



METHOD AND DEVICE FOR PRODUCING MACHINE PARTS PROVIDED WITH
AT LEAST ONE SLIDE SURFACE

The present invention relates to a method and a device for producing machine parts provided with at least one slide surface, particularly piston rings and/or pistons and/or cylinder liners of motors, preferably large two-stroke diesel motors, which are provided in the region of their slide surface with a coating applied to the base material.

Machine parts having a welded-on single layer or multilayer coating made of, for example, aluminum bronze, have already been suggested. Only one homogeneous material may be applied at a time by welding. The achievable properties of the coating are therefore essentially determined by the properties of this welded-on material. A material mixture made of multiple materials is not possible.

On this basis, it is the object of the present invention to provide a method and a device of the type initially described, the properties of the coating being improved in relation to a pure aluminum-bronze coating.

This object is achieved in connection with the method according to the species in that the coating is formed by an aggregation of aluminum bronze and at least one further material which is not alloyed with the aluminum bronze and the coating is sprayed onto the base material in the thermospray method.

In this case, it is advantageously possible to supply multiple materials to the spray jet. The coating sprayed on in the thermospray method may therefore be made of a material mixture including multiple materials which are not alloyed with one another. In this way, it is possible to influence the properties of the aluminum bronze, which is



used as the matrix material for the other material, in one direction or the other by adding another material and/or other materials. In this way, a coating may be achieved whose qualities in regard to both wear resistance and corrosion resistance and the like may be significantly improved in relation to a coating made only of aluminum bronze.

Advantageous embodiments and expedient refinements of the measures above are indicated in the sub-claims. Thus, the coating may expediently contain, in addition to an aluminum bronze, a material which is harder than the aluminum bronze used. In this context, the use of a chromium alloy suggests itself in many ways. Aluminum bronze has comparatively good break-in properties. By adding a chromium alloy, the wear and corrosion resistance and the seizing resistance may be significantly increased. The chromium alloy should expediently contain at least the elements Cr, C, and Fe. This leads to an improvement of the service life, in relation to a coating made only of aluminum bronze, which is well suitable for most uses, more variations being possible by adding and/or replacing individual elements.

The final properties of the coating may also be influenced by variation of the alloy components of the aluminum bronze, which is to expediently contain at least the elements Al, Fe, and Cu. Thus, an aluminum bronze having 9 % Al, 1 % Fe, and the remainder Cu results in a comparatively soft matrix having particularly good break-in properties. On the other hand, an aluminum bronze having 14 % Al, 4 % Fe, 2 % Mn, and the remainder Cu results in a comparatively hard matrix, a particularly large hardness of the overall coating being achievable by combination with specific chromium alloys.

According to a particularly advantageous embodiment of the measures above, the coating may contain intercalations,

harder than the other coating materials, which are sprayed on in the form of a powder which is not melted with the other coating materials, which are melted for spraying, during the spray procedure. The other coating materials may be exclusively aluminum bronze or a mixture of aluminum bronze and a further material melted during the spray procedure, such as a chromium alloy of the type described above. The intercalations added in the form of a powder, which may expediently be made of carbides and/or oxides of, for example, tungsten, nickel, chromium, etc., result in a particularly large increase of the achievable hardness. At the same time, the intercalations mentioned function in many cases as a type of abrasive grit, which leads to a certain honing effect. In this way, oil pockets arise after the break-in, in which lubricant may be stored, which has an advantageous effect on the achievable overall service life.

To form a spray jet, two wires may advantageously be melted at a predetermined distance from the base material and have a gas jet directed toward the base material applied to them, one wire being made of aluminum bronze and the other wire being assigned to at least one further material. In this case, the composition of the coating may be influenced by the advancing speed of the wires and also by the thickness of the wires.

A further possibility for influencing in this case is the selection of a specific gas. Thus, the use of air favors the formation of oxides, which elevates the wear resistance. The use of nitrogen leads to extensive suppression of oxides, which allows a high hardness to be achieved. The use of argon and/or helium and/or hydrogen allows the application of particularly high temperatures, which results in a particularly compact coating.

For melting the wires, an electric arc is expediently generated between these wires. For this purpose, the wires are simply connected to different poles of an appropriately strong power source, a further variation of the properties of the coating to be produced being possible through the assignment of positive and negative to one or the other wire. It is expedient in many cases if the wire made of aluminum bronze is connected to the positive pole.

An advantageous measure for producing a coating provided with non-melted intercalations is that a wire implemented as a hollow wire whose cavity contains the powder forming the intercalations is melted.

