AN INFLUENCE OF BEARING LENGTH ON IT'S PERFORMANCE DATA

Anna Krzymień
Institute of Combustion Engines and Transportation
Poznań University of Technology ul. Piotrowo 3, 60-965 Poznań
tel.: +48(61) 665 22 39, fax: +48(61) 665 22 04
e-mail: Anna.Krzymien@put.poznan.pl

Abstract

A number of technical data that assure optimal conditions of bearing run should be foreseen in order to achieve a reliable operation and compact design of engine crank mechanism. The bearing length belongs to those most important factors at the stage of bearing design or redesign. The length decisively affects the load carrying capacity as well as hydrodynamic parameters.

An effect of bearing length on performance data is to be presented on the basis of computer calculation results. The presented results of computations show an exceptional effect of bearing length on parameters of its run. An increase in bearing effective length gives an increase in oil film thickness and decrease in maximum hydrodynamic pressure.. Beside the rotational speed, engine loading and bearing clearance the bearing length belongs to the factors of the most significant effect on bearing operation.

1. Introduction

Proper operation of crank mechanism bearings is one of basic conditions of engine reliable run. A thorough analysis of bearing run conditions results from high requirements in relation to engine reliability and durability. New constructions force modernization of bearing knots both in design as well as material aspect.

Correct design of engine bearings requires overcome the difficulties resulting from dimensional limitations that are caused by bore diameter, distance between cylinders, dimensions, rigidity and weight of connecting rod, cooling system and other factors that limit the diameter of journal and the bearing effective length. Bearing optimal design – the crank one in particular – is a very difficult task, due to the very narrow margin of maneuver.

The bearing length is the one of the most important constructional parameters affecting the bearing operation. The bush length is the effective axial length of the bush which takes part in carrying the load. It significantly affects the bearing performance data as well as the elastic deformation of bush and the relative deformation of journal.

2. Calculations of the parameters of engine bearing run and their analysis

The studies [2, 3, 5] present the theoretical foundations of hydrodynamic calculations of engine crank mechanism bearings.

The very calculations have been carried out for the 4CT90 engine made by the Diesel Engine Factory ANDORIA S.A., Andrychów, Poland. The engine basic performance data have been presented in the study [4]. The MB30 alloy has been selected as the bearing material [1]. The most loaded main bearing B has been subjected to the analysis. The design of bush has been presented in Fig. 2 and the courses of bearing loading for 2500 rpm (maximum torque) and 4100 rpm (maximum power) velocities – in Fig. 3.

When analyzing the effect of bearing length on parameters of its operation following quantities have been selected for computations:

– b/d^* = 0.143 (b = 0.0100 m),
– b/d = 0.163 (b= 0.0114 m),

[*] Most often the bearing length relates to the bearing nominal diameter and is presented as b/d ratio.

