A heat shield, in particular for a turbocharger, has a disk or a pot shape which is stepped once or multiple times. The disc or pot shape has an outer edge, and the outer edge is provided with at least one opening section. The opening section forms a web section with the outer edge, said web section being bent outward in order to form a spring arm. The web section is either designed as closed or as open at one point.
FIG. 1
PRIOR ART
FIG. 3
PRIOR ART
FIG. 5
PRIOR ART
FIG. 10

Comparison of force-deflection curves

\[ F \text{ [N]} \]

maximum permissible force

possible spring deflection
spring-arm heat shield
small working range/displacement

possible spring deflection
wave-spring heat shield
large working range/displacement

spring heat shield with radially arranged spring arms

wave-spring heat shield with tangentially arranged spring arms
HEAT SHIELD AND TURBOCHARGER HAVING A HEAT SHIELD

[0001] The invention relates to a heat shield, in particular in a turbocharger, and a turbocharger having such a heat shield, to protect a bearing system of the turbocharger from heat penetrating by means of a warm or hot medium such as hot exhaust gas.

[0002] Turbochargers normally have a housing, in which a turbine wheel and a compressor wheel are mounted by radial bearings on a shaft so that they can rotate on the shaft. The shaft can reach rotational speeds of up to 300,000 rpm for example. In order to be able to absorb axial forces that arise, at least one axial bearing can also be provided, for example. The bearings are here lubricated by a suitable lubricating oil.

[0003] The high exhaust-gas temperatures in the turbocharger mean that a large amount of heat penetrates the bearing system. This results in coking of the lubricating oil for lubricating the bearings, and in the worst case in total failure of the bearing system. A shield between the turbine and the bearing system reduces the heat penetration and avoids coking of the lubricating oil.

[0004] It is already known from the prior art to provide a heat shield that is fitted either in series or in a parallel arrangement between the bearing housing and the turbine housing. When the heat shield is arranged in series, the thickness tolerance affects the axial contour gap between turbine wheel and turbine housing, which has a negative impact on the turbine efficiency. In a parallel arrangement, the heat shield must be designed as a spring, which enables adjustment for component tolerances and the thermal expansion of components. The spring is formed either by three or more spring arms arranged radially outwards or by a circumferential collar. As described in even greater detail below with reference to FIGS. 3 and 5 by way of example, such a spring has the disadvantage, however, that the spring arms can easily break off and the circumferential collar has a high spring force for a small spring deflection.

[0005] Hence it is the object of the present invention to provide an improved heat shield or, more precisely, a turbocharger having an improved heat shield, with which the heat penetrating a bearing system of the turbocharger can be reduced.

[0006] This object is achieved by a heat shield having the features of claim 1.

[0007] As claimed in claim 1, according to the invention a heat shield is provided, in particular for a turbocharger, said heat shield being designed in the form of a disc or a pot shape containing one or more steps,

[0008] said disc or said pot shape having an outer rim, said outer rim being provided with at least one slotted section,

[0009] said slotted section forming a web section with the outer rim, said web section being bent outwards (preferably in an axial direction i.e. towards the turbine housing or towards the bearing housing) in order to form a spring arm, said web section being designed either to be closed or to be open at one point.

[0010] The flange on the outer rim can also be discontinuous in the circumferential direction.

[0011] The heat shield here has the advantage that as a result of the web section, which is bent outwards as a spring arm, a longer spring arm can be implemented than is the case in the known heat shields, whose spring arms are relatively short. The longer spring arms in turn enable a flat shape for the force-deflection curve, i.e. the spring force remains constant over the working range of the spring. Thanks to the flat curve, the axial spring displacement can be chosen to be relatively large, thereby enabling adjustment for tolerances and for thermal expansion without a reduction in the spring force. It can thereby be guaranteed that the heat shield with its spring arm or spring arms does not become loose.

[0012] Advantageous embodiments and developments of the invention follow from the subclaims and the description with reference to the drawings.

[0013] According to one embodiment of the invention, the web section has, for example, an elongated, circular and/or oval shape. In principle, the web section can have any shape. The crucial factor is that the web section can be bent sufficiently outwards in order to form a spring arm having a suitable spring force and a suitable spring deflection. The longer the slot section is chosen to be, for example, the longer the web section also accordingly becomes, and the further the web section can be bent outwards. The shape and length of the web section is chosen here, for example, so that the web section can be bent outwards sufficiently while enabling a sufficient spring force to be achieved.

