

Large two-stroke diesel engine

Specification

The present invention relates to a large two-stroke diesel engine having at least one cylinder, whose combustion chamber comprises an exhaust opening which is controllable by an exhaust valve actuatable by an actuating device comprising an advance arrangement and a return arrangement, and on whose cylinder head a valve housing is mounted which comprises an exhaust duct adjoining to the exhaust opening of the combustion chamber, and further a guide sleeve extending through the upper wall of the said exhaust duct for a stem of the exhaust valve extending through the exhaust duct, with the return arrangement comprising a piston provided on the valve stem and an operating chamber limited by such piston and chargeable with compressed air, which operating chamber is sealed towards an annular gap to which oil can be fed and which lies between the guide surfaces of the mutually facing guide sleeve and valve stem and communicates with the exhaust duct, by means of a sealing device arranged in the region of the upper, exhaust duct-far end of the annular gap and possessing at least one sealing ring.

An arrangement of this kind is known from DE 101 61 438 A1. The feeding of oil to the annular gap between the guide surfaces of the guide sleeve and the valve stem provides for a reliable protection from combustion residues penetrating from the exhaust duct into the annular gap, which in the past have resulted in the corrosion of the valve stem and the destruction of the sealing ring of the sealing device. In the arrangement known from the aforesaid DE 101 61 438 A1 the annular gap, by means of an associated metering device, is fed with oil branched off from the hydraulic actuating device associated with the exhaust valve. The metering device provided in the known arrangement causes a relatively high complexity of design and involves high prime and maintenance costs.

On these premises it is the object of the present invention to improve a device as described initially above by simple and low-cost means in such a way that the metering device which has hitherto been necessary is no longer required, while the annular gap between the valve stem and the guide sleeve is reliably fed with oil and a reliable functioning of the return arrangement designed as an air spring is ensured.

According to the invention, this object is achieved in that above that sealing ring of the sealing device which faces the exhaust duct provision is made for an oil reservoir which can be supplied with oil which latter is present on the upper side of the said sealing ring away from the annular gap.

By these measures, it is ensured that the sealing ring facing the exhaust duct and provided at the upper, "cold" end of the annular gap of the sealing device is permanently flooded with the oil present in the oil reservoir. This oil, which is forced into and fed through the sealing gap of the sealing device by the pressure existing in the operating chamber of the pneumatic return arrangement and by the movement of the valve stem, not only ensures in an advantageous manner a gas-tight sealing of the operating chamber of the return arrangement and a good lubrication of the contact surfaces of the sealing ring, but at the same time also provides for a controlled supply of the annular gap located underneath the seal with oil. Correspondingly, the oil reservoir provided above the seal serves as an oil source for supplying the said annular gap with oil which can reliably prevent the penetration of combustion residues into the annular gap. The fact that the oil is conveyed by the pressure in the operating chamber and the movement of the valve stem provides for a very simple and maintenance-free design. By suitably designing the geometry of the sealing ring the oil consumption can be kept within certain defined limits, so that despite using a simple design, reliable metering of the oil as well as low oil consumption are ensured. All in all, the measures according to the invention thus afford an excellent degree of economic efficiency.

Advantageous embodiments and expedient developments of the main-claim measures will be evident from the sub-claims.

The oil reservoir is in an advantageous manner supplied at least in part with leakage oil issuing from a hydraulic valve advance arrangement associated with the exhaust valve, which circumstance ensures a particularly simple and low-cost design.

As a rule, the exhaust valve is associated with a hydraulic valve advance arrangement and underneath thereof a valve return arrangement which is designed as an air spring comprising a piston of an air-charged operating chamber limited by such piston, which air spring is provided at the valve stem. The leakage oil issuing from the hydraulic actuating device can drip onto the piston of the air spring and flows thereafter into the operating

chamber past the circumferential guide surfaces of the piston. In an expedient manner, the oil is allowed to collect within the region of the bottom of the operating chamber which circumstance results in the desirable formation of the oil reservoir, with a return line being expediently provided extending from such oil reservoir and comprising a safety valve to relieve the operating chamber. By adjusting the pressure at which the safety valve opens, a desirable oil level in the oil reservoir can be maintained.