The device according to the present invention for performing the method expediently contains a spray head having an outlet opening, having a nozzle assigned to the outlet opening which may have a pressurized gas applied to it, and having two wire feed lines, assigned to the outlet opening, for wires, connected to different poles of an electrical power source, which form the coating material and which are meltable by an electrical arc formed in the region of the outlet opening. A device constructed in this way has been shown to be very simple and robust.

Further advantageous embodiments and expedient refinements of the measures described above are indicated in the remaining sub-claims and may be understood in more detail from the following exemplary description with reference to the drawing.

In the drawing described below:

Fig. 1 shows an exemplary application in the form of a detail from a cylinder of a large motor,

Fig. 2 shows a schematic illustration of a device for performing the method according to the present invention, and

Fig. 3 shows a variant of Fig. 2.

The main area of application of the present invention is large motors, such as large two-stroke diesel motors, which are used, for example, as propulsion for ships, and in this regard particularly the parts provided with bearing surfaces, such as the cylinder liners, pistons, piston rings, etc. The example on which Fig. 1 is based shows a cylinder liner 1 having a piston 2 positioned therein which is provided with piston rings 3. These rings are provided here in the region of their circumferential bearing surface with a coating 4, which is to extend the service life. Of course, it would also be conceivable to simultaneously or alternatively coat the bearing surfaces of cylinder liner 1 and/or the piston skirt, etc.

Coating 4 may be implemented as a single-layer or multilayer coating and is made of an aggregation, i.e., a material mixture, of aluminum bronze and at least one further material not alloyed with the aluminum bronze. In a multilayer coating, the individual layers may each be made of the same material mixture or of different material mixtures. In this case, the aluminum bronze functions for practical purposes as a matrix which absorbs the further material. The different materials are sprayed, as may be seen best in Fig. 2, onto the base material of the component to be coated using a joint spray jet 5 in the thermospray method. In this case, the melt formed from the different materials has a gas jet directed toward the base material to be coated applied to it. The base material to be coated may be a cast-iron or steel material.

The device on which Fig. 2 is based contains a receiving device, in this case in the form of a table 6, to receive the base material to be coated, in this case a piston ring 3. A spray head 7 is provided at a distance above table 6. This spray head has a tubular, conically tapered housing 9 which is provided with an outlet opening 8 on its forward end, facing the table. This housing may be provided with a handle, not shown in more detail here, for manual operation or may be movably accommodated on a frame assigned to table 6. Of course, it would also be conceivable to position spray head 7 stationary and provide table 6 with a movable workpiece receiver.

Two wire feed lines 10, 11 are assigned to outlet opening 8 which end at a small distance from outlet opening 8. A wire 14 and/or 15 which may be drawn off from an assigned drum 12, 13 is supplied to each of wire feed lines 10, 11. The wire advance is produced by an advancing device 16 in each case.

Drums 12, 13, and therefore wires 14, 15 drawn off of them, are connected to different poles of a power source 17. The current intensity of power source 17 is dimensioned in such a way that an electrical arc 18 results between the ends of the wires protruding from wire feed lines 10, 11, which leads to the forward ends of wires 14, 15 melting, even in the case of different melting temperatures of the materials on which wires 14 and/or 15 are based. The melting temperatures of the materials on which wires 14 and/or 15 are based may therefore differ. As a rule, the melting temperature of aluminum bronze is lower than the melting temperature of the chromium alloys described.

Since wires 14, 15 are advanced continuously, continuous melts are produced. These are blown away in the form of small droplets using a gas jet directed toward table 6. Spray jet 5 formed in this way forms coating 4, which in

this case contains both the material of wire 14 and the material of wire 15, when it hits the base material to be coated. A jet 24, which is connected to a suitable pressurized gas source, not shown, ending in a nozzle above the melting ends of wires 14, 15, is provided to produce the gas jet described.

In the example shown in Fig. 2, only one spray head 7 is provided for two wires, between which electrical arc 18 is ignited. However, it would also be conceivable to assign each wire its own spray head, an electrical arc, which may be driven out by a gas jet of a gas applied to the tubular jacket, able to be ignited between two spray head parts at a time, e.g., between a wire outlet nozzle and a tubular jacket which encloses it.

In simple cases, it is sufficient if coating 4 has a single layer, since in many cases the desired properties are achievable merely by a suitable material mixture. A coating of this type may be advantageously applied in one work cycle. However, a multilayer, e.g., two-layer design of coating 4 is possible and often advantageous.

