center is called the "line of centers".

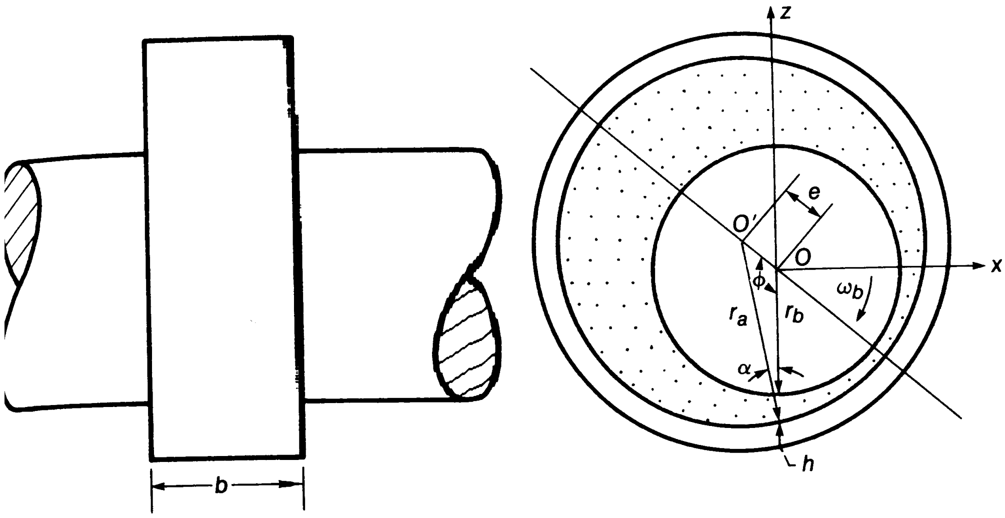

Figure 1: Hydrodynamic journal bearing geometry

The pressure generated and therefore the load-carrying capacity of the bearing depend on the shaft eccentricity, the angular velocity, the effective viscosity of the lubricant, and the bearing dimensions and clerance.

The load and the angular velocity are usually specified and the minimum shaft diameter is often predetermined. To complete the design, it will be necessary to calculate the bearing dimensions and clearance and to choose a suitable lubricant if this is not already specified.

After an important discussion on the boundary conditions that can be used, two approximate journal bearing solutions will be given: (1) for an infinite-width journal bearing (side leakage neglected) and (2) for a short-width-journal bearing.