According to a particularly advantageous further development, an overflow pipe extending into the oil reservoir may be arranged upstream of the safety valve, with the overflow edge of the said overflow pipe arranged at a higher level than the oil-flooded sealing ring. This facilitates the adjustment of the safety valve, since the oil level is defined by the overflow pipe whose upper rim serves the purpose of an) overflow edge.

In those cases in which the leakage oil is not sufficient, the operating chamber of the air spring may be supplied with oil and/or oil mist via an external oil source. For the purpose of forming oil mist, an oil admixing device may simply be associated with the compressed air line provided for supplying compressed air to the operating chamber.

A further advantageous measure may consist in that a cover cap overlapping the sealing device is provided with at least one radial recess above the sealing ring facing the exhaust duct, which communicates with the oil reservoir and extends up to the bore of the cover cap associated with the valve stem. In this manner, particularly reliable flooding of that sealing ring which faces the exhaust duct of the sealing device can be achieved.

According to a further advantageous embodiment of the main-claim measures, the above-mentioned cover cap above the sealing ring facing the exhaust duct may comprise an inner annular groove which contains the oil reservoir and can be fed with oil via a supply line. This arrangement results in a particularly space saving design comprising a highly compact oil reservoir which can be filled with a comparably small amount of oil.

Expediently, the annular groove may extend to the upper rim of the cover cap. Such upper rim serves as an overflow edge, whereby the desirable oil level in the oil reservoir is ensured in a most simple manner.

When leakage oil is used to supply the annular groove with oil, the supply line associated therewith may simply be connected with a collecting channel extending underneath a drip-off edge formed in the operating chamber. The operating chamber itself does not contain a bottom side oil reservoir, which circumstance affords a certain freedom of design with respect to the arrangement of the safety valve.

A further preferred embodiment of the main-claim measures may consist in that the sealing device comprises two sealing rings arranged one above the other and that the annular gap region provided between such sealing rings for forming the oil reservoir is connected with a supply line and a discharge line. This arrangement results in a particularly compact design. Since the oil reservoir is thus subjected to a permanent flow of oil, a reliable oil supply is ensured.

Further advantageous embodiments and expedient developments of the main-claim measures will be evident from the remaining sub-claims and from the description of an example given below in conjunction with the accompanying drawing(s), wherein -

Figure 1 shows a first embodiment of the invention depicting a vertical section of the upper region of a cylinder with an associated exhaust valve arrangement of a large two-stroke diesel engine;

Figure 2 shows a second embodiment of the invention depicting a detailed view of a vertical section comprising the upper end region of the guide sleeve associated with the valve stem according to Fig. 1;

Figure 3 shows a third embodiment of the invention as shown in Fig. 2; and

Figure 4 shows a radial section of a sealing ring of the sealing device provided in the upper end region of the guide sleeve.

The main field of application of the invention is in the realm of large two-stroke diesel engines as utilized, for example, for propulsion systems of ships. The design and the method of operation of such arrangements are in general known to the art.

As a rule, such engines possess several cylinders arranged side by side in a row. In Fig. 1 the upper region of such a cylinder 1 is indicated. The latter comprises a cylinder liner not shown in Fig. 1 and a cylinder head 2 mounted on top thereof. The cylinder contains a combustion chamber 3 provided with an upper coaxial exhaust opening 4 which is controllable by means of an associated exhaust valve 5.

