

OUTLET VALVE ON A RECIPROCATING ENGINE

The invention relates to an outlet valve on a reciprocating engine, with a movable valve body comprising a valve shaft and a valve plate which has a ring-shaped seat region made of a first alloy which is different from a second alloy forming at least the base body of the valve plate in the form of a nickel-based alloy.

The invention further relates to a method for producing a movable valve body for an outlet valve on a diesel engine.

Such valve bodies, also known as valve spindles or valve cones, are highly loaded components in diesel engines, in particular large diesel engines in ship drives, power stations, emergency power generators or the like. As a result of the high mechanical and thermal stresses, the seat and guide faces of such valve cones are exposed to high wear loads. Outlet valves are subject to particularly high corrosion loads in the region of the valve plate owing to the combustion gases. Special valve steels have therefore been developed in the present field of use. In the field of highly loaded surfaces of the valve plate, special alloys, preferably based on nickel, are increasingly being used.

In a known outlet valve of the type mentioned at the start (EP 0 521 821 B1) it is provided for the valve base body to be formed from a heat-resistant nickel-based alloy such as NIM80A or NIM81 and for a nickel-based alloy known as IN625 or IN671 to be used in the seat region to increase the wear resistance and corrosion resistance. (The known alloys are the brands Nimonic and Inconel manufactured by Inco Alloys International, Inc.) The seat region is produced by plasma spraying, deposition welding or also powder metallurgy methods with subsequent hot deformation in a rolling process or by cold deformation.

In the region of the valve shaft, it is known (DE 10 2005 013 088 A1) to use alloys consisting of heat-resistant steels and, because of the bending stresses occurring in the region of the valve guide, high fatigue strength and toughness, such as typical valve steel X45CrSi9-3.

It can also be expedient to harden the surface of the valve shaft and improve its sliding properties by plasma nitriding or plasma carbonitriding.

Finally, it is provided in a known outlet valve (EP 0 901 565 B1) for the valve base body to be provided in the region of the valve plate, which consists of austenitic valve steel, for example AISI316, with a plating of a nickel-based alloy of high resistance to hot gas corrosion in the region of the valve base. Various nickel-based alloys are proposed for the seat region of the valve, such as IN625, IN671, IN690, IN718 and the like. After depositing the seat alloy, a further increase in its hardness or yield strength is proposed by means of a thermomechanical forming method.

Despite the high-quality nickel-based alloys used in the known outlet valves, it is to be found again and again in practice that in engines which run under high load or are also briefly overheated, cracks occur in the seat region and in the region of the rounded portion (fillet) of the valve plate which continue into the base material. If such damage is not discovered in good time, consequent damage such that valves tear off or parts of valve plates become detached and lead to destruction to pistons, connection rods and even downstream turbochargers are a highly undesirable result.

In contrast to this, the present invention is based on the object of as far as possible preventing such crack formation as a consequence of high temperature changes in

the region of the valve seat or of the rounded portion of the valve plate, or at least limiting the negative effects of this crack formation, of keeping the seat region of the valve body as crack-free as possible without having to do without or restrict the use of high-quality alloys which resist hot gas corrosion and wear.

Furthermore, a production method is to be indicated, by means of which the properties of the alloys used can be improved further so that they give the valve bodies particularly long service lives even under extremely high loads.

This object is achieved according to the invention in an outlet valve of the type mentioned at the start in that the first alloy consists of a nickel- or cobalt-based alloy with higher wear resistance than the second alloy, that a region of the valve plate which forms the plate base is formed by a third alloy and an adjacent circumferential region is formed by a fourth alloy, which consist in each case of a nickel-based alloy with high resistance to hot gas corrosion, and that an edge region of the valve plate, which is adjacent to the circumferential region and consists of a fifth, likewise nickel-based alloy with high corrosion resistance, extends beneath the seat region, completely lining the latter.

The cracks caused from the start by very different thermal expansions do not occur due to the fact that only nickel- or cobalt-based alloys are used in the region of the valve plate in the outlet valve according to the invention. Added to this is the feature according to the invention of lining the seat region with the fifth alloy which forms the edge region of the valve plate and in an advantageous embodiment can have essentially the same composition as the third and fourth alloy.

However, it cannot be completely ruled out that cracks occur during operation, in particular under overheating conditions with subsequent cooling, but thanks to the configuration of a cohesive shell body consisting of plate base, circumferential region and edge region these cracks run within the shell body.

This effect can be reinforced in that the plate base, circumferential region and edge region of the valve plate are formed from the same alloy by deposition onto the base body and further in that the hardness of the alloy forming the shell body is less than that of the first or second alloy.

