SLOVENSKI STANDARD
SIST ISO 12167-1:2002

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Drsni leǵaji - Hidrostatiļ ni radialni drsni leǵaji z drenaǵnimi ǵlebovi pri stacionarnih pogojih obratovanja - 1. del: Preraļ un oljnih hidrostatiļ nih radialnih drsnih leǵajev z odtoļ nimi ǵlebovi

Plain bearings -- Hydrostatic plain journal bearings with drainage grooves under steady-state conditions -- Part 1: Calculation of oil-lubricated plain journal bearings with drainage grooves

Paliers lisses -- Paliers lisses radiaux hydrostatiques avec rainures d'écoulement fonctionnant en régime stationnaire -- Partie 1: Calcul pour la lubrification des paliers lisses radiaux avec rainures d'écoulement

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INTERNATIONAL STANDARD

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Plain bearings — Hydrostatic plain journal bearings with drainage grooves under steady-state conditions —

Part 1: Calculation of oil-lubricated plain journal bearings with drainage grooves

Paliers lisses — Paliers lisses radiaux hydrostatiques avec rainures d'écoulement fonctionnant en régime stationnaire —

Partie 1: Calcul pour la lubrification des paliers lisses radiaux avec rainures d'écoulement

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 12167 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12167-1 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 4, *Methods of calculation of plain bearings*.

ISO 12167 consists of the following parts, under the general title *Plain bearings — Hydrostatic plain journal bearings with drainage grooves under steady-state conditions*:

— *Part 1: Calculation of oil-lubricated plain journal bearings with drainage grooves*

— *Part 2: Characteristic values for the calculation of oil-lubricated plain journal bearings with drainage grooves*

Annexes A and B form a normative part of this part of ISO 12167.

Introduction

The functioning of hydrostatic bearings is characterized by the fact that the supporting pressure of the bearing is generated by external lubrication. The special advantages of hydrostatic bearings are lack of wear, quiet running, wide useable speed range as well as high stiffness and damping capacity. These properties also demonstrate the special importance of plain journal bearings in different fields of application such as e.g. machine tools.

Basic calculations described in this part of ISO 12167 may be applied to bearings with different numbers of recesses and different width/diameter ratios for identical recess geometry.

Oil is fed to each bearing recess by means of a common pump with constant pumping pressure (system p_{en} = constant) and through preceding linear restrictors, e.g. capillaries.

The calculation procedures listed in this part of ISO 12167 enable the user to calculate and assess a given bearing design as well as to design a bearing as a function of some optional parameters. Furthermore, this part of ISO 12167 contains the design of the required lubrication system including the calculation of the restrictor data.

Plain bearings — Hydrostatic plain journal bearings with drainage grooves under steady-state conditions —

Part 1: Calculation of oil-lubricated plain journal bearings with drainage grooves

1 Scope

This part of ISO 12167 applies to hydrostatic plain journal bearings under steady-state conditions.

In this part of ISO 12167 only bearings with oil drainage grooves between the recesses are taken into account. As compared to bearings without oil drainage grooves, this type needs higher power with the same stiffness behaviour.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12167. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12167 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3448:1992, *Industrial liquid lubricants — ISO viscosity classification*

ISO 12167-2:2001, *Plain bearings — Hydrostatic plain journal bearings with drainage grooves under steady-state conditions — Part 2: Characteristic values for the calculation of oil-lubricated plain journal bearings with drainage grooves*

3 Bases of calculation and boundary conditions

Calculation in accordance with this part of ISO 12167 is the mathematical determination of the operational parameters of hydrostatic plain journal bearings as a function of operating conditions, bearing geometry and lubrication data. This means the determination of eccentricities, load-carrying capacity, stiffness, required feed pressure, oil flow rate, frictional and pumping power, and temperature rise. Besides the hydrostatic pressure build-up the influence of hydrodynamic effects is also approximated.

Reynolds' differential equation furnishes the theoretical basis for the calculation of hydrostatic bearings. In most practical cases of application it is, however, possible to arrive at sufficiently exact results by approximation.

The approximation used in this part of ISO 12167 is based on two basic equations intended to describe the flow via the bearing lands, which can be derived from Reynolds' differential equation when special boundary conditions are observed. The Hagen-Poiseuille law describes the pressure flow in a parallel clearance gap and the Couette equation the drag flow in the bearing clearance gap caused by shaft rotation. A detailed presentation of the theoretical background of the calculation procedure is included in annex A.

The following important premises are applicable to the calculation procedures described in this part of ISO 12167:

a) all lubricant flows in the lubrication clearance gap are laminar;

b) the lubricant adheres completely to the sliding surfaces;

c) the lubricant is an incompressible Newtonian fluid;

d) in the whole lubrication clearance gap as well as in the preceding restrictors the lubricant is partially isoviscous;

e) a lubrication clearance gap completely filled with lubricant is the basis of frictional behaviour;

f) fluctuations of pressure in the lubricant film normal to the sliding surfaces do not take place;

g) half bearing and journal have completely rigid surfaces;

h) the radii of curvature of the surfaces in relative motion to each other are large in comparison to the lubricant film thickness;

i) the clearance gap height in the axial direction is constant (axial parallel clearance gap);

j) the pressure over the recess area is constant;

k) there is no motion normal to the sliding surfaces.

With the aid of the above-mentioned approximation equations, all parameters required for the design or calculation of bearings can be determined. The application of the similarity principle results in dimensionless similarity values for load-carrying capacity, stiffness, oil flow rate, friction, recess pressures, etc.

The results indicated in this part of ISO 12167 in the form of tables and diagrams are restricted to operating ranges common in practice for hydrostatic bearings. Thus the range of the bearing eccentricity (displacement under load) is limited to ε = 0 to 0,5.