The exhaust valve 5 possesses a valve disc 6 which cooperates with a valve seat provided in the region of the exhaust opening 4, such valve disc 6 being provided at the lower end of a spindle-shaped valve stem 7. Adjacent to the exhaust opening 4 is an exhaust duct 8 which is open towards the combustion chamber 3 when the exhaust valve is lifted off the associated valve seat and vice versa. Associated with the exhaust valve 5 is an exhaust valve housing 9 mounted on the cylinder head 2, which contains the exhaust duct 8. Joined to the valve housing 9 is a valve seat ring 9a extending into the cylinder head 2 and containing the valve seat which limits the exhaust opening 4. The valve housing 9 further comprises a guide sleeve 10 associated with the stem 7 of the exhaust valve 5. The guide sleeve 10 is arranged coaxially to the exhaust opening 4 and extends from the point where the valve stem 7 emerges from the upper wall region of the exhaust duct 8 to the upper region of the valve housing 9. The guide sleeve 10 extends through the upper wall region of the exhaust duct 8, so that the annular gap 11 between the mutually facing guide surfaces of the guide sleeve 10 and the valve stem 7 of the exhaust valve 5 is accessible from the exhaust duct 8.

The valve stem 7 extends through the guide sleeve 10 and with its section exceeding the guide sleeve 10 extends into an upper structure 12 accommodated on the valve housing 9, such upper structure 12 comprising an actuating device associated with the exhaust valve 5 for carrying out the opening and closing movements. The actuating device comprises a valve advance arrangement designed as a hydraulic unit and a return arrangement designed as an air spring. The said upper structure 12 possesses a bipartite housing whose upper part 12a comprises the hydraulic unit forming the valve advance arrangement and whose lower part 12b comprises the air spring forming the valve return arrangement.

The hydraulic unit forming the advance arrangement comprises a piston 13 attached to the upper end of the valve stem 7, and a pressure chamber 14 limited by such piston 13 arranged in the upper part 12a, which pressure chamber 14 can be supplied with high-

pressure hydraulic oil at a certain cycle by a pressure source not shown, which is expediently designed as a pump drivable by the engine. The air spring provided underneath the hydraulic unit and acting as a return arrangement comprises a piston 15 through which extends the valve stem 7 and which is mounted thereon, such piston 15 limiting an operating chamber 17 enclosed by a collar 16 formed integral with the lower part 12b, which operating chamber 17 is supplyable with compressed air via a compressed air line 18 connected with a compressed air source. To reduce any overpressure forming in the operating chamber 17, the latter is provided with an outlet with which an adjustable safety valve 19 is associated which opens at a certain defined pressure.

The collar 16 limiting the operating chamber 17 and acting as a cylinder associated with the piston 15 extends into an associated recess at the lower end of the upper part 12a with a certain axial and radial play, which results in a space 20 between the upper part 12a and the lower part 12b. The leakage oil issuing from the hydraulic unit above the space 20 flows off into the space 20 from which a pressure-free return line may branch off. The latter is expediently connected with the bottom of that region of the space 20 which encloses the collar 16.

The operating chamber 17 supplyable with compressed air is sealed off towards the annular gap 11 between the mutually facing guide surfaces of the guide sleeve 10 and the valve stem 7 by a sealing device comprising at least one sealing ring 22. Such sealing device may be designed as a stuffing box comprising at least one sealing ring 22. In the embodiments according to Fig. 1 and Fig. 2, provision is made for one sealing ring 22. In the embodiment according to Fig. 3, provision is made for sealing rings 22, 23 arranged one above the other.

Since the annular gap 11 between the mutually facing guide surfaces of the guide sleeve 10 and the valve stem 7 is open towards the exhaust duct 8, there exists the danger of combustion residues penetrating into the annular gap 11 which may cause damage to the guide surfaces and in particular to the sealing ring 22, or to the lower sealing ring 22, i.e. the one facing the exhaust duct 8, of the sealing device, as the case may be. In order to prevent this effect, the annular gap 11 is supplied with oil from above. The oil may then issue at the lower end of the annular gap 11 of the exhaust duct 8 where it can burn up.

To supply the annular gap 11 with oil, provision is made for an oil reservoir 24 arranged above the sealing ring 22 of the sealing device, which can be supplied with oil which, as its level is higher than the upper side of the said sealing ring 22 away from the annular gap 11, floods the said sealing ring 22, thus serving as an oil source supplying the annular gap 11 with oil and lubricating the sealing ring 22 at the same time.