In a multilayer coating, a first, comparatively soft layer may be expediently provided, followed by a comparatively hard layer. In this case, the first layer provides good bonding of the external layer to the base material. Therefore, a material mixture which results in a very large hardness, which would be subject to a high danger of chipping without the softer first layer, may therefore be used for the external layer. The external layer may be 3 to 5 times harder than the base material without anything further in this case, which results in good stability. The material mixture for the first layer is expediently selected in such a way that a hardness lying between hardnesses of the base material and the external layer, and therefore lower jumps in hardness, results. The corrosion

resistance may also be influenced by appropriate material selection.

In a multilayer coating, a comparatively large overall thickness of the coating may be advantageously achieved. A coating of this type may be compressed somewhat after the application procedure, which advantageously leads to an increase of the hardness. The compression desired in this regard may be achieved by a processing procedure, e.g. a polishing procedure, and/or may result on its own during operation, particularly during the break-in phase. The compression described is also possible in a single-layer coating, if to a lesser degree due to the lesser thickness.

Coating 4 contains, as already mentioned above, an aluminum bronze on one hand and at least one further material, not alloyed with the aluminum bronze used, on the other hand. Correspondingly, one wire, e.g. wire 14, is made of an aluminum bronze and the other wire, e.g. wire 15, is made of the further material used to form coating 4. In this case, the aluminum bronze forms a matrix which absorbs the further material. Through an aggregation of this type of materials which are not alloyed with one another, the qualities of the aluminum bronze forming the matrix material may be improved in any desired direction. As a rule, the aluminum bronze has good break-in properties. By using a further material which is harder than aluminum bronze, for example a chrome alloy, greater hardness and therefore good wear and corrosion resistance may additionally be achieved. The corrosion resistance may also be influenced by suitable selection of the material.

The properties of the matrix formed by the aluminum bronze may be influenced by selection of the alloy components of the aluminum bronze. Thus, an aluminum bronze having 7 % to 12 %, preferably 9 % Al, 0.5 % to 2 %, preferably 1 % Fe, and the remainder Cu forms a relatively soft matrix. If a

comparatively hard matrix is desired, an aluminum bronze having 14 % Al, 2 % to 8 %, preferably 4 % Fe, 0.5 % to 5 %, preferably 2 % Mn and the remainder Cu may be used. A cost-effective chromium alloy may contain 10 % to 15 %, preferably 13 % Cr, 0.2 % to 0.5 %, preferably 0.35 % C, and the remainder Fe. To increase the hardness, the proportions may be changed and further elements may be added and/or replaced. Thus, using a chromium alloy having 25 % to 35 %, preferably 28 % Cr, 2 % to 7 %, preferably 5 % C, 0.5 % to 3 %, preferably 1 % Mn, and the remainder Fe, a larger hardness results than with the chromium alloy described above. A further increase may be achieved using a chromium alloy having 25 % to 35 %, preferably 28 % Cr, 2 % Mn, 3.7 % B, 1.7 % Si, and the remainder Fe, the proportions of Mn, B, and Si able to vary by ± 1 %. A chromium alloy having 40 % to 50 % Cr, 6 % to 12 % Mo, 2 % to 5 % C, 2 % to 5 % Fe, and the remainder Ni results in a particularly large hardness. In this case, 45 % Cr, 9 % Mo, 3.5 % C, 3.5 % Fe, and the remainder Ni may preferably be provided.

Each of the chromium alloys described above may be combined with each of the aluminum bronzes described further above. In this case, a combination with the harder aluminum bronzes results in a greater hardness of the coating and vice versa. In this way, favorable coatings may be produced for each individual case. Experiments have shown that a combination of one of the aluminum bronzes described above with the first chromium alloy described above having preferably 13 % Cr, 0.2 % to 0.5 % C, and the remainder Fe results in a particularly good piston skirt coating, its hardness able to be influenced by using one or another aluminum bronze. A combination of one or another aluminum bronze of the type described above with the second or third chromium alloy preferably having, respectively, 28 % Cr, 5 % C, 1 % Mn, and the remainder Fe or 28 % Cr, 2 % Mn, 3.7 % B, 1.7 % Si, and the remainder Fe results in a

coating which is particularly well suitable for piston rings.

The combination of one or another aluminum bronze of the type described above with a chromium alloy having 40 % to 50 % Cr, 6 % to 12 % Mo, 2 % to 5 % C, 2 % to 5 % Fe, and the remainder Ni or preferably 45 % Cr, 9 % Mo, 3.5 % C, 3.5 % Fe, and the remainder Ni results in a particularly good cylinder sleeve coating, the overall hardness being guided downward by using the aluminum bronze having preferably 9 % Al, 1 % Fe, and the remainder Cu and able to be elevated by using the aluminum bronze preferably having 14 % Al, 4 % Fe, 2 % Mn, and the remainder Cu, as in the other cases.

