

Reciprocating piston engine

5 The invention relates to a reciprocating piston engine,
in particular a two-stroke large diesel engine, having
at least one cylinder whose cylinder liner, in the
region of its running surface facing the piston,
contains areas of material having a greater wear
resistance than the base material of the cylinder liner
for the lateral delimitation of at least one groove-
shaped oil pocket.

10 A reciprocating piston internal combustion engine of
this type is known from JP 6-105102 B2. In this known
arrangement the cylinder liner is provided with a wave
15 contour for forming groove-shaped oil pockets on the
running surface side, the elevated places in this wave
contour being hardened by a hardening process. To
improve the run-in properties the hardened places can
be provided with an MoS₂ coating which disappears
20 quickly, however. Producing a wave contour and
carrying out a hardening process limited locally to the
raised areas are relatively expensive procedures.
There is also the fact that, from experience, the
hardening depth which can be achieved by the hardening
25 process is relatively small. In addition, the degrees
of hardness that can be achieved merely by a hardening
process are also limited. In the known arrangement,
therefore, only a relatively short service life is
achieved for the wave contour. There is a further
30 disadvantage in that the hardening limited locally to
the raised areas may also lead to undesirable
distortion and undesirable changes in structure in the
adjacent material areas. Accordingly, the known
arrangement has not proved to be simple enough or to
35 have a sufficiently long service life.

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With this as a starting point, it is therefore the aim of the present invention to improve a reciprocating piston engine of the above type with simple and inexpensive means so that a long service life of the cylinder liner can be achieved.

This aim is achieved in accordance with the invention in that the material areas each provided with an oil pocket for lateral delimitation are configured as a filling for a groove, the depth of which corresponds at least to the maximum wear thickness of the cylinder liner.

These steps advantageously make possible the free selection of material as regards the filling for the grooves and hence the oil pocket delimitations. A material which is different from the base material and is better suited to any requirements that occur than the hardened base material can therefore be used. The depth of the grooves may far exceed the depth of hardness which can be achieved during a hardening process. During production there is first of all a smooth surface which can be processed, preferably honed, relatively easily. Because the base material has a lower resistance to wear and tear, it wears faster in the area between the groove fillings made of foreign material, and hence the desired oil pockets are automatically produced. These remain until the cylinder liner is completely worn. Using the steps of the invention, therefore, the disadvantages of the known arrangement that are set out above are completely avoided.

Preferred constructions and suitable developments of the principal steps can be found in the sub-claims. Thus the filling may preferably comprise an at least

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partially ceramic material, preferably a ceramic-metal-
mixture (Cermet). This gives a particularly good
stability. Furthermore, materials of the above type
are applied in an extremely simple manner, for instance
5 by the high speed plasma spraying process or by the
laser coating process.

A further possible preferred provision is that the
depth of the grooves each laterally defining an oil
10 pocket is greater than the maximum wear and tear
thickness of the cylinder liner. This ensures that the
groove fillings are well secured in the base material
until the cylinder liner is completely worn. It may
also be conducive to this if the cross-section of the
15 groove increases inwardly.

Further preferred constructions and suitable
developments of the principal steps can be found in the
other sub-claims and can be seen in greater detail in
20 the following description of an example by means of the
drawings.

The drawings described below show:

25 Figure 1 a partial section of a cylinder of a two-
stroke large diesel engine,

Figure 2 an enlarged section of the area provided with
oil pockets in the arrangement according to
30 Figure 1 and

Figure 3 an enlarged section through a groove provided
with a filling in the arrangement according
to Figure 1.

35 The present invention is used in reciprocating piston

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engines, in particular internal combustion
reciprocating piston engines, preferably in the form of
slowly-running two-stroke large diesel engines. The
structure and method of operation of such arrangements
are known *Cper se* and therefore need no further
explanation in the present connection.

The cylinder of a two-stroke large diesel engine shown
in Figure 1 contains a cylinder liner 2 provided with
inlet slots 1, onto which is placed a cylinder head 3
containing an outlet arrangement not shown in detail
here. The inside of the cylinder liner 2 is formed as
a running surface 4, and co-operating with it is a
backwards- and forwards-moving piston 6 provided with
piston rings 5 on the circumferential side. The
running surface 4 is supplied with lubricating oil by
means of lubricating oil supply lines 7.

