

Thrust Bearing Arrangement

This invention relates to thrust bearing arrangements for apparatus having a rotatable shaft about which shaft are arrayed a plurality of axially facing thrust pad surfaces, and in particular to tilting pad thrust bearing arrangements in which individual thrust pad surfaces are able to tilt or rock to a limited extent about a generally radially extending fulcrum ridge.

Tilting pad thrust bearing arrangement are well known per se, having either discrete bearing pads or an integral ring of pads joined to each other by webs of pad material that are thin enough to permit the individual pads to tilt relative to supporting carrier means of the pads and against which, in both forms, the pads bear to transmit axial thrust forces.

The supporting carrier means is formed either as a metal ring of such thickness as to support the thrust loads without deformation or sometimes as a prepared surface of the apparatus housing the bearing arrangement. In either case it is conventional for the pad-supporting face of the carrier means to be substantially flat in the axial direction, except possibly for lubricant nozzles at the surface at locations between adjacent pads, and for the face of each thrust pad opposite to a bearing surface to be machined

- 2 -

away except at a central or circumferentially offset location to leave a radially-extending fulcrum ridge by way of which the pad is supported on said supporting face of the carrier means and about which fulcrum ridge it is able to make limited tilting movements.

It will be appreciated that in the case of individual pads or an integral ring of such pads, the provision of such fulcrum ridge on the supported pad surfaces involves an additional and non-trivial manufacturing stage the cost of which may not be fully realised during the life of the bearing arrangement because the machined ridge is upon a consumable item and discarded with any bearing pad that needs replacing due to wear of the opposite, bearing face.

GB-A-1535165 describes a thrust bearing arrangement wherein parallel surfaced bearing pads are supported on a smooth faced carrier by way of an intervening plate machined such that it presents an upstanding fulcrum ridge to each bearing pad. Whereas this construction permits the consumable components, the bearing pads, to be of simpler and cheaper construction, the machined plate nevertheless requires considerable manufacturing effort and, by virtue of its manufacture, has dimensions which add significantly to those of the bearing arrangement.

It is an object of the present invention to provide a tilting pad thrust bearing assembly which is simpler and more cost-effective to manufacture and use.

According to the present invention a tilting pad thrust bearing arrangement comprises a plurality of flat parallel faced bearing pads arrayed about a longitudinal axis and supported on pad carrier means, comprising a carrier body having a flat support face extending about the longitudinal axis and between said support face and the bearing pads support means defining



- 3 -

associated with each pad a support member including a substantially radially extending fulcrum ridge about which the supported pad can tilt, each support member comprising a shim member formed by a thin flexible shim material of substantially uniform thickness and each fulcrum ridge by adjacent integral parts of the material overlying each other in face to face contact.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which

Figure 1(a) is a plan view of a first embodiment of tilting pad thrust bearing assembly in accordance with the present invention having carrier means in the form of a load bearing annular body, a unitary ring of bearing pads and therebetween shim means in the form of members of uniform thickness, the material of which is displaced as folded back tabs to define fulcrum ridges, joined as a unitary shim member ring,

Figure 1(b) is a sectional elevation through the bearing arrangement of Figure 1(a) taken in the direction b-b, illustrating also locating means of the bearing pads with respect to the carrier,

Figure 1(c) is a plan view of the carrier means annular body of Figure 1(b),

Figure 1(d) is a plan view of the unitary annular shim member of Figure 1(b), showing the formation of fulcrum ridges thereon by folding back tabs of the shim member,

Figure 1(e) is a sectional elevation through the shim member of Figure 1(d) along the direction e-e and showing the fulcrum ridge in section,

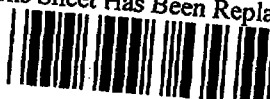


Figure 2(a) is a plan view by way of the carrier body of a second embodiment of bearing arrangement in accordance with the present invention, in which discrete bearing pads are supported on carrier means, including a load bearing annular body (shown ghosted), by way of a unitary annular shim member ring having folded-tab fulcrum ridges and wherein the pads, shim member ring and annular body of the carrier means are secured to each other at intervals by spot welds,

Figure 2(b) is a sectional elevation through the arrangement of Figure 2(a) along the line b-b thereof,

Figure 3(a) is a plan view of a third embodiment of a bearing arrangement in accordance with the present invention comprising discrete bearing pads, each supported on carrier means including a load bearing annular body (shown ghosted), and shim means in the form of a discrete rectilinear shim member for each pad, secured by spot welds to the pad adjacent the fulcrum ridge and to the annular body at a position between adjacent pads,

Figure 3(b) is a sectional elevation through the arrangement of Figure 3(a) along the line b-b thereof,