Limitation to this eccentricity range means a considerable simplification of the calculation procedure as the load-carrying capacity is a nearly linear function of the eccentricity. However, the applicability of this procedure is hardly restricted as in practice eccentricities $\varepsilon > 0,5$ are mostly undesirable for reasons of operational safety. A further assumption for the calculations is the approximated optimum restrictor ratio [1] $\xi = 1$ for the stiffness behaviour.

As for the outside dimensions of the bearing, this part of ISO 12167 is restricted to the range bearing width/bearing diameter B/D = 0,3 to 1 which is common in practical cases of application. The recess depth is larger than the clearance gap height by the factor 10 to 100. When calculating the friction losses, the friction loss over the recess in relation to the friction over the bearing lands can generally be neglected on account of the above premises. However, this does not apply when the bearing shall be optimized with regard to its total power losses.

To take into account the load direction of a bearing, it is necessary to distinguish between the two extreme cases, load in the direction of recess centre and load in the direction of land centre.

Apart from the afore-mentioned boundary conditions, some other requirements are to be mentioned for the design of hydrostatic bearings in order to ensure their functioning under all operating conditions. In general, a bearing shall be designed in such a manner that a clearance gap height of at least 50 % to 60 % of the initial clearance gap height is assured when the maximum possible load is applied. With this in mind, particular attention shall be paid to misalignments of the shaft in the bearing due to shaft deflection which may result in contact between shaft and bearing edge and thus in damage of the bearing. In addition, the parallel clearance gap required for the calculation is no longer present in such a case.

In the case where the shaft is in contact with the bearing lands when the hydrostatic pressure is switched off, it might be necessary to check the contact zones with regard to rising surface pressures.

It shall be assured that the heat originating in the bearing does not lead to a non-permissible rise in the temperature of the oil.

If necessary, a means of cooling the oil shall be provided. Furthermore, the oil shall be filtered in order to avoid choking of the capillaries and damage to the sliding surfaces.

Low pressure in the relieved recess shall also be avoided, as this leads to air being drawn in from the environment and this would lead to a decrease in stiffness (see 5.7).

4 Symbols, terms and units

See Table 1.

Table 1 — Symbols, terms and units

Symbol	Term	Unit
a	Inertia factor	1
A_{lan}	Land area	m^2
A^*_{lan}	Relative land area $\left(A^*_{lan} = \dfrac{A_{lan}}{\pi \times B \times D}\right)$	1
A_p	Recess area	m^2
b	Width perpendicular to the direction of flow	m
b_{ax}	Width of axial outlet $\left[b_{ax} = \dfrac{\pi \times D}{Z} - (l_c + b_G)\right]$	m
b_c	Width of circumferential outlet $(b_c = B - l_{ax})$	m
b_G	Width of drainage groove	m
B	Bearing width	m
c	Stiffness coefficient	N/m
c_p	Specific heat capacity of the lubricant (p = *constant*)	J/kg·K
C_R	Radial clearance $\left[C_R = (D_B - D_J)/2\right]$	m
d_{cp}	Diameter of capillaries	m
D	Bearing diameter (D_J: shaft; D_B: bearing; $D \approx D_J \approx D_B$)	m
e	Eccentricity (shaft displacement)	m
F	Load-carrying capacity (load)	N
F^*	Characteristic value of load-carrying capacity [$F^* = F/(B \times D \times p_{en})$]	1
F^*_{eff}	Characteristic value of effective load-carrying capacity	1
$F^*_{eff,0}$	Characteristic value of effective load-carrying capacity for $N = 0$	1
h	Local lubricant film thickness (clearance gap height)	m
h_{min}	Minimum lubricant film thickness (minimum clearance gap height)	m
h_p	Depth of recess	m

Table 1 (*continued*)

Symbol	Term	Unit
K_{rot}	Speed-dependent parameter	1
l	Length in the direction of flow	m
l_{ax}	Axial land length	m
l_c	Circumferential land length	m
l_{cp}	Length of capillaries	m
N	Rotational frequency (speed)	s^{-1}
p	Recess pressure, general	Pa
$\bar{p}$	Specific bearing load [$\bar{p} = F/(B \times D)$]	Pa
p_{en}	Feed pressure (pump pressure)	Pa
p_i	Pressure in recess i	Pa
$p_{i,0}$	Pressure in recess i, when $\varepsilon = 0$	Pa
P^*	Power ratio ($P^* = P_f/P_p$)	1
P_f	Frictional power	W
P_p	Pumping power	W
P_{tot}	Total power ($P_{tot} = P_p + P_f$)	W
P^*_{tot}	Characteristic value of total power	1
Q	Lubricant flow rate (for complete bearing)	m^3/s
Q^*	Lubricant flow rate parameter	1
R_{cp}	Flow resistance of capillaries	$Pa \cdot s/m^3$
$R_{lan,ax}$	Flow resistance of one axial land $\left(R_{lan,ax} = \frac{12 \times \eta \times l_{ax}}{b_{ax} \times C_R^3} \right)$	$Pa \cdot s/m^3$
$R_{lan,c}$	Flow resistance of one circumferential land $\left(R_{lan,c} = \frac{12 \times \eta \times l_c}{b_c \times C_R^3} \right)$	$Pa \cdot s/m^3$
$R_{P,0}$	Flow resistance of one recess, when $\varepsilon = 0$, $\left(R_{P,0} = \frac{R_{lan,ax}}{2 \times (1+\kappa)} \right)$	$Pa \cdot s/m^3$
Re	Reynolds number	1
So	Sommerfeld number	1
T	Temperature	°C
ΔT	Temperature difference	K
u	Flow velocity	m/s
U	Circumferential speed	m/s
$\bar{w}$	Average velocity in restrictor	m/s
Z	Number of recesses	1