

Reciprocating-piston engine

- // The invention relates to a reciprocating-piston engine, in particular to a large two-stroke diesel engine, having at least one cylinder, the cylinder lining of which in the region of its running surface facing the associated piston is provided with at least one groove so as to form an oil pocket.
- 10 A reciprocating-piston internal combustion engine of said type is known from GB 1473058. In said known arrangement, the cross section of the oil pocket or oil pockets corresponds to the cross section of the
() respective associated groove cut into the cylinder
15 lining. The depth of the grooves decreases with progressive wear of the cylinder lining. The depth of the oil pockets formed by the grooves themselves also decreases to the same extent in the known arrangement. The result is therefore a deterioration of conditions
20 with increasing age. A further, quite particular drawback of the known arrangement however lies in the fact that material particles, which have broken off the cylinder lining as a result of e.g. heat corrosion etc., are not fixable in the grooves of the known arrangement.
25 There is therefore the risk of said material particles getting between cylinder lining and piston and being pulverized or crushed there, which may lead to damage and extreme local heating and hence to accelerated heat corrosion and/or seizure. The known arrangement
() therefore proves to be insufficiently operationally
30 reliable. ,

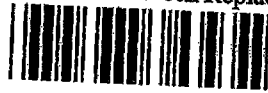
Against said background, the object of the present invention is therefore, while avoiding the described
35 drawbacks, to employ simple and inexpensive means to improve the arrangement of the type described in such a way that a high operational reliability is achieved over an extended period of time. //

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//Said object is achieved according to the invention in that a filling is associated with the groove, the depth of which corresponds at least to the maximum wear thickness of the cylinder lining, and that the material forming the filling of the groove is less resistant to wear than the basic material of the cylinder lining.

In the new state, the groove may be completely closed by the associated filling. The result is therefore a smooth, unprofiled surface which is easy to machine. As early as during the running-in phase, however, the fact that the filling material wears faster than the basic material leads to the formation of the desired oil pocket, the depth of which is however smaller than the depth of the groove and with increasing wear of the cylinder lining progresses to an extent dependent thereon. This leads, despite the decreasing depth of the groove, over an extended period of time to substantially uniform conditions with regard to the cross section of the oil pocket, which over an extended period of time guarantees reliable lubrication in the associated region of the cylinder lining and hence reliably prevents heat corrosion and seizure. The depth of the developing oil pocket or oil pockets correlates with the intensity of the wear. The higher the wear, the deeper the oil pockets and hence the more intensive the lubrication, and vice versa. The result is therefore almost a type of self-regulation. It is therefore also possible to reduce the specific oil consumption. A further, quite particular advantage of the measures according to the invention is however that material particles, which break off the cylinder lining as a result of unavoidable wear, may be pressed into the comparatively soft filling material and fixed in said manner. Thus, the free movement of said material particles is stopped by means of the groove provided with a filling. The groove provided according to the



// invention with a filling accordingly functions also as a highly effective stop groove. The measures according to the invention therefore also effectively prevent the damage and disturbance which may be caused by material particles which have broken off the cylinder lining, e.g. fused and/or caked material which would lead to accelerated heat corrosion and seizure. With the measures according to the invention, therefore, a long service life is advantageously guaranteed.

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Advantageous refinements and developments of the measures outlined above are indicated in the sub-claims. Thus, the material forming the filling of the groove may expediently present a higher thermal expansion than the basic material of the cylinder lining. The effect achieved thereby is that in the event of overheating the filling expands more quickly than the basic material, thereby stabilizing the piston and hence preventing a so-called seizure. Said advantage is heightened when the filling material advantageously also has dry lubricating properties.

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In an advantageous refinement of the measures outlined above, the filling of the groove may at least partially comprise aluminium and/or aluminium bronze and/or graphite, wherein preferably an aluminium bronze comprising 9 - 11% Al, 0.5 - 2% Fe and the remainder Cu may be used. A material of said type possesses the previously mentioned desired properties to an outstanding extent. It would however also be conceivable to use e.g. a graphite alloy preferably comprising 15 - 25% graphite and 75 - 85% aluminium bronze. Said material also possesses the desired properties to a great extent.