Figure 4(a) is a plan view of a fourth embodiment of the present invention, similar to that of Figure 2(a), but in which each of the bearing pads and the annular body of the carrier means are located with respect to each other by a pair of locating members formed by curled spring pins,

Figure 4(b) is a sectional elevation through the arrangement of Figure 4(a) in the direction b-b,

Figure 4(c) is a sectional elevation through the arrangement of

- 5 -

Figure 4(a) in the direction c-c,

Figure 5(a) is a plan view of a fifth embodiment of the present invention differing from that of the fourth embodiment in that a discrete and circumferentially short shim member is associated with each discrete bearing pad,

Figure 5(b) is a sectional elevation through the arrangement of Figures 5(a) in the direction b-b,

Figure 5(c) is a plan view of the discrete shim member of Figure 5(a) and illustrating in ghosted form, its manufacture in a strip of such members from which it is detached for use,

Figures 6(a) and 6(b) are sectional elevations illustrating different forms of locating members and fulcrum ridge,

Figures 7(a) and 7(b) are plan and sectional elevation views respectively of a form of shim member defined by a flattened tubular body with a fulcrum ridge between locating holes,

Figures 7(c) and 7(d) are plan and sectional elevation views respectively of a variant of the shim member of Figures 7(a) and (b) in which the locating holes extent through the fulcrum ridge, and

Figures 8(a) to 8(d) are sectional elevations through shim members illustrating different members of increasing fulcrum ridge thickness.

Referring to Figures 1(a) to 1(e), a first embodiment of the bearing arrangement according to the invention, indicated at 100, is centred on longitudinal axis 101 and comprises a plurality of flat parallel surfaced bearing pads 102₁, 102₂, 102₃ arrayed about the longitudinal axis. The bearing pads have respective

- 6 -

bearing surfaces 103₁, 103₂, 103₃, and opposite thereto parallel supported surfaces 103'₁, 103'₂,, and are joined to each other remote from their bearing surfaces by a relatively thin flexible web 104. The ring of bearing pads is supported on carrier means, indicated generally at 105, comprising an annular carrier body 106 of mild steel of axial thickness of between 5 mm and 10 mm, or of other suitable material, having a flat support face 107.

Between the support face 107 and supported faces 103'₁, 103'₂, of the bearing pads is support means, indicated generally at 108, that has associated with each bearing pad a support member including a radially extending fulcrum ridge about which the pad supported thereon can tilt.

In accordance with the invention the support means comprises shim means indicated generally at 110 formed by a thin flexible shim material of substantially uniform thickness and each support member comprises a shim member 112₁, 112₂, ... in which the fulcrum ridge is formed by adjacent integral parts of the material overlying each other in face-to-face contact.

The shim means extends in directions generally circumferential and radial with respect to each associated bearing pad and is formed from steel having a thickness less than 3 mm, and preferably 0.5 mm or less, or of material having suitable strength, flexibility and working properties. For convenience in association with a ring of bearing pads the individual shim members 112₁, 112₂, ... are joined as a planar unitary annular shim member ring 112. Each of the effective individual shim members includes, a respective fulcrum ridge 115₁, 115₂, in the form of a tab 116₁, 116₂, of shim material, defined by circumferentially and radially extending slits 117₁, 117₂, through the shim material and folded out of the plane of the shim member to lie against, and parallel to, an adjacent portion of

- 7 -

the shim member.

The displacement of each tab is shown as being in a direction towards the bearing pad so that the pad when untilted abuts only the flattened crest of the tab displacement and the remainder of the shim member is borne on the surface 107 of the annular body 106, but it will be appreciated that the displacement may be in the opposite direction such that the fulcrum ridge abuts the surface of the annular body and the bearing pad is supported on the greater expanse of shim member.

The annular body 106 has at least two through-apertures 120, 121 therein through which headed locating screws 122 or the like can extend by way of a clearance fit to threaded or interference engagement with the thrust pad ring. The clearance of the locating screws with respect to the carrier body is such that the thrust pad ring is held against radial and circumferential displacement with respect thereto but permitted limited axial displacement insofar as this is confined to that necessary to permit tilting function of the thrust pad components 102₁, 102₂ ... about the fulcrum ridges.

It is found by calculation that for a wide variety of bearing pad sizes a required degree of tilt is provided by a single thickness of shim means material of less than 0.5 mm thickness. In fact a thickness down to 0.025 mm may suffice, although difficulties may be encountered in handling the material and shim means formed therefrom.