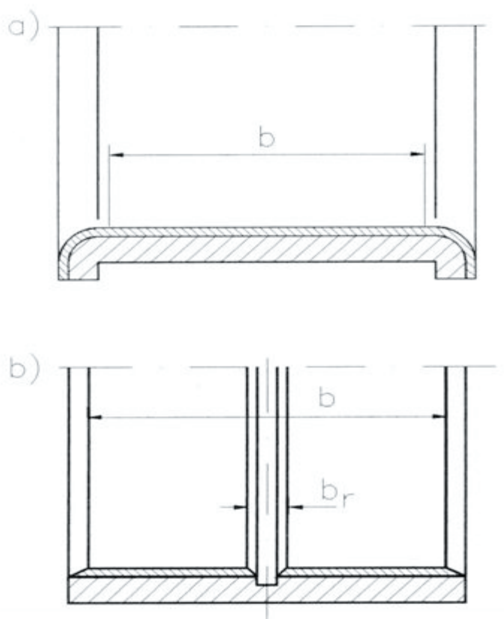
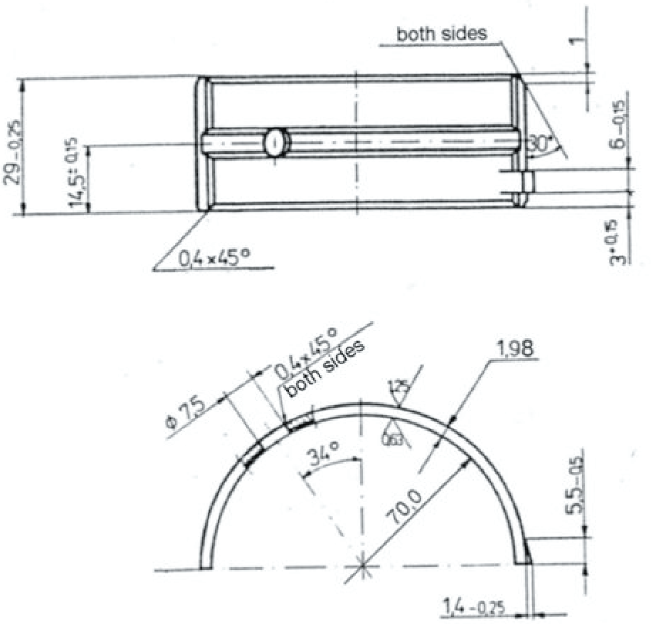
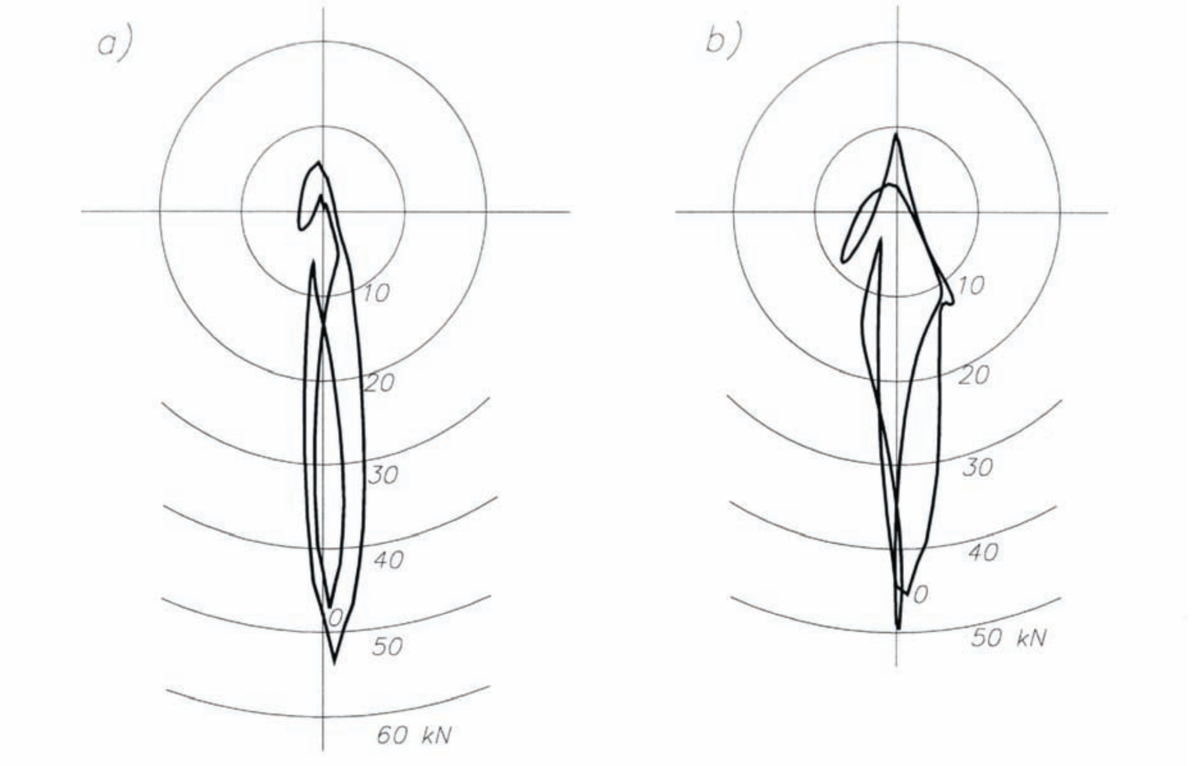


Fig. 1. Definition of the bearing effective length for the bush without (a) and with the groove (b)



bearing nominal diameter d = 0.070 m
half of grooved bearing effective length b = 0.01142 m

Fig. 2. Design of main bearing bush B



n = 2500 rpm	n = 4100 rpm
P_{max} = 53.37 kN	P_{max} = 49.69 kN
P_{mean} = 11.30 kN	P_{mean} = 13.43 kN
p_{max} = 33.38 MPa	p_{max} = 31.04 MPa
p_{mean} = 7.07 MPa	p_{mean} = 8.40 MPa

Fig. 3. Course of the main bearing B polar load diagram

– b/d = 0.220 (b = 0.0154 m),
– b/d = 0.286 (b = 0.0200 m).

Other data: bearing specific clearance $\psi = 0.99 \cdot 10^{-3}$, LOTOS 15W/40 mineral oil of following properties:

– viscosity at 100 °C $\nu_{100} = 14.2 \cdot 10^{-6}$ m²/s,
– viscosity at 50 °C $\nu_{50} = 63.0 \cdot 10^{-6}$ m²/s,
– density at 20 °C $\rho = 878$ kg/m³,

and oil pressure at inlet to bearing $p_o = 4.4 \cdot 10^5$ Pa.