It could be demonstrated by the results of field experiments that crack formation begins in the region of the plate base in the region of the outer diameter, to continue slowly in the circumferential region and then into the edge region and that the seat region remains essentially crack-free. Extremely good emergency operation properties are produced in this manner in the sense that the valve still remains usable thanks to the largely intact seat region even in the event of severe crack formation until the damage becomes detectable by a clear increase in the exhaust gas temperature and can be rectified in good time.

The field experiments also showed that the cracks do not propagate into the base body of the valve plate, even if the base body is also forged from a nickel-based alloy, for example NIM80A. As both the base body as a forged part and the seat region consist of harder alloys than the shell body, the latter is provided as a suitable place for crack propagation, that is, the base body and the seat region remain essentially undamaged. In the worst case of a greatly enlarged crack, combustion gases can blow through

under the seat region in an undesirable manner, that is, into the region of its lining and beyond.

A predetermined breaking point for the start of crack formation can to a certain extent be created according to the invention in that the thickness measured in the radial direction of the circumferential region is increased within a limited circumferential section, the arc length of which is expediently between 20 and 40 degrees. In this manner it is possible to keep the remaining circumference of the valve plate largely free of cracks. With cracks within the reinforced circumferential region, their propagation can be controlled in such a manner that it is possible to detect them early while avoiding serious damage.

With regard to suitable materials for the different regions of the valve plate, reference is made to Patent Claims 10 to 17. The full composition of the preferred alloys are defined there, without it being an exhaustive list. It can be left up to the person skilled in the art to select suitable alternative alloys whose chemical and physical properties meet the respective requirements. It should be noted that within the scope of the invention, the selected alloys should as far as possible not have a thermal expansion of more than $\Delta\alpha = 2[m/m^{\circ}K] \cdot 10^{-6}$ difference and that the alloys forming the shell body should have a hardness below the values of the base body and the seat region. In a concrete example, a hardness value of 200 to 350 HV is sufficient for a shell body consisting of IN625 if the base body is forged from NIM80A which has a hardness of more than 400 HV and wherein Stellite 6 with a hardness of 400 to 500 HV is used as the seat region alloy.

In a method according to the invention for producing valve bodies of the present type it is provided for a cohesive shell body to be created by deposition welding on the base body of the valve plate in the region of the plate base and

in its circumferential region and an adjacent edge region. A residual compressive stress is advantageously built up in the seat region by subsequent cold forming.

Such residual compressive stress is particularly advantageous because this to a certain extent forms a reserve in the event of overheating of the engine with subsequent cooling. The associated tensile stresses effect a reduction in the compressive stress present before the feared crack forms. As a result of the residual compressive stress present, the yield point in the region of the plate base is only reached later in the event of such tensile stresses.

An exemplary embodiment of the invention is described below using the drawing. In the figures,

Fig. 1 shows a view of the valve plate

Fig. 2 shows a cross section through the valve base according to II-II of Figure 1

Fig. 3 shows a longitudinal section in the circumferential region of the valve plate according to III-III of Figure 2, and

Fig. 4 shows a longitudinal section in the circumferential region of the valve plate according to IV-IV of Figure 2.

Figure 1 shows a movable valve body 1 with a valve shaft 2 which is shown in a shortened form and a valve plate 3 which has a ring-shaped seat region 4 consisting for example of the cobalt-based alloy Stellite 6. The valve plate has on its underside a plate base 5 which consists for example of the nickel-based alloy IN625. Adjacent to the plate base 5 is a circumferential region 6 likewise consisting of IN625 and to this an edge region 7 likewise

consisting of IN625. A base body 8 which forms the interior of the outlet valve extends from the valve plate 3 to the shaft 2 and forms at least its lower part depending on whether it is a full body valve or a bimetal valve in which an upper shaft part usually consists of a valve steel which is connected to the lower shaft part by friction welding. The base body 8 according to the present example consists of Nimonic 80A and is produced by forging. A shell body consisting of a plate base 5, circumferential region 6 and edge region 7 is produced on the base body 8 by deposition. After depositing the shell body, the seat alloy which consists of Stellite 6 and forms the seat region 4 is likewise formed by deposition in a circumferential groove 9 of the shell body.

The diagram according to Fig. 4 differs from that according to Fig. 3 in that in Figure 4 the circumferential region 6 has a thickened configuration as can be seen in the sectional diagram according to Figure 3. In the region of the thickened portion, the inner side 10 thereof in the sectional diagram according to Figure 2 looks like a chord which extends within an arc b of approximately 30 degrees.

After the deposition, the outer face of the valve plate is deformed by cold forming, for example by rolling or cold pressing. The shell body is in the process deformed, in particular in the circumferential region 6, in such a manner that a residual compressive stress is produced in the region of the plate base 5 from the residual tensile stress present after the deposition.