To achieve a good distribution of the lubricating oil,
and in particular a good supply of lubricating oil to
areas in which it is known from experience that the
lubricating oil supply is insufficient, for instance in
the upper region of the running surface 4, oil pockets
8 which are suitable for this purpose are provided in
this area but indicated only in Figure 1. The
depressions forming the oil pockets 8 are not present
from the start. However, provisions are made at the
start which, in the course of operation, cause the
automatic formation of depressions forming the basis of
the oil pockets 8 by wear and tear of the base material
of the cylinder liner 2.

The oil pockets 8 are each laterally defined by
material areas 9 flanking them. An oil pocket 8 can be
formed between two respective material areas 9 of this
type. As can be seen from Figures 2 and 3, the



material areas 9 each laterally defining an oil pocket 8 are configured as a filling 11 for a respectively associated groove 10. The material forming the filling 11 has a greater resistance to wear than the base material of the cylinder liner 2 which is generally made of cast steel. As is indicated in Figure 3, in the new state the grooves 10 are filled to the level of the running surface 4, producing a smooth surface which can be easily processed, for instance honed. First of all the grooves 10 are cut in. Then the filling 11 is introduced. Finally the running surface 4 is finished.

Because of the greater wear resistance of the material forming the filling 11 with respect to the base material of the cylinder liner 2, the wear of the base material is already greater during the run-in phase than the wear of the fillings 11, as shown in broken lines in Figure 3. This therefore means that the respectively desired groove-shaped oil pocket 8 is produced between two adjacent fillings 11.

A material which is completely or at least partially made of ceramic material, e.g. a ceramic metal mixture (Cermet) may preferably be used to form the filling 11. This material may preferably contain carbides and/or oxides and/or nitrides and/or borides and/or silicates with Cu and/or Al-bronze and/or Ni and/or NiCr and/or Mo and/or Al graphites and/or Ni-graphite and/or Al-Br-graphites and an organic binder, whereby the carbides, oxides, nitrides, borides, silicates are preferably present with 10-60% in the hard phase and 5-80% in the soft phase. It has proved to be particularly advantageous if the carbides, oxides, nitrides, borides, silicates are present as Cr-compounds. CrO is a particularly useful material since it not only has good stability and allows a high

working temperature, but is also non-corrosive and non-oxidising.

5 In a preferred embodiment of the above-listed
specifications, the filling (11) may contain 20-50%,
preferably 20-40%, carbides and/or oxides and/or
nitrides and/or borides and/or silicates, and at least
Al-bronze with at least 20-40%, preferably 60-80%.
Preferred embodiments may contain 20-40% oxides mixed
10 with 60-80% Al-bronze or 30-50% oxides, nitrides or
carbides mixed with at least Al-bronze, or preferably
with 10-20% Mo and 20-30% Ni or NiC or 20-40% Al-
bronze. Materials of this type can be applied/
introduced into the associated groove 10 in the arc-,
15 flame-, plasma- or high speed spraying process.

Another material group which contains silicon and boron
with a content of respectively 0.1-10% can also be
applied in the above manner. Preferred material
20 compositions in this connection are 10-18% Cr, 2-3% Fe,
2-4% Si, 2-4% B, 0.1-0.5% C and Ni as the remainder, or
10-18% Cr, 2-3% Fe, 2-4% Si, 2-4% B, 0.1-0.5% C,
6-12% Mo, 0.1-0.5% C, 30-40% Co and Ni as the
remainder, or 10-18% Cr, 2-3% I, 2-4% Si, 2-4% B, 0.1-
25 0.5% C, 6-12% Mo, 1-6% Cu, 0.1-0.5% C and Ni as the
remainder or 10-18% Cr, 2-3% I, 2-4% Si, 2-4% B,
0.1-0.5% C, 6-12% Mo, 10-20% Ni, 65-88% WC and 12% Co.
Flame-, induction- or laser sintering can also be
considered here.