Further possibilities for influencing the properties of the coating exist in the selection of the blowout gas. In simple cases, air may be used for this purpose. However, it would also be conceivable to use N₂, argon, helium, or hydrogen or combinations of these gases. The use of air favors the formation of oxides, which improves the wear resistance. If N₂ is used, fewer oxides arise, which leads to a comparatively large hardness. If argon and/or helium and/or hydrogen are used, comparatively high temperatures may be applied, which causes the coating produced to be particularly compact.

In connection with the combination of one of the aluminum bronzes described above with the chromium alloy preferably having 13 % Cr, 0.2 % to 0.5 % C, and the remainder Fe, the use of air as a blowout gas has been shown to be particularly expedient. In connection with the chromium alloy preferably having 28 % Cr, 5 % C, 1 % Mn, and the remainder Fe, the use of N₂ as a blowout gas has been shown to be particularly expedient. In connection with the chromium alloy preferably having 28 % Cr, 2 % Mn, 3.7 % B, 1.7 % Si, and the remainder Fe, experience has shown argon

is preferable as a blowout gas. In connection with the chromium alloy preferably having 45 % Cr, 9 % Mo, 3.5 % C, 3.5 % Fe, and the remainder Ni, helium or a combination of helium and/or argon and/or N₂ is preferred as a blowout gas.

Further possible variations exist in the selection of the advancing speed of wires 14, 15 and/or the thickness of wires 14, 15. These dimensions are expediently selected in such a way that the proportion of the aluminum bronze in the coating is at least 50 %, preferably over 50 %, so that a roomy matrix for the further material still to be added results.

The general description of the coating given above also applies, of course, for the individual layers in a multilayer coating.

In the example on which Fig. 3 is based, two wires 19, 20 are also melted, one wire 19 being implemented as a more massive wire made of an aluminum bronze of the type described above. Other wire 20 is implemented as a hollow wire, which is made of a chromium alloy of the type described above, preferably the chromium alloy having 40 % to 50 % Cr, 6 % to 12 % Mo, 2 % to 5 % C, 2 % to 5 % Fe, and the remainder Ni, which has the largest hardness of the chromium alloys described. The hollow of hollow wire 20 contains a filling 21 which is made of carbides or oxides existing in powdered form, for example WoC, CrC, NiC, or CrO. This powder is released when wires 19, 20 melt, without melting itself, and is carried away with the droplets of the molten materials by the gas jet supplied.

The carbides and/or oxides existing in powdered form are correspondingly sprayed onto the base material together with the melted materials to form a coating. In the example shown in Fig. 3, the workpiece to be coated is a cylinder

sleeve 1 which is provided in the region of its bearing surface with a coating 22. The carbides and/or oxides existing as powder and sprayed on together with the molten materials formed by wire 19 and hollow wire 20 form grains 23 intercalated in coating 22 in this case. As soon as these grains are exposed, they lead to a certain honing effect, through which break-in residues located on the surface of the counter workpiece after the break-in phase are removed. Simultaneously, oil pockets form, which ensure reliable lubrication.

In a multilayer coating, only the external layer and/or one of the external layers which bears after the break-in phase is expediently provided with intercalations in the form of grains 23.

Several preferred embodiments of the present invention were described in more detail above, without, however, a restriction to be connected with this. Rather, an array of possibilities are available to one skilled in the art in order to tailor at the general ideas of the achievement of the object to the circumstances of the individual case. Thus, it would be conceivable, for example, for the coating and/or a layer of the coating to be formed only by aluminum bronze and intercalations in the form of grains 23 described above. To produce a coating of this type, for example, a hollow wire made of the desired aluminum bronze which is filled with the powdered material provided to form the intercalations could be used.

CLAIMS

1. A method for producing machine parts provided with at least one slide surface, particularly piston rings (3) and/or pistons (2) and/or cylinder sleeves (1) of motors, preferably large two-stroke diesel motors, which are provided in the region of their slide surface with a coating (4 and/or 22), applied to the base material and containing an aluminum bronze, wherein the coating (4 and/or 22) is formed by an aggregation of aluminum bronze and at least one further material which is not alloyed with the aluminum bronze, and the coating (4 and/or 22) is sprayed onto the base material in the thermospray method.
2. The method according to Claim 1,

characterized in that

the coating (4, 22) contains, in addition to aluminum bronze, a material which is harder than the aluminum bronze used, preferably a chromium alloy.
3. The method according to Claim 2,

characterized in that

the chromium alloy contains at least the elements Cr, C, and Fe.
4. The method according to one of the preceding claims,

characterized in that

the chromium alloy contains 10 % to 15 %, preferably 13 % Cr, 0.2 % to 0.5 %, preferably 0.35 % C, and the remainder Fe.