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At least one helical groove may advantageously be provided. This leads to particularly good distribution



and particularly good transportation of the oil over a greater region of the cylinder lining and hence to a particularly high degree of reliability.

- 5 According to a further advantageous refinement of the measures outlined above, the filling may, depending on the suitability of the materials being used, take the form of a welded or sprayed coating. In a simple manner this guarantees a pore-free filling with reliable
10 adherence to the basic material. ✓

Further advantageous refinements and developments of the measures outlined above are indicated in the remaining sub-claims and are more clearly evident from the
15 following description of examples with reference to the drawings.

The drawings described below show:

- 20 Figure 1 a cylinder of a large two-stroke diesel engine, partially in section,
- Figure 2 an enlarged view of a region of the running surface of the cylinder lining provided with a groove according to the
25 invention,
- Figure 3 a variant as regards the groove cross section and
30
- Figure 4 a further variant as regards the groove cross section.

35 The present invention is used in reciprocating-piston engines, in particular reciprocating-piston internal combustion engines, preferably in the form of slow-running large two-stroke diesel engines. The

construction and mode of operation of such arrangements are known as such and therefore require no further explanation in the present context.

5 The cylinder of a large two-stroke diesel engine illustrated in Figure 1 comprises a cylinder lining 2, which is provided with inlet slots 1 and onto which is mounted a cylinder head 3, which here comprises an outlet arrangement not shown in detail. The inside of
10 the cylinder lining 2 is designed as a running surface 4, with which a reciprocating piston 6 provided at its periphery with piston rings 5 cooperates. The running surface 4 is supplied with lubricating oil via lubricating oil supply lines 7.

15 To achieve a good distribution of the lubricating oil and, in particular, a good supply of lubricating oil supply to regions where empirically the lubricating oil supply is deficient, e.g. the top region of the running
20 surface 4, the latter is provided with suitable oil pockets 8, which are merely indicated in Figure 1.

For said purpose, as may best be seen from Figure 2, in the region of the running surface 4 at least one incised
25 groove 9 is provided, in which an associated oil pocket 8 is formed. The groove 9 contains a filling 10 made of a material which is less resistant to wear than the basic material of the cylinder lining. The cylinder lining is normally made of cast steel. An aluminium
30 bronze may advantageously be used to form the filling 10. As experiments have demonstrated, said aluminium bronze is to comprise at least 2 - 20%, preferably 9 - 11% Al, 0.5 - 8%, preferably 0.5 - 2% Fe and a remainder of Cu. The specific composition is
35 geared to the given circumstances of each individual case. Here it is a case of the higher the Fe fraction, the greater the hardness of the material. In the case

of a cylinder lining of a large two-stroke diesel engine, good results were achieved with an aluminium bronze comprising the following constituents:

- 2 - 20%, preferably 9 - 11% Al,
- 5 0.5 - 8%, preferably 0.5 - 2% Fe,
- 0.1 - 8% Mn, 0.1 - 2% Si, 0.1 - 1% Ni,
- 0.1 - 2% C, in each case at most 5 - 20% of at least one of the components Sb, Co, Be, Cr, Sn, Cd, Zn, Pb and the remainder Cu.

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It would however also be conceivable to use a graphite alloy such as nickel graphite or silicon graphite or aluminium graphite or aluminium bronze graphite comprising in each case 5 - 60%, preferably 15 - 25%
 15 graphite and a fraction of 40 - 95%, preferably 75 - 85% of the respective other component. With an aluminium bronze graphite alloy particularly good anti-corrosion and anti-seizure properties may be achieved. The composition of the aluminium bronze may in said case
 20 correspond to the composition described above.