30 A material containing carbides and/or oxides and/or
nitrides and/or borides and/or silicates with 10-60%
in the hard phase and 5-80% in the soft phase and
2-10% Cu, 20-30% Al-bronze, 10-85% Ni or NiCr,
35 10-30% Cr, 0.1-5% carbon, 1-8% Fe, 2-15% Mo or
Mo-sulphide or Mo-disulphide or Mo-oxide or

Mo-dioxide or Mo-peroxide, 2-7% Cu, 10-40% Co, 30-80% WC or 88% WC and 12% Co can also be used when the filling 11 is made as a sinter filling.

5 Powder materials are also suitable. So, for instance, a powder having 0.2-5% C, 20-50% Cr, 1-20% Mo, 1-20% V, 0.1-4% Si or B, 0.1-5% Mn, 0.1-5% Fe, 0.5-50% carbides, oxides, nitrides, borides or silicates, Mo-sulphides/-dioxides/-oxides/-disulphides
10 or Mo-peroxides can be used, where silicon and/or boron with respectively 0.1-5%, and as the remainder Ni, can be provided. A particularly preferred material in this connection comprises 20-30% Cr, 1-10% Mo, 2-3% C, 2-5% V, 0.2-1% Mn, 0.2-4% Si or B and Ni as the
15 remainder.

Alternatively, however, the filling 11 can also be formed as a welded coating. A material can be used which contains 2-20% Al, 0.5-10% Fe, 0.1-8% Mn, 0.1-2%
20 Si, 0.1-10% Ni, 0.1-2% C and at least one of the components Sb, Co, Be, Cr, Sn, Cd, Zn, Pb with 50-20% at the most and the remainder Cu. A particularly preferred composition may contain 14-17% Al, 3-5% Fe, 1-3% Mn, 0.1-2% Si, 0.3% C at the most and the
25 remainder Cu.

The depth of the groove 10 indicated in Figure 3 at d corresponds at least to the maximum wear thickness of the cylinder liner 4. The depth d is preferably
30 greater than the maximum wear thickness, so that even with a completely worn cylinder liner 2, good anchoring of the filling 11 in the base material is guaranteed. In this connection it may also be advantageous if the cross-section of the groove 10 is inwardly widened, as
35 shown in Figure 2 by the cross-section shape 12 shown by broken lines. A preferred groove depth may be in

the range between 0.1 to 0.4% of the diameter D of the running surface 4. The inside width of the oil pockets 8 being formed corresponds to the spacing of the associated grooves 10, each provided with a filling 11. This distance indicated in Figure 2 at w is preferably within the range of between 1 to 2% of the diameter D of the running surface 4. The inside width of the grooves 10 and hence the width b of the fillings 11 associated with them preferably corresponds to the groove depth d. Good stability with respect to shear stress is thus achieved.

One or more oil pockets 8 can be provided. The grooves 10 associated with them and each provided with a filling 11 are preferably arranged where, from experience, the danger of insufficient lubrication and accordingly the danger of heat corrosion etc. is particularly great. This is the case particularly in the upper region of the running surface. In Figure 1 the means provided for forming an oil pocket 8 are arranged in the region of the running surface limited by the first and second piston ring 5 in the upper dead centre position of the piston 6. A further oil pocket 8 or the means necessary for this can be provided in the region below the lowermost piston ring 5. In the example shown, other oil pockets 8, arranged even deeper, are also provided.

The oil pockets 8 and accordingly the material areas defining them may be of circular construction. In addition, or as an alternative to this, however, one or more oil pockets 8 extending helically, and hence helical material areas 9 defining them, can also be provided. These may extend over an area or over the entire guide length of the running surface 4.

In the case of a helically extending oil pocket 8 the pitch indicated in Figure 1 at p may be about 1.5% to 20% of the diameter D of the running surface 4. This pitch may be constant over the entire length. However, a variable pitch would also be possible in order to obtain an oil pocket density that is greater in areas particularly at risk than in areas less at risk.

In the example shown, the groove 10 and accordingly also the filling 11 associated with it has a rectangular or trapezoidal cross-section. The inner edges may be rounded so as to avoid notch tensions.