In the embodiment according to Fig. 1 the leakage oil issuing from the pressure chamber 14 of the hydraulic unit serves firstly to supply the oil reservoir 24 with oil. The same likewise applies to Fig. 2. As mentioned before, the said leakage oil drips into the space 20 and flows at least in part to the upper side of the piston 15 of the air spring arrangement. From here, the leakage oil flows around the circumferential surface of the piston surface into the operating chamber 17 where it collects at the bottom and forms the oil reservoir 24, as is clearly illustrated in Fig. 1.

As a rule, a sufficient amount of leakage oil, which is lost by the hydraulic unit and flows into the pressure chamber 17, ensures a sufficient supply of the oil reservoir 24. In those cases, in which this is not ensured, additional oil can of course be supplied to the pressure chamber 17, as it is indicated by a supply line 25 discharging into the bottom region of the pressure chamber 17. An external oil source may be associated with the supply line 25. It would, of course, likewise be possible to branch off the oil supplied via the supply line 25 from the oil that is supplied to the pressure chamber 14 of the hydraulic unit. Alternatively, or in addition, the operating chamber 17 may also be supplied with oil mist. For this purpose, an oil admixing device 26 may be associated with the compressed air line 18. The oil carried along by the compressed air is sprayed into the operating chamber 17 in the form of oil mist which condenses on the walls and drips off into the oil reservoir 24.

As the piston 15 is moved in a downward direction, the already compressed air present in the operating chamber 17 is further compressed. The higher the oil level in the reservoir 24, the more the air is compressed. At a certain pressure, the safety valve 19 opens. The oil level in the oil reservoir 24 can thus be maintained at a certain height level by adjusting the safety valve 19 accordingly. The safety valve 19 controls a flow path from the oil reservoir 24 to an oil return line 21, as has been described above.

In the embodiment shown in Fig. 1, an overflow tube 27 projecting into the oil reservoir 24 is

associated with the safety valve 19, with the upper end of the said overflow tube 27 forming an overflow edge, thus defining the height of the oil level in the oil reservoir 24. The safety valve 19 in this embodiment may be adjusted at a fixed pressure, irrespective of the height of the oil level in the oil reservoir 24, which facilitates adjustment. The oil in the oil reservoir 24 is nevertheless maintained at a constant level. The overflow edge formed by the upper end of the overflow tube 27 is, of course, higher than the sealing ring 22 so that the latter is reliably flooded with oil.

The guide sleeve 10 accommodating the sealing ring 22 rests with an upper flange 10a on the valve housing 9. The sealing ring 22 is inserted into a circular groove of the flange 10a opening towards the top which is overlapped by a cover cap 28. The latter, in a region below the oil level of the oil reservoir 24 and above the sealing ring 22, respectively, is provided with radial passages 29 correspondingly leading from the oil reservoir 24 to the section of the annular gap 11 above the sealing ring 22, which is of advantage for the flooding of the sealing ring 22 with oil. The radial passages 29 may be designed as holes or, recesses, etc.

In the embodiment underlying Fig. 2 the bore of the above-mentioned cover cap 28 through which the valve stem 7 extends possesses a certain radial oversize relative to the diameter of the valve stem 7, which results in an annular groove 31 encompassing the valve stem 7, which annular groove 31 can accommodate an oil reservoir 32 which is supplyable with oil by means of a supply line 33 connected with the annular groove 31. The supply line 33 like the supply line 25 of the embodiment according to Fig. 1 may be connected with an external oil source, etc. In the example illustrated, as has been mentioned above, leakage oil is again utilized for supplying the oil reservoir 32.

The leakage oil entering the operating chamber 17 in the region of the guide surfaces of the piston 15 drips off at the bottom edge of the cylindrical running face associated with the piston 15. Arranged underneath the drip-off edge 34 in this example is a collecting channel 35 from which the supply line 33 branches off. The annular groove 31 containing the oil reservoir 32 extends to the top side of the cover cap 28 whose top side correspondingly forms an overflow edge ensuring a constant oil level in the oil reservoir 32. The overflowing oil flows into the region of the bottom of the operating chamber 17 from where the flow path controlled by the safety valve 19 branches off, via which excess oil can be discharged. In

this arrangement, the safety valve 19 may be adjusted irrespective of the oil level in the oil reservoir 32, which facilitates adjustment. An overflow tube arranged upstream of the safety valve 19 is not required in this example, which constitutes an advantage with respect to space requirements.