The filling 10 may advantageously be introduced into the previously manufactured groove 9 as a sprayed coating applied by means of a laser spraying technique or an arc
 25 spraying technique, such as a plasma spraying technique. Naturally, the filling 10 of the groove 9 may also be manufactured as a welded coating. An aluminium bronze comprising 9 - 11% Al, 1 - 3% Fe, 4 - 6% Ni, 1 - 2% Mn and the remainder Cu is particularly suitable for said
 30 purpose.

Filling of the groove 9 is in said case expediently effected up to the level of the running surface 4. The running surface 4 may then be machined, e.g. honed,
 35 throughout. Because the material forming the filling 10 is less resistant to wear than the basic material of the cylinder lining 2, as early as during the running-in

phase the wear of the filling 10 is higher than the wear of the cylinder lining 2. The eroded material is washed away by the lubricating oil. The result is therefore the desired oil pocket 8, which is retained throughout the service life of the cylinder lining 2.

The depth of the groove 9, indicated by d in Figure 2, therefore corresponds at least to the wear thickness of the cylinder lining 2 and is preferably slightly greater. As said deep groove 9 is however provided with the filling 10 which likewise wears in dependence upon the wear of the cylinder lining 2, wherein only a slightly faster wear arises, the result is cross-sectional configurations of the oil pocket 8, which are substantially uniform throughout the service life of the cylinder lining 2 and differ from the cross section of the groove 9 itself.

To form the filling 10, a material may advantageously be used, which has the property of expanding under the influence of heat to a greater extent than the basic material of the cylinder lining. The previously proposed material has said property. In the event of local overheating, therefore, the filling 10 expands to a greater extent than the basic material of the cylinder lining 2, with the result that the piston 6 may be stabilized, as is indicated in Figure 2 by a discontinuous expansion line 11. The material proposed above for the filling 10 also has good dry lubricating properties, which particularly in the event of overheating is a useful advantage. It would however also be conceivable to integrate and/or embed an additional material with good dry lubricating properties in the filling material.

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One or more grooves 9 may be provided. They are expediently disposed in positions where, according to

previous experience, there is a high risk of insufficient lubrication and hence of heat corrosion etc. This is the case above all in the top region of the running surface 4. In Figure 1, in the region of the running surface 4 delimited by the first and second piston ring 5 in the top dead-centre position of the piston 6 a circumferential groove with corresponding oil pocket 8 is provided. A further groove with associated oil pocket 8 is provided in the region below the bottom piston ring 5. Yet more oil pockets 8 disposed even deeper are indicated in the illustrated example.

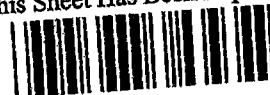
The grooves 9 forming the basis of the oil pockets 8 may take the form of circumferential radial grooves. However, in addition or alternatively thereto one or more helically extending grooves 9 with associated oil pocket 8 may be provided. The latter may extend over a region or over the entire length of the running surface 4.

Figure 2 is based on a helically extending groove 9. The lead - indicated by P - of said groove 9 may be 1.5% - 20% of the diameter D of the running surface 4. The lead P may be constant over the entire length of the groove. A variable lead would however also be conceivable in order to obtain a greater oil pocket density in particularly vulnerable regions than in less vulnerable regions. The already previously mentioned depth d of the groove 9 is expediently in the region between 0.1% - 0.4% of the diameter D. The initial width w is expediently 1% - 2% of the diameter D.

In the illustrated examples, the groove 9 has a cross section, which narrows inwards from the initial width w. This takes account of the fact that the rate of wear increases with advancing age. In Figure 2 the groove 9 has an approximately U-shaped cross section with flanks

which are inclined relative to the base of the groove.
The angle of inclination of the flanks, which is
indicated by α , may be in the region between $30^\circ - 60^\circ$.
The transitions between the groove base and the groove
5 flanks are expediently rounded off, as is indicated by a
radius arrow.