5. The method according to one of preceding Claims 1 to 3,

characterized in that

the chromium alloy contains 25 % to 35 %, preferably 28 % Cr, 2 % to 7 %, preferably 5 % C, 0.5 % to 3 %, preferably 1 % Mn, and the remainder Fe.

6. The method according to one of preceding Claims 1 and 2,

characterized in that

the chromium alloy contains 25 % to 35 %, preferably 28 % Cr, approximately 2 %, preferably exactly 2 % Mn, approximately 3.7 %, preferably exactly 3.7 % B, approximately 1.7 %, preferably exactly 1.7 % Si, and the remainder Fe.

7. The method according to one of preceding Claims 1 or 2,

characterized in that

the chromium alloy contains 40 % to 50 %, preferably 45 % Cr, 6 % to 12 %, preferably 9 % Mo, 2 % to 5 %, preferably 3.5 % C, 2 % to 5 %, preferably 3.5 % Fe, and the remainder Ni.

8. The method according to one of the preceding claims,

characterized in that

the aluminum bronze contains at least the elements Al, Fe, and Cu.

9. The method according to one of the preceding claims, characterized in that

the aluminum bronze contains 7 % to 12 %, preferably 9 % Al, 0.5 % to 2 %, preferably 1 % Fe, and the remainder Cu.

10. The method according to one of the preceding Claims 1 to 8,

characterized in that

the aluminum bronze contains 13 % to 18 %, preferably 14 % Al, 2 % to 8 %, preferably 4 % Fe, 0.5 % to 5 %, preferably 2 % Mn, and the remainder Cu.

11. The method according to one of the preceding claims, characterized in that

the proportion of the aluminum bronze in the coating is at least 50 %, preferably more than 50 %.

12. The method according to one of the preceding claims, characterized in that

the coating (22) contains intercalations (23), harder than the other coating materials, which are sprayed on, in the form of a powder not melted during the spraying procedure, with the other coating materials melted for spraying.

13. The method according to Claim 12,

characterized in that

the intercalations (23) are made of carbides and/or oxides.

14. The method according to one of the preceding claims,

characterized in that

two wires (14, 15; 19, 20) are melted at a predetermined distance from the base material and have at least one gas jet directed toward the base material applied to them to form a spray jet (5), one wire (14, 19) being assigned to the aluminum bronze and one wire (15, 20) being assigned to at least one further material.

15. The method according to one of the preceding claims,

characterized in that

at least one electric arc (18) is generated to melt the wires (14, 15; 19, 20).

16. The method according to Claim 15,

characterized in that

the wires (14, 15; 19, 20) are connected to different poles of a power source (17), the wire (14, 19) assigned to the aluminum bronze preferably being connected to the positive pole and the further wire (15, 20) being connected to the negative pole.

17. The method according to one of preceding Claims 14 to 16,

characterized in that

the diameter of the wire (14, 19) assigned to the aluminum bronze is greater than the diameter of the other wire (15, 20).

18. The method according to one of preceding Claims 12 to 17,

characterized in that

a wire (20) is melted which is implemented as a hollow wire whose hollow contains a powder forming the intercalations (23).

19. The method according to one of the preceding claims,

characterized in that

the gas jet produced for spraying contains air and/or nitrogen and/or argon and/or helium and/or hydrogen.

20. The method according to one of the preceding claims,

characterized in that

the coating (4, 22) is sprayed on in multiple layers, preferably two layers.

21. The method according to Claim 20,

characterized in that

in a multilayer coating (4, 22), the outer layer(s) is/are implemented as thicker than the inner layer.

22. The method according to Claim 20 or 21,

characterized in that

in a multilayer coating (4, 22), the outer layer(s) is/are implemented as harder than the inner layer.

23. The method according to one of preceding Claims 1 to 19,

characterized in that

the coating (4, 22) is sprayed on in one layer.

24. The method according to one of the preceding claims,

characterized in that

the coating (4, 22) is compressed after being sprayed on.

25. A device for performing the method according to one of the preceding claims,

characterized by at

least one spray head (7) having an outlet opening (8), having at least one nozzle (24) assigned to the outlet opening (8) which may have a pressurized gas applied to it, and having two wire feed lines (10, 11) assigned to the outlet opening (8) for wires (14, 15; 19, 20) connected to the different poles of an electric power source (17), which are meltable by an

electric arc (18) formed in the region of the outlet opening (8).