In the example according to Fig. 3, provision is made for two sealing rings 22, 23 arranged at a certain space one above the other, as has been mentioned earlier above. The section of the annular gap 11 which is limited by the two sealing rings 22, 23 is supplied with oil for the purpose of forming an oil reservoir 36. In the example illustrated, the oil is supplied continuously. The said section of the annular gap is correspondingly connected with a supply line 37 and a discharge line 38. The supply line 37 may be connected with an external oil source. The discharge line 38 may discharge into a pressure-free oil return line. Also in this example, the sealing ring facing the exhaust duct 8, in this example the bottom sealing ring 22, that is to say the lower sealing ring of the seal arrangement, is reliably flooded with oil, which ensures a reliable supply of the annular gap 11 with oil. The forced supply of the oil to the reservoir 36 ensures a particularly high degree of reliability.

As a rule, the supply of the annular gap 11 with oil entering via the sealing ring 22 reliably prevents penetration of combustion residues into the annular gap 11. In order to enhance this effect, the annular gap 11 may additionally be supplied with compressed air which is expediently supplied below the sealing ring 22, as is indicated in Fig. 1 by an oil line 39 provided underneath the sealing ring 22 and leading to the annular gap 11. It would be likewise conceivable to supply oil mist and/or additional oil via such an oil line.

The oil flow rate through the annular gap 11 may be comparatively low and may amount to a quantity of 1 litre of oil per day in a large two-stroke diesel engine. For such an engine the leak oil issuing from the hydraulic unit amounts to approximately 10 litres of oil per day and can therefore easily satisfy the oil consumption required to supply the annular gap 11.

The oil is supplied to the annular gap 11 past the sealing ring 22 and can be influenced by its geometrical configuration. It can be assumed that a hydrodynamic lubricating film is formed between the sealing ring 22 and the valve stem 7, whose thickness mainly depends on the geometrical configuration of the sealing ring 22 and other defined parameters, such as the relative speed. A wedge-shaped inlet of the gap between the surfaces disposed

relative to each other has a positive effect on the formation of such a lubricating film. Likewise, the width of the contact surface adjacent to the inlet has an influence on the thickness of the lubricating film.

In the example underlying Fig. 4 the sealing ring 22 possesses a cross-section which is symmetrical to a horizontal axis of symmetry and which has a wedge-shaped inlet 41 on both sides and a large-width contact surface 40. The wedge shape of the inlet possesses a comparatively large wedge angle. The contact surface 40 is of substantial width and extends almost over the entire height of the sealing ring 22. Owing to such a geometrical configuration of the sealing ring 22, an oil flow rate of the above-mentioned quantity can be achieved.

Claims

1. A large two-stroke in-line type diesel engine having at least one cylinder (1), whose combustion chamber (3) comprises an exhaust opening (4) which is controllable by an exhaust valve (5) actuatable by an actuating device comprising an advance arrangement and a return arrangement, and on whose cylinder head (2) a valve housing (9) is mounted which comprises an exhaust duct (9) adjoining to the exhaust opening (4) of the combustion chamber (3), and further a guide sleeve (10) extending through the upper wall of the said exhaust duct (8) for a stem (7) of the exhaust valve (5) extending through the exhaust duct (8), with the return arrangement comprising a piston (15) provided on the valve stem (7) and an operating chamber (17) limited by such piston and chargeable with compressed air, which operating chamber (17) is sealed towards an annular gap (11) to which oil can be fed and which lies between the guide surfaces of the mutually facing guide sleeve (10) and valve stem (7) and communicates with the exhaust duct (8), by means of a sealing device arranged in the region of the upper, exhaust duct-far end of the annular gap (11) and possessing at least one sealing ring (22), **characterised in that** above that above the sealing ring facing the exhaust duct (8) of the sealing device provision is made for an oil reservoir (24 or 32 or 36, respectively) which can be supplied with oil and whose oil content is present at the top side pointing away from the exhaust duct (8) of the sealing ring (22) facing the exhaust duct of the sealing device provided at the upper end of the annular gap and thus permanently floods the said sealing ring (22) from above for the purpose of supplying the annular gap with oil.