The above dimensional data apply also to the further
variants forming the basis of Figures 3 and 4. Figure 3
10 shows a V-shaped groove 9 with associated filling 10
comprising the oil pocket 8. The groove 9 forming the
basis of Figure 4 has a cross section in the shape of a
segment of a circle. Here too, the result is an
inwardly narrowing cross section and hence an inwardly
15 decreasing width of the filling 10 and the oil pocket 8
formed therein.



Claims

1. Reciprocating-piston engine, in particular a large
two-stroke diesel engine, having at least one
5 cylinder, the cylinder lining (2) of which in the
region of its running surface (4) facing the
associated piston (6) is provided with at least one
groove (9) so as to form an oil pocket (8),
characterized in that a filling (10) is associated
10 with the groove (9), the depth of which corresponds
at least to the maximum wear thickness of the
cylinder lining (2), and that the material forming
the filling (10) of the groove (9) is less
resistant to wear than the basic material of the
15 cylinder lining (2).
2. Reciprocating-piston engine according to claim 1,
characterized in that the material forming the
filling (10) of the groove (9) presents a higher
20 heat expansion than the basic material of the
cylinder lining (2).
3. Reciprocating-piston engine according to one of the
preceding claims, **characterized in that** the
25 material forming the filling (10) of the groove (9)
has dry lubricating properties.
4. Reciprocating-piston engine according to one of the
preceding claims, **characterized in that** the
30 material forming the filling (10) of the groove (9)
at least partially comprises aluminium and/or
aluminium bronze and or graphite.
5. Reciprocating-piston engine according to claim 4,
35 **characterized in that** the aluminium bronze used to
form the filling (10) of the groove (9) contains at
least aluminium, iron and copper. //



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6. ~~Reciprocating~~-piston engine according to one of the preceding claims, **characterized in that** the aluminium bronze used to form the filling (10) of the groove (9) comprises at least the following alloy constituents:
- 5 2 - 20%, preferably 9 - 11% Al,
 0.5 - 8%, preferably 0.5 - 2% Fe
 and a remainder of Cu.
- 10 7. Reciprocating-piston engine according to claim 5 or 6, **characterized in that** the aluminium bronze used to form the filling (10) of the groove (9) comprises at least the following alloy constituents:
- 15 2 - 20%, preferably 9 - 11% Al,
 0.5 - 8%, preferably 0.5 - 2% Fe,
 0.1 - 8% Mn, 0.1 - 2% Si, 0.1 - 1% Ni
 0.1 - 2% C, in each case at most 5 - 20% of at least one of the components Sb, Co, Be, Cr, Sn, Cd, Zn, Pb and a remainder of Cu.
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8. Reciprocating-piston engine according to one of claims 4 - 7, **characterized in that** the material forming the filling (10) of the groove (9) comprises 5 - 60%, preferably 15 - 25% graphite and 40 - 95%, preferably 75 - 85% aluminium and/or aluminium bronze and/or nickel and/or silicon.
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9. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** at least one helical groove (9) is provided.
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10. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** at least in the top region of the cylinder lining (4) at least one groove (9) is provided.
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11. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** at least in the region of the running surface (4) delimited by the first and second piston ring (5) in the top dead-centre position of the piston (6) at least one groove (9) is provided.
12. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** at least in the region below the bottom piston ring (5) in the top dead-centre position of the piston (6) at least one groove (9) is provided.
13. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** at least one groove (9) extends continuously over the guide length of the running surface (4).
14. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** the lead of a helical groove (9) is 1.5% - 20% of the diameter of the running surface (4).
15. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** the depth of the groove (9) is 0.1% - 0.4% of the diameter of the running surface (4).
16. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** the initial width of the groove (9) is 1% - 2% of the diameter of the running surface (4).
17. Reciprocating-piston engine according to one of the preceding claims, **characterized in that** the groove (9) has an inwardly tapering cross section.



18. Reciprocating-piston engine according to one of the preceding claims, characterized in that the filling (10) of the groove (9) takes the form of a welded or sprayed coating.

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