[0014] In a further embodiment according to the invention, the web section has a uniform thickness or at least one or more segments having a different thickness. In other words, the thickness of the web section can be designed to remain constant or can vary.

[0015] In another embodiment according to the invention, the heat shield can have one or a multiplicity of web sections, said web sections being all arranged in a track on the outer rim. The web sections can also be radially offset within a track. In this context, it is possible to provide not just one track having at least one or a multiplicity of web sections, but at least two or a multiplicity of tracks. The web sections of a track can also have an identical or different design. The same also applies to the web sections where there are a plurality of tracks; for instance the web sections of two or more tracks can have an identical or different design depending on the function and application. The web sections of the tracks can be arranged here with a mutual offset, for example, or be arranged substantially in line. In this way it is possible to implement a multiplicity of heat shields having spring arms, which can be adapted, for example, to suit the physical circumstances or different applications and functions.

[0016] In a further embodiment according to the invention, one or more web sections can be designed to be open at one end or, for example, in the center or in another position of the web. The respective segment of the web section is bent outwards accordingly in this case. The respective web section or a segment of the web section is here bent outwards by a predetermined amount, for example, in order to set a predetermined spring displacement of the spring arm. Owing to the fact that the web section can here be bent outwards tangentially, a greater spring deflection can be achieved than in the known heat shields having their spring arms that can be bent only at a slight angle.

[0017] In a further embodiment, the web sections or the segments of the web sections for one track or a plurality of tracks can be bent outwards, for example, by the same amount or by different amounts depending on the function and application or physical circumstances.
According to a further embodiment according to the invention, the disc-shaped heat shield within the outer rim is designed to curve outwards. Here the curvature can be designed to be continuous or stepped, for example in the form of, one, two or more steps. This curvature can be provided, for example, in order for the heat shield to fit suitably between the bearing housing and the impeller housing of a turbocharger. In principle, however, it is also possible for the heat shield to have a substantially flat design, apart from the spring arms that are bent outwards. In principle, the heat shield can have any shape depending on the function, application or physical circumstances.

In another embodiment according to the invention, the heat shield is made of a heat-resistant or high-temperature resistant material depending on its place of use. In other words, the heat-shield material is also selected according to what temperatures the heat shield is exposed to. This means that it can be sufficient, for example, where temperatures are not so high, to use a heat-resistant material, whereas at high temperatures a high-temperature resistant material is practicable. Such a heat-resistant or high-temperature resistant material may be, for example, a suitable metal or a suitable metal alloy or another suitable material or material combination provided that these are suitable for forming spring arms.

According to a further embodiment according to the invention, the heat shield can be made, for example, as a turned part or a bent (sheet-)metal part. The invention is not restricted to these methods, however.

The invention is described in greater detail below with reference to the exemplary embodiments shown in the schematic diagrams of the drawings, in which:

FIG. 1 shows a section of a “sandwich” heat shield according to the prior art in its installed state;

FIG. 2a-e shows three perspective views of the “sandwich” heat shield according to FIG. 1;

FIG. 3 shows a section of a “spring-arm” heat shield according to the prior art in its installed state;

FIG. 4a-e shows three perspective views of the spring-arm heat shield according to FIG. 1;

FIG. 5 shows a section of a heat shield having circumferential flange according to the prior art in its installed state;

FIG. 6a-e shows three perspective views of the heat shield having circumferential flange according to FIG. 5;

FIG. 7a-e shows three perspective views of a wave-spring heat shield according to the invention;

FIG. 8 shows a section of a wave-spring heat shield according to the invention in its installed state, with the turbine housing and the bearing housing being connected together by a screw fastening;

FIG. 9 shows a section of the wave-spring heat shield according to FIG. 7a-7c in its installed state, with the turbine housing and the bearing housing being connected together by a clamp-band fastening; and

FIG. 10 shows a graph in which are compared the force-displacement curves of the wave-spring heat shield and the spring heat shield having radially arranged spring arms.

In all figures, identical or functionally equivalent elements and devices have been given the same reference numerals, unless otherwise stated.

FIG. 4 shows a section of a “sandwich” heat shield 10 according to the prior art in its installed state. The “sandwich” heat shield 10 here lies between a turbine housing 12 and a bearing housing 14 of a turbocharger 16, and is braced axially in series with these components either by a screw fastening or by a clamp-band fastening.