CLAIMS

1. Outlet valve on a reciprocating engine, with a movable valve body comprising a valve shaft and a valve plate which has a ring-shaped seat region made of a first alloy which is different from a second alloy forming at least the base body of the valve plate in the form of a nickel-based alloy,

characterised in that

the first alloy consists of a nickel- or cobalt-based alloy with higher wear resistance than the second alloy,

a region of the valve plate (3) which forms the plate base (5) is formed by a third alloy and an adjacent circumferential region (6) is formed by a fourth alloy, which consist in each case of a nickel-based alloy with high resistance to hot gas corrosion, and

an edge region (7) of the valve plate (3), which is adjacent to the circumferential region (6) and consists of a fifth, likewise nickel-based alloy with high corrosion resistance, extends beneath the seat region (4), completely lining the latter.

2. Outlet valve according to Claim 1,

characterised in that

the third, fourth and fifth alloys have essentially the same composition.

3. Outlet valve according to Claim 2,

characterised in that

the plate base (5), circumferential region (6) and edge region (7) of the valve plate (3) are formed from the same alloy by deposition onto the base body (8).

4. Outlet valve according to Claim 3,

characterised in that

the plate base (5), circumferential region (6) and edge region (7) of the valve plate (3) form a cohesive shell body, within the edge region (7) of which a circumferential groove (9) for receiving the first alloy which forms the seat region (4) is provided.

5. Outlet valve according to Claim 4,

characterised in that

the hardness of the alloy forming the shell body is less than that of the first or second alloy.

6. Outlet valve according to Claim 4,

characterised in that

the thermal expansion of the second alloy is approximately equal to that of the alloys forming the shell body.

7. Outlet valve according to Claim 1,

characterised in that

the thickness measured in the radial direction of the circumferential region (7) is increased within a limited circumferential section.

8. Outlet valve according to Claim 7,

characterised in that

the increased circumferential region corresponds to an arc length between 20 and 40 degrees.

9. Outlet valve according to Claim 5,

characterised in that

the hardness of the alloys forming the shell body is 200 to 350 HV.

10. Outlet valve according to Claim 1,

characterised in that

the first alloy (L1) forming the seat region (4) corresponds to the composition known under the name Stellite 6 with the main components 27% Cr, 5% W, 2.5% Fe, 2.5% Ni, 1% Si, 1% C, remainder Co, in per cent by weight.

11. Outlet valve according to Claim 1,

characterised in that

the first alloy (L1) forming the seat region (4) corresponds to the composition known under the name Stellite 12 with the main components 30% Cr, 9% W, 2.5% Fe, 2.5% Ni, 1% Si, 1.8% C, remainder Co, in per cent by weight.

12. Outlet valve according to Claim 1,

characterised in that

the first alloy (L1) forming the seat region (4) corresponds to the composition known under the name Triballoy T700 with the main components 32% Mo, 15% Cr, 3.3% Si, 0.1% C, remainder Ni, in per cent by weight.

13. Outlet valve according to Claim 1,

characterised in that

the first alloy (L1) forming the seat region (4) corresponds to the composition known under the name Triballoy T800 with the main components 28% Mo, 17% Cr, 3.4% Si, 0.8% C, remainder Co, in per cent by weight.

14. Outlet valve according to Claim 1,

characterised in that

the first alloy (L1) forming the seat region (4) corresponds to the composition known under the name IN718 with the main components 19% Cr, 18% Fe, 5.2% Nb, 3% Mo, 1% Ti, 0.55% Al, 0.04% C, remainder Ni, in per cent by weight.

15. Outlet valve according to Claim 1,

characterised in that

the second alloy (L2) forming the base body (8) corresponds to the composition known under the name NIM80A with the main components 19.5% Cr, 2.35% Ti, 1.4% Al, 0.06% C, remainder Ni, in per cent by weight.

16. Outlet valve according to Claim 1,

characterised in that

the alloys (L3, L4, L5) forming the shell body correspond to the composition known under the name IN625 with the main components 22% Cr, 9% Mo, 3.5% Nb, 3% Fe, remainder Ni, in per cent by weight.

17. Outlet valve according to Claim 1,

characterised in that

the alloys (L3, L4, L5) forming the shell body correspond to the composition known under the name IN671 with the main components 46% Cr, 0.35% Ti, 0.05% C, remainder Ni, in per cent by weight.

18. Method for producing movable valve bodies for outlet valves according to one of Claims 1 to 15,

characterised in that

a cohesive shell body is produced by welding on the base body (8) of the valve plate (3) in the region of the plate base (5) and in its circumferential region (6) and an adjacent edge region (7).

19. Method according to Claim 18,

characterised in that

after the deposition welding the valve cone is subjected to a heat treatment at 600 to 800°C in such a manner that a residual tensile stress is partly or wholly reduced in the shell body.

20. Method according to Claim 18,

characterised in that

after the deposition welding the valve plate (3) is subjected to a thermomechanical forming process to create a residual compressive stress in the seat region (4).