Claims

1. Reciprocating piston engine, in particular a two-stroke large diesel engine, having at least one cylinder whose cylinder liner (2) in the region of its running surface (4) facing the piston (6) has a greater resistance to wear than the base material of the cylinder liner (2) for the lateral delimitation of at least one groove-shaped oil pocket (8), characterised in that the areas of material (9) provided for the lateral delimitation of each oil pocket (8) are configured as a filling (11) for a groove (10), the depth (d) of which corresponds at least to the maximum wear thickness of the cylinder liner (2).
2. Reciprocating piston engine according to claim 1, characterised in that the filling (11) is made of an aluminium bronze which contains 2-20% Al, 0.5-10% Fe, 0.1-8% Mn, 0.1-2% Si, 0.1-10% Ni, 0.1-2% C and at least one of the components Sb, Co, Be, Cr, Sn, Cd, Zn, Pb each with at the most 5-20% and the remainder Cu, preferably 14-17% Al, 3-5% Fe, 1-3% Mn, 0.1-2% Si, at the most 0.3% C and the remainder Cu.
3. Reciprocating piston engine according to claim 2, characterised in that the filling (11) is configured at least partially as a welded coating.
4. Reciprocating piston engine according to claim 1, characterised in that the filling (11) is comprised at least partially of ceramic material.
5. Reciprocating piston engine according to claim 4, characterised in that the filling (11) comprises a ceramic-metal-mixture (Cermet).

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- 5 6. Reciprocating piston engine according to claim 4 or 5, characterised in that the filling (11) contains carbides and/or oxides and/or nitrides and/or borides and/or silicates with Cu and/or Al-bronze and/or Ni and/or NiCr and/or Mo and/or Al-graphite and/or Ni-graphite and/or Al-Br-graphite and an organic binder.
- 10 7. Reciprocating piston engine according to claim 6, characterised in that the carbides, oxides, nitrides, borides, silicates are present with 10-60% in the hard phase and 5-80% in the soft phase.
- 15 8. Reciprocating piston engine according to claim 6 or 7, characterised in that the carbides, oxides, nitrides, borides, silicates are present as Cr-compounds.
- 20 9. Reciprocating piston engine according to one of the preceding claims 4 to 7, characterised in that the filling (11) contains 20-50%, preferably 20-40%, carbides and/or oxides and/or nitrides and/or borides and/or silicates and at least Al-bronze with at least 20-40%, preferably 60-80%.
- 25 10. Reciprocating piston engine according to one of the preceding claims, characterised in that the filling (11) is configured at least partially as a spray coating.
- 30 11. Reciprocating piston engine according to one of the preceding claims, characterised in that the filling (11) is configured at least partially as a sintered material.
- 35 12. Reciprocating piston engine according to one of

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the preceding claims, characterised in that the depth d of the grooves (10) is greater than the maximum wear thickness of the cylinder liner (2).

5 13. Reciprocating piston engine according to one of the preceding claims, characterised in that the cross-section of the grooves (10) increases inwardly.

10 14. Reciprocating piston engine according to one of the preceding claims, characterised in that the depth (d) of the grooves (10) is within the range of between 0.1% to 0.4% of the diameter (D) of the running surface (4).

15 15. Reciprocating piston engine according to one of the preceding claims, characterised in that the distance between two grooves (10) associated with the fillings (1) each defining an oil pocket (8) is in the range of between 1% to 2% of the diameter (D) of the running surface (4).

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25 16. Reciprocating piston engine according to one of the preceding claims, characterised in that the width (b) of the grooves (10) corresponds approximately to the groove depth (d).

30 17. Reciprocating piston engine according to one of the preceding claims, characterised in that grooves (10) are provided, associated with at least one screw-shaped oil pocket (8), and are each provided with a filling (11), whereby the pitch is preferably 1.5% to 20% of the diameter D of the running surface (4).

35 18. Reciprocating piston engine according to one of the preceding claims, characterised in that the grooves (10) associated with at least one oil pocket (8), and

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each provided with a filling (11), are provided at least in the upper region of the cylinder liner (1).

- 5 19. Reciprocating piston engine according to one of the preceding claims, characterised in that grooves (10) are provided, associated with at least one continuous oil pocket (8) over the guide length of the running surface (4) and each provided with a filling (11).

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