Putting these data to the program, following operational parameters of the main bearing B have been determined:

h_{min} – oil film minimum thickness,
$(p_{max})_{max}$ – oil film maximum pressure,
ε_{mean} – mean relative eccentricity,
T_{mean} – mean temperature of bearing run,
η_{mean} – oil mean dynamic viscosity,
N_t – power necessary to overcome the frictional resistance,
V_{ol} – intensity of oil flow through the bearing.

The obtained results have been presented in Fig. 4 in a form of diagram.

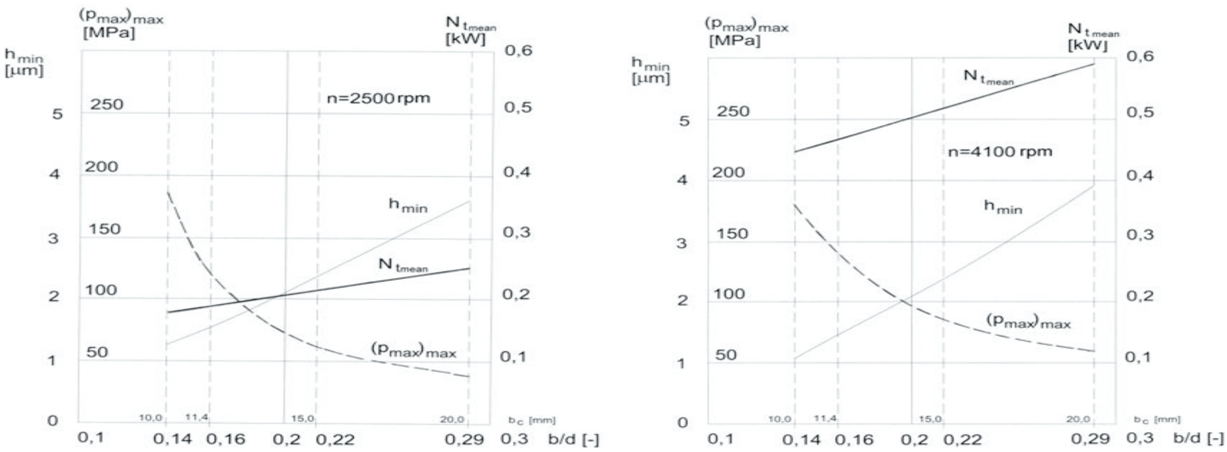


Fig. 4. Dependence of minimum oil film thickness h_{min}, maximum oil film pressure $(p_{max})_{max}$ and mean friction power N_{tmean} on bearing length b_c (bearing with circumferrential groove)

This diagram has been prepared for two crankshaft velocities and contains such hydrodynamic parameters as h_{min}, $(p_{max})_{max}$, and N_{tmean} depending on bearing length. An extremely high effect of bearing length on operational parameters analyzed could be noticed in this diagram. An increase in bearing length results in the rise of oil film thickness and mean friction power as well as decrease in maximum hydrodynamic pressure. The change in bush length from b = 10 mm to b=15 mm almost doubles the oil film minimum thickness and decreases the maximum hydrodynamic pressure triple fold for n= 2500 rpm, and double fold for n= 4100 rpm.

The fluid lubrication has been encountered for all analyzed bearing lengths, because the oil film thickness exceeds the value of h_{dop}. It is assumed that for thoroughly made bearings, properly installed and run-in the value of h_{min} should exceed 1 μm.

The value of maximum oil film pressure makes the basis for determination of regions where a hazard of arising the fatigue cracks which are the result of pressure pulsations appears. In the case of bearing analyzed along with the rise in its length, the drop in maximum pressure is being observed which is extremely advantageous because the overloading of bearing material leads to the damage of bearing bush.

Knowledge of bearing run temperature is fundamental (beside the specific load) for proper selection of bearing material and a number of parameters connected with oil flow. The mean temperature of bearing run does not exceed that allowable for the material used for different b/d ratios. The values of temperature differ each other slightly and a little temperature fall is observed along with the increase in bearing length.

On the basis of computational results obtained for the 4CT90 engine main bearing B of effective length b_c = 0.01142 m (b/d = 0.163) (see Fig. 2) one might conclude that the 3.6 mm increase in bearing length would cause the increase in oil film thickness of about 1 μm (up to 2.4 μm) and a parallel drop of maximum hydrodynamic pressure from 133.5 MPa to 68.5MPa (for n = 2500 rpm). Such change in length would improve the operational conditions of the bearing. However, one should remember that the increase in bearing length affects its stiffness and stringent requirements relative to the macrogeometry of journal and collaborating bush.

3. Final remarks

The presented results of computations show an exceptional effect of bearing length on parameters of its run. An increase in bearing effective length gives an increase in oil film thickness and decrease in maximum hydrodynamic pressure. So, it is possible to manipulate the both most important parameters of bearing operation through the increase in bearing length already at the design stage. Beside the rotational speed, engine loading and bearing clearance the bearing length belongs to the factors of the most significant effect on bearing operation.

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