The “sandwich” heat shield 10, however, has the problem that the thickness tolerance of the heat shield 10 affects the axial contour gap 18 between a turbine wheel 20 of the turbocharger 16 and the turbine housing 12. The contour gap 18 in turn affects the thermodynamics and hence the efficiency of the turbine. A larger axial distance must be provided between the turbine wheel 20 and the turbine housing 12 as a result of the thickness tolerance of the “sandwich” heat shield 10, which can be made as a sheet-metal part or turned part. Hence the turbine has a lower efficiency.

FIGS. 2a and 2e show the “sandwich” heat shield 10 in two perspective views, with the views each showing the “sandwich” heat shield 10 from the side that has the contact surface 22 for the turbine housing 12. In addition, FIG. 2b shows a side view of the “sandwich” heat shield 10, with the flat contact surface 24 for the bearing housing and the flat contact surface 26 for the turbine housing being shown. The “sandwich” heat shield 10 is here curved outwards in two steps on the turbine-housing side, and has a hole 34 in order to be mounted on the bearing housing 14 or on the shaft 28 of the turbocharger 16.

In addition, FIG. 3 shows a section of a “spring-arm” heat shield 10 according to the prior art in its installed state. The turbine housing 12 here lies axially directly against the bearing housing 14. In this case, the spring-arm heat shield 10 is braced in parallel between the bearing housing 14 and the turbine housing 12, and hence has no effect on the contour gap 18. FIG. 3 shows a contact surface 22 for the turbine housing 12 against the bearing housing 14, for example with a clamp-band fastening. It also shows an arm 30, having radial spring action, of the heat shield 10, as clamped between the bearing housing 14 and the turbine housing 12. In addition, the figure shows an axial gap 32 between the turbine housing 12 and the bearing housing 14, which is defined by the contact surface 22.

FIGS. 4a and 4c show a perspective view of the spring-arm heat shield 10, said spring-arm heat shield 10 being shown from the side that faces the turbine wheel when in its installed state. The heat shield 10 here has three spring arms 30, which are bent outwards. In addition, FIG. 4b shows a side view of the spring-arm heat shield 10. The heat shield 10 is here curved outwards on the turbine-wheel side and has a hole 34 in the center in order to be mounted on the shaft 30 of the turbocharger 16 or on the bearing housing 14.

The spring-arm heat shield 10 has the disadvantage that rapid heating of the components causes the components to expand very rapidly. The short spring arms 30, constrained by the physical space, are attached by a very small corner radius, which, under expansion, can result in excessive thermo-mechanical stresses and to deformation of the components in this corner radius. An excessive stress of this kind can cause the spring arms 30 to crack or to break off entirely. The heat shield 10 thereby becomes loose and can co-rotate and hence lose the heat-shielding function. In this case it can also come into contact with the turbine wheel, which will result in total failure of the turbocharger.

Another problem with the short spring arms 30 is the steep force-deflection curve of the spring, which means that the spring force rises very steeply over the working range for a small change in deflection, as shown in FIG. 10. To prevent the spring force from becoming too high, and hence increasing the risk of plastic deformation of the spring arms 30 and
of difficult assembly, the maximum possible spring deflection, and hence also the working range, is very small. The fact that the spring must cover the tolerance chain and dynamic thermal expansion of the installation space while being defined by the steep force-deflection curve and the limited spring deflection/working range means that there can be a loss in pretension force during operation. This problem is known in the prior art, and results time and again in failure of the turbocharger.

In addition, FIG. 5 shows a section of a heat shield 10 having a circumferential flange 36 according to the prior art in its installed state. The heat shield 10 is here installed in the same way as the heat shield 10 having the spring arms 30. In this case the turbine housing 12 lies axially directly against the bearing housing 14, with, for example, a contact surface 22 for the turbine housing 12 against the bearing housing 14 being provided with the use of a clamp-band fastening. The heat shield 10 having the circumferential flange 36 is braced in parallel between the bearing housing 14 and the turbine housing 12, in other words its circumferential flange 36 is held under spring tension. The heat shield 10 thereby has no effect on the contour gap 18 between the turbine wheel 20 and the turbine housing 12. In addition, FIG. 5 shows an axial gap 32 between the turbine housing 12 and the bearing housing 14, which is defined by the contact surface 22 for the turbine housing 12.