Referring to Figures 2(a) and 2(b), a second embodiment of bearing arrangement 200 is shown viewed from the direction of the annular body 106 of the carrier means (which is ghosted) to show the structure of the shim means. The arrangement has the ring of bearing pads, indicated generally at 201, formed of discrete pads 202₁, 202₂ ... not connected to each other by web means, and the

- 8 -

shim means, 210, comprises a unitary annular shim member 212 corresponding to the shim member 112 in respect of the fulcrum ridges 215₁, 215₂, and comprising effective individual shim members 212₁, 212₂,associated with the individual pads that are joined to each other.

The arrangement also differs from the previously described embodiments by the form of locating means, each bearing pad 202₁, 202₂ ... being secured to the associated part of the shim member only and the shim member 212 being secured to the annular body 106 such that the it is prevented from moving circumferentially and radially with respect to the annular body and bearing pad. Each part of the shim member, say 212₁, is secured to the associated bearing pad 202₁ at 218₁ adjacent the fulcrum ridge and to the annular body at a position 219₁ between adjacent bearing pads, that is, laterally of the pad where it is accessible from the front (bearing surface side) of the pad. Preferably the shim member is secured to the pad at two radially spaced points, 218_{1A}, 218_{1B}, to prevent the member responding to rotational forces. Also conveniently, the member is secured at said points by spot welds or the like.

It will be appreciated that whereas the array of bearing pads may be secured to the annular shim member before disposing them with respect to the annular body, with full access to surfaces thereof, securing of the shim means to the annular body may only be possible by way of the spaces between adjacent pads. Whereas it is convenient as illustrated to secure each effective shim member of the ring to the annular body adjacent each bearing pad, the ring as a unitary body may be secured at fewer locations.

It will be apparent from Figure 2(a) and the method of securing each effective shim member of the ring to both the associated pad and region of the carrier body, that the shim members need not be joined integrally in the form of a unitary annular shim member

- 9 -

ring.

Referring to Figures 3(a) and 3(b), a third embodiment of bearing arrangement 300 is shown viewed from the direction of the annular body 106 of the carrier means (which is ghosted) to show the structure of the shim means. The arrangement has the ring of bearing pads, indicated generally at 301, formed of discrete pads 302₁, 302₂ ... not connected to each other by web means, and the shim means, 310, comprises a discrete member 312₁, 312₂ ... associated with each discrete pad rather than a unitary annular member. Each shim member extends generally circumferentially with respect to the pad but, being radially smaller, conveniently as a rectilinear strip extending tangentially rather than arcuately in a truly circumferential direction. Each fulcrum ridge 315₁, 315₂ ... is formed as a folded tab 316₁, 316₂ ..., but from an end of the strip folded back and extending radially for the full width of the strip.

Each shim member strip, say 312₁, is secured to the associated bearing pad 302₁ at 318₁ adjacent the fulcrum ridge and to the annular body at a position 319₁ between adjacent bearing pads, that is, laterally of the pad where it is accessible from the front (bearing surface side) of the pad. Preferably the shim member is secured to the pad at two radially spaced points, 318_{1A}, 318_{1B}, and to the body at two radially spaced points 319_{1A}, 319_{1B}, to prevent the member responding to rotational forces. Also conveniently, the member is secured at said points by spot welds or the like.

It will be appreciated that other forms of locating means may be employed both with discrete shim members and shim members joined together as a unitary shim member ring.

Referring to Figures 4(a) and 4(b) the fourth embodiment of bearing arrangement 400 also viewed through the annular body is

- 10 -

generally similar to the arrangement 200 of Figure 2(a) and (b) in respect of shim means 410 comprising annular shim member 412 having fulcrum ridges 415₁, 415₂ ... formed thereon as folded-back tabs 416₁, 416₂ Each bearing pad 402₁, 402₂ ... of the arrangement is secured to the annular body of the carrier means by way of a pair of axially-extending locating members 430, 431 disposed adjacent to, but spaced from, the ends of the fulcrum ridge. The locating members comprise curled, or scrolled, radially contractible spring pins which form an interference fit in co-operating apertures 432-435 in the bearing pad and carrier body whilst passing through the shim member 412, optionally with a clearance fit. The pins, being in line with the fulcrum ridge but spaced from the ends thereof, permit sufficient pivoting of the spaced pad and carrier parts for satisfactory tilting.

Such locating means which locates each bearing pad directly and extends through the shim member associated with each pad to locate it in the vicinity of the pad also permits the use of discrete, circumferentially short, shim members.