2. A large two-stroke diesel engine as claimed in Claim 1, **characterised in that** the exhaust valve (5) can be moved into opening position against the force of the return arrangement by means of a hydraulic advance arrangement acting upon the valve stem (7) of the said exhaust valve (5) and that the oil reservoir (24 or 32,) is supplyable at least in part with leakage oil issuing from the hydraulic actuating arrangement.

3. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the oil level in the oil reservoir (24 or 32) is limited by an overflow edge.
4. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the return arrangement is provided underneath the hydraulic actuating device and that the bottom region of the operating chamber (17) of the pneumatic return device arranged opposite the piston (15) contains the oil reservoir (24) and can be relieved by means of a safety valve (19) which is arranged in an oil return line (21) branching off from the oil reservoir (24).
5. A large two-stroke diesel engine as claimed in Claim 4, **characterised in that** an overflow pipe (27) extending into the oil reservoir (24) is arranged upstream of the safety valve (19), with the overflow edge of the said overflow pipe (27) arranged at a higher level than the oil-flooded sealing ring (22).
6. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the operating chamber (17) can at least in part be supplied with oil from the exterior via an associated supply line (25).
7. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the operating chamber (17) can at least in part be supplied with oil mist via an associated supply line.
8. A large two-stroke diesel engine as claimed in Claim 7, **characterised in that** operating chamber (17) can be supplied with compressed air via a compressed air line (18) and that an oil admixing device (26) is associated with the compressed air line (18).
9. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the guide sleeve (10) is provided with a cover cap (28) overlapping the sealing device and comprising at least one radial recess (29) above the oil-flooded sealing ring (22) which communicates with the oil reservoir (24) and extends up to the bore of the cover cap (28) through which the valve stem (7)

passes.

10. A large two-stroke diesel engine as claimed in any of the preceding Claims 1-3, **characterised in that** the guide sleeve (10) is provided with a cover cap (28) overlapping the sealing device, which cover cap (28) above the seal (22) flooded with oil comprises an inner annular groove (31) which contains the oil reservoir (32) and can be fed with oil via a supply line (33).
11. A large two-stroke diesel engine as claimed in Claim 10, **characterised in that** the return device is designed as an air spring provided underneath the hydraulic actuating device, such air spring comprising a piston (15) attached to the valve stem (7) and an operating chamber (17) limited thereby and supplyable with air, in which operating chamber (17) an oil drip-off edge (34) is formed, underneath which extends a collecting channel (35) from which the supply line (33) branches off.
12. A large two-stroke diesel engine as claimed in Claim 11 or 12, **characterised in that** the annular groove (31) extends to the upper rim of the cover cap (28) forming an overflow edge.
13. A large two-stroke diesel engine as claimed in Claim 10, **characterised in that** the sealing device (2) comprises two sealing rings (22, 23) arranged one above the other, and further in that the annular gap region provided between the sealing rings (22, 23) is, for the purpose of forming the oil reservoir (36), connected with a supply line (37) and a discharge line (38).
14. A large two-stroke diesel engine as claimed in Claim 13, **characterised in that** the supply line (37) is connected with an oil source provided outside the operating chamber (17).
15. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** at least the sealing ring (22) facing the exhaust duct (8) of the sealing device possesses a cross-section symmetrical to a horizontal plane, with a wedge-shaped inlet (41) on both sides and a large-width contact surface (40).

16. A large two-stroke diesel engine as claimed in any of the preceding Claims, **characterised in that** the annular gap (11) limited by the mutually facing guide surfaces of the guide sleeve (10) and valve stem (7) is supplyable with air and/or oil mist via a supply line (39) below the sealing ring (22) facing the exhaust duct (8).