FIGS. 6a and 6c show a respective perspective view of the heat shield 10 having circumferential flange 36, with the heat shield 10 being shown from the side that faces the turbine wheel when in its installed state. In addition, FIG. 6a shows a side view of the heat shield 10. In this case, the heat shield 10 has a stepped curvature 38 that curves outwards towards the turbine wheel, and a spring-action flange 36. In addition, a hole 34 is provided in order to mount the heat shield 10 on the shaft of the turbocharger or on the bearing housing 14.

FIGS. 7a and 7c now show a perspective view of a wave-spring heat shield 100 according to the invention from the side that faces a turbine wheel when in its installed state. The wave-spring heat shield 100 has, for example, a hole 34 for mounting the heat shield 100 on a turbocharger 16. In addition, the wave-spring heat shield 100 is shown in a side view in FIG. 7b.

The wave-spring heat shield 100 according to the invention has a circumferential rim or flange 40, on which are arranged, for example, three web sections 42, which are curved outwards in order for each to provide a spring-action section, or more precisely a spring arm 30. The web sections 42 are here formed in the circumferential rim 40 by making a corresponding slotted section 44 in the rim 40. For the elongated web sections 42, as are shown in FIGS. 7a and 7c, an elongated web section 42 is accordingly provided radially on the circumferential rim 40 of the heat shield 100, with, in each case, an elongated slotted section 44 being provided for this purpose radially on the circumferential rim 40 in order to form the respective web section 42. The web section 42 can have a constant thickness in each case, as is shown in FIGS. 7a and 7c, or can be designed to have a thickness that varies along the length, depending on the function or application.

The respective web sections 42 are bent outwards, for example curved outwards substantially tangentially, in order to produce a spring arm 30 having a suitable spring displacement. The spring displacement in this case can be designed to be larger than the spring displacement, for example, of the heat shield 10 having a circumferential flange 36, as is shown in FIGS. 5 and 6.

The wave-spring heat shield 100 can here have at least one, two, three or more web sections 42, which are bent outwards as spring arms 30. The web sections 42 can be arranged radially on the circumferential rim 40 of the heat shield 100 either in the same manner as the heat shield 10 having the spring arms 30. In addition, instead of one track 46 having web sections 42, as is shown in FIGS. 7a and 7c, it is also possible to provide two, three and more tracks, each having at least one or more web sections 42. In FIG. 7a, a second track 46 having an additional web section 42 is indicated by a dashed line, with the web sections 42 of the two tracks 46 being arranged substantially in line, for example. Alternatively, the web sections 42 can also be mutually offset or partially offset from each other (not shown).

Furthermore, the web sections 42 of the tracks 46 can each be designed to have an identical or different shape and/or size, for example. For instance, the outer track 46 can have the longest web sections 42, and the innermost track 46 the shortest web sections 42 and vice versa, or being possible for the web sections 42 of the tracks 46 to have the same shape or a different shape and size, for example. In addition, the web sections 42 of one track 46 or a plurality of tracks 46 can be designed to have an identical or different level of curvature, in other words to have the same or a different spring displacement. In principle, the web sections 42 of one track 46, and the web sections 42 of a plurality of tracks 46 can be as varied as required depending on the function and application, for example.

FIG. 8 now shows a section of the wave-spring heat shield 100 in its installed state, with the turbine housing 12 and the bearing housing 14 being connected together via a screw fastening, for example. FIG. 8 also shows a corresponding contact surface 22 of the turbine housing 12.

Substantially longer spring arms 30 for the same installation space can be achieved by the bent-outwards web sections 42, or more precisely by the tangential arrangement of the spring arms 30. The longer spring arms 30 in turn enable a flat shape of the force-displacement curve, as is shown in FIG. 10, i.e. the spring force remains constant over the working range of the spring. Thanks to the flat curve, the axial spring displacement can be chosen to be very large, thereby enabling adjustment for tolerances and for thermal expansion without a reduction in the spring force. It is thereby always guaranteed that the spring will not become loose.

The level of the spring force in the working range can be defined by the shape of the spring arms 30, or in other words, by the shape and bending of the web sections 42. It is also conceivable to design the spring arms 30 so that, unlike the case shown in FIGS. 7a and 7c, they are not closed in the circumferential direction. Instead, the spring arm 30 can also be designed to be open at one end or, for example, in the center, as is indicated by a dashed line in FIGS. 7a and 7c. This allows one or both section(s) of the spring arm to be bent even further outwards in order to achieve a longer spring deflection, it being possible to bend the two sections of the spring arms 30 outwards by an equal or different amount.