2. <u>Boundary conditions</u>

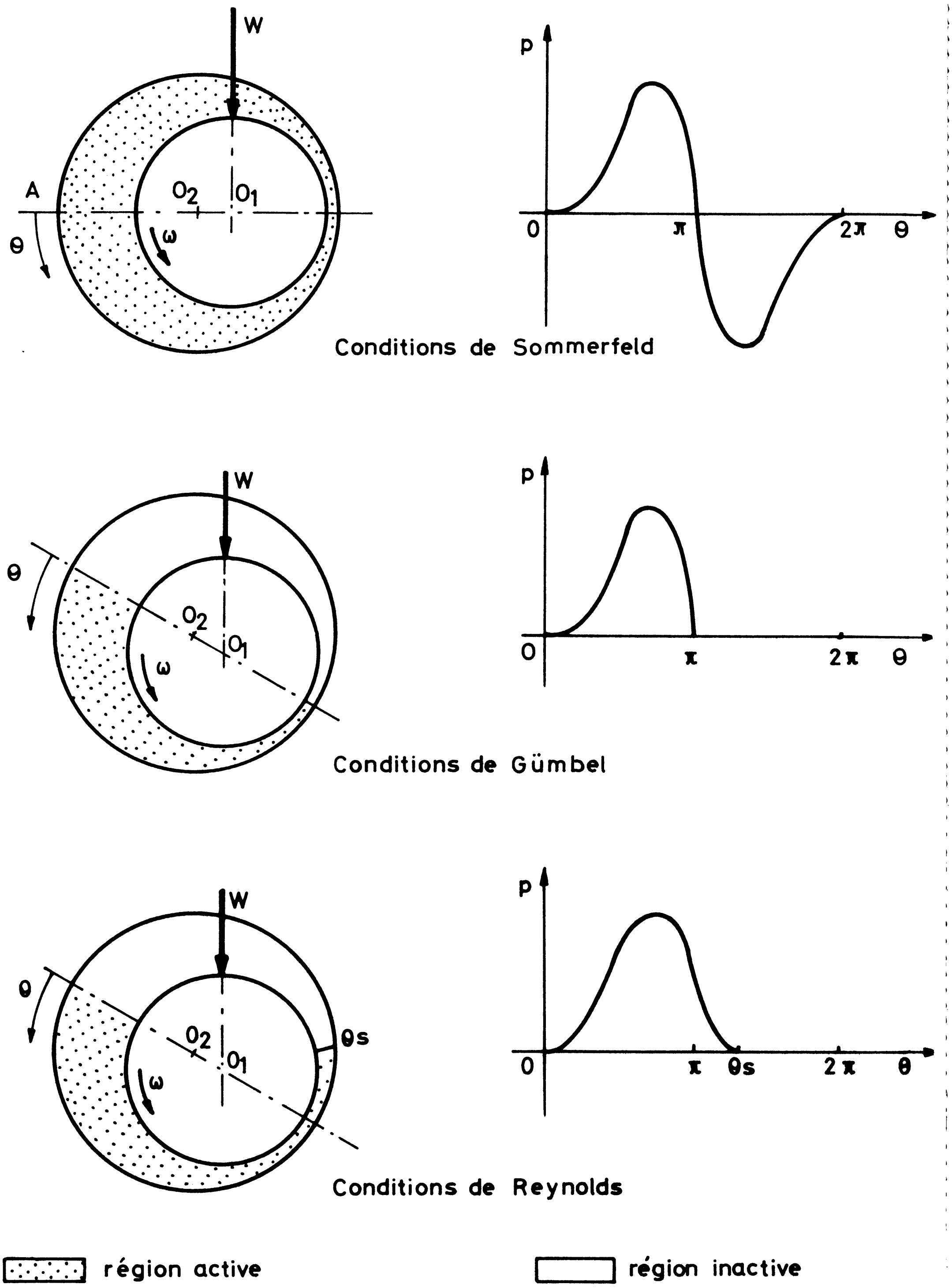

Fig. 2 : Répartition de pression pour les différentes conditions aux limites

3. Infinitely wide-journal-bearing solution

1. Show that the lubricant film thickness $h(\theta)=C(1+\varepsilon.\cos\theta)$

2. Give the simplified form of the Reynolds equation in the case where

2.1 the reference frame is attached to the bearing

2.2 the reference frame is attached to the shaft

4. Short-width-journal bearing theory

3. Determine the pressure profile

4. The load-carrying capacity W and the attitude angle Φ.

5. The side-leakage fluid flow

6. The friction torque

6.1 Acting on the shaft

6.2 Acting on bearing

6.3 Check the equilibrium of the bearing

L/D = 1/2

ε	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95
S	4,32	2,03	1,21	0,784	0,508	0,3180	0,184	0,0912	0,0309	0,0116
ϕ	82	75	68,5	61,53	55	48	41	33	23,5	17
$\frac{R}{C} f_a$	82,10	37,71	22,55	14,75	9,94	6,67	4,33	2,59	1,27	0,70
Q/(LCV)	0,0938	0,187	0,281	0,374	0,468	0,562	0,657	0,751	0,845	0,890
$\overline{C}_a$	19	18,57	18,64	18,81	19,57	20,97	23,53	28,4	41,1	60,34

L/D = 1

ε	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95
S	1,33	0,631	0,388	0,260	0,178	0,120	0,0776	0,0443	0,0185	0,00831
ϕ	79,5	74	68	62,5	56,5	50,5	44	36	26	19
$\frac{R}{C} f_a$	25,36	11,87	7,35	5,07	3,67	2,70	1,99	1,40	0,859	0,563
Q/(LCV)	0,0801	0,159	0,237	0,314	0,390	0,466	0,542	0,616	0,688	0,721
$\overline{C}_a$	19,06	18,81	18,94	19,5	20,62	22,5	25,64	31,6	46,43	67,75

L/D = 2

ε	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95
S	0,559	0,271	0,173	0,122	0,0893	0,0654	0,0463	0,0297	0,0143	0,00707
ϕ	75	71	67	62,5	58	52,5	46,5	39	29	21
$\frac{R}{C} f_a$	10,76	5,21	3,40	2,50	1,96	1,60	1,31	1,04	0,730	0,517
Q/(LCV)	0,0538	0,104	0,153	0,199	0,243	0,285	0,329	0,369	0,406	0,422
$\overline{C}_a$	19,25	19,22	19,65	20,49	21,95	24,46	28,29	35,01	51,05	73,12

"Palier long" : L/D ≥4

ε	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95
S	0,247	0,123	0,0823	0,0628	0,0483	0,0389	0,0297	0,0211	0,0114	0,00605
ϕ	69	67	64	62	58	54	49	42	32	23
$\frac{R}{C} f_a$	5,02	2,61	1,84	1,47	1,25	1,10	0,98	0,852	0,658	0,494
$\overline{C}_a$	19,54	19,85	20,68	22,03	24,03	26,89	31,39	38,80	55,42	78,42