In addition, FIG. 9 shows a section of the wave-spring heat shield 100 in its installed state, with the turbine housing 12 and the bearing housing 14 being connected via a
clamp-band fastening, for example. FIG. 9 also shows a corresponding contact surface 22 of the turbine housing 12 and also an axial gap 32 between the turbine housing 12 and the bearing housing 14. The wave-spring heat shield 100 is here mounted by its hole 34 on the shaft 28 of the turbocharger 16 or on a projection of the bearing housing 14. The figure shows a web section 42, which is bent forwards, preferably substantially tangentially, in order to form the spring arm 30, with the bearing housing 14 and the turbine housing 12 being braced against each other via a clamp-band fastening, for example. In this case, the wave-spring heat shield 100 has a stepped pot shape, although it can also be designed as a disc, for example, with the web sections being bent outwards accordingly in order to form spring arms. Hence the embodiments made above also apply accordingly to a wave-spring heat shield 100 in the form of a disc.

[0051] Although the present invention has been described above with reference to the preferred exemplary embodiments, it is not restricted to these, but can be modified in a variety of ways. The embodiments described above, in particular individual features of these embodiments, can also be combined with each other.

1-17. (canceled)
18. A heat shield, comprising:
   a disc or pot shape formed with one or more steps;
   said disc or pot shape having an outer rim formed with at least one slotted section;
   a web section formed between said slotted section and said outer rim, said web section being bent outwards in order to form a spring arm and said web section being either closed or open at one point.
19. The heat shield according to claim 18, wherein said web section has a shape selected from the group consisting of elongated, circular, and oval shapes.
20. The heat shield according to claim 18, wherein said web section has a uniform thickness or at least one or more segments having a different thickness.
21. The heat shield according to claim 18, wherein said web section is one, two, three, four, or more web sections arranged in a track on said outer rim.
22. The heat shield according to claim 18, wherein said disc or pot shape has at least one or more additional tracks, said tracks each having one, two, three, four, or more web sections.
23. The heat shield according to claim 22, wherein said tracks each has a common number or a different number of web sections.
24. The heat shield according to claim 18, wherein said web sections of one track or of a plurality of tracks are substantially identical in terms of shape, size, and/or arrangement.
25. The heat shield according to claim 18, wherein said web sections of one track or of a plurality of tracks are substantially different in terms of shape, size, and/or arrangement.
26. The heat shield according to claim 18, wherein at least one or more web sections are open at one end, and the respective said segment of said web section is bent outwards.
27. The heat shield according to claim 18, wherein at least one or more web sections are open at a center thereof, and the respective said segment of said web section is bent outwards.
28. The heat shield according to claim 18, wherein said web sections of at least two or more tracks are arranged mutually offset or partly offset from one another.
29. The heat shield according to claim 18, wherein said web sections of at least two or more tracks are substantially in line with one another.
30. The heat shield according to claim 18, wherein the respective said web section or a segment of said web section is bent outwards by a predetermined amount, setting a predetermined spring displacement of said spring arm.
31. The heat shield according to claim 30, wherein said web sections or said segments of said web sections are bent outwards by a common amount.
32. The heat shield according to claim 30, wherein said web sections or said segments of said web sections are bent outwards by mutually different amounts.
33. The heat shield according to claim 18, wherein said outer rim of said disc is curved outwardly with a uniform curvature.
34. The heat shield according to claim 18, wherein said outer rim of said disc is curved outwardly with a stepped contour having one, two, or more steps.
35. The heat shield according to claim 18, formed of a heat-resistant or high temperature-resistant material configured according to an intended use thereof.
36. The heat shield according to claim 18, formed of a heat-resistant or high temperature-resistant metal or metal alloy.
37. The heat shield according to claim 18, formed of a turned part, or of a bent metal part, or of a bent sheet metal part.
38. The heat shield according to claim 18, wherein said web section or said segment of said web section is bent outwards substantially tangentially.
39. The heat shield according to claim 18, formed with a through-hole for fixing or centering the heat shield on a turbocharger.
40. A turbocharger, comprising a heat shield according to claim 18.
41. The turbocharger according to claim 40, which further comprises a bearing housing, a turbine housing, and a compressor housing, and wherein said heat shield is disposed between said bearing housing and said turbine housing and/or between said bearing housing and said compressor housing.