Referring to Figures 5(a) and 5(b) these show plan and sectional elevation views similar to Figures 4(a) and 4(b), of a fifth embodiment of bearing arrangement 500. This comprises carrier ring 106 and discrete bearing pads 502₁, 502₂ It differs from the fourth embodiment in respect of the provision of discrete shim members of short circumferential extent. The fulcrum ridge 515₁, 515₂ ... is formed on each by folding a tab of shim material back to lie in face-to-face contact as discussed above and the individual shim members are located and retained by locating members 530 and 531, corresponding to the pins 430 and 431 described above, passing through apertures 536, 537 through the shim material in line with, but spaced from the ends of, the fulcrum ridge.

An individual shim member 512, is shown in greater detail in

- 11 -

Figure 5(c), which figure also illustrates how such shim members may be made simply in a continuous strip form from which individual members may be detached for use.

It will be appreciated that such discrete shim members located by locating means in the form of such pins or the like may be employed when the array of bearing pads is present as a unitary ring joined by webs, that is, in the form shown in Figures 1(a), provided of course that each bearing pad of the ring is located by such members extending through the associated shim member.

The above describes locating means in the form of several pins or the like which form an interference fit in both bearing pad and annular body of the carrier, but if desired a more conventional locating means may be effected in which the locating member is secured tightly with respect to the bearing pad only and relatively loosely with respect to the carrier means, analogously to Figure 1(b).

It will be appreciated that when the locating members have clearance movement with respect to the carrier means then it is less important that the supported surfaces of the bearing pad and surface of the annular body are separated, and in such circumstances it is feasible to have the apertures through the shim member defined through the fulcrum ridge rather than alongside its ends at parts of lesser thickness.

Considering the above outlined variants of locating members and fulcrum ridge, Figure 6(a) illustrates in sectional elevation respectively a radial locating member that is a profiled pin 61 forced into an interference fit in the bearing pad 502, and a clearance fit in the annular body 106 where it is retained by a head 61. Figure 6(b) illustrates a radially contractible spring pin 62 that is a clearance fit in the carrier body 106 where it is retained by a splayed end 62. In both cases the pins extend

- 12 -

through the fulcrum ridge 615 of shim members 612 formed by folding the shim material to double thickness.

It will be appreciated that it is possible to obtain a face-to-face contact between integral parts of shim material in uniform thickness other than by simple folding back of a tab or end region of a flat strip of the material.

Locating means in the form of the above described pins or like members may extend other than parallel to each other and/or the longitudinal axis. In particular, if such pins are inclined with respect to each other in a radial direction and an interference fit in the bearing pads, they may be a clearance fit in the carrier body and be retained therein without the provision of a splayed or headed end.

Referring to Figures 7(a) and 7(b) these show in plan and sectional elevation respectively a shim member 712_A formed by flattening an initially tubular body, the end regions 713_A, 714_A being cut to provide a single thickness through which locating holes 736_A, 737_A pass adjacent the ends of the fulcrum ridge 715_A.

Figures 7(c) and 7(d) show similar views of a modified form 712_B in which the locating holes 736_B, 737_B extend through the fulcrum ridge, that is, the fulcrum ridge extends for the full length of the member.

It will also be appreciated that if required the shim means may be provided with a fulcrum ridge height or thickness more than provided by a single additional thickness of the shim material.

Referring to Figures 8(a) to 8(d) which show various options in sectional elevation various options for defining fulcrum ridge thickness, Figure 8(a) shows how an integral annular shim member ring 212' corresponding to 212 may be pleated by pleat 814 to define a fulcrum ridge 815 adding two thicknesses per pleat.

- 13 -

Figure 8(b) illustrates how an elongate tab (or end of member) 816 may be folded in a pleated manner to increase the fulcrum ridge 817 thickness. Figure 8(c) illustrates how a shim member 812_c may have tabs 820, 821 folded back to lie against opposite surfaces 822, 823 to define fulcrum ridge 824. Figure 8(d) illustrates how a circumferentially short shim member 812_d may have an elongate tab 825 folded repeatedly, that is coiled, about it to increase thickness of fulcrum ridge 826.



THIS SHEET HAS BEEN
REPLACED

CLAIMS

1. A tilting pad thrust bearing arrangement (100; 200; 300; 400; 500) comprising a plurality of flat parallel faced bearing pads (102₁; 202₁; 302₁; 402₁; 502₁) arrayed about a longitudinal axis (101) and supported on pad carrier means (105), comprising a carrier body (106) having a flat support face (107), extending about the longitudinal axis and, between said support face and the bearing pads, support means (108) defining associated with each pad a support member including a substantially radially extending fulcrum ridge about which the supported pad can tilt, characterised in that each support member comprises a shim member (112₁; 212₁; 312₁; 412₁; 512₁; 612; 712_A; 712_B;) formed by a thin flexible shim material of substantially uniform thickness and each fulcrum ridge (115₁; 215₁; 315₁; 415₁; 515₁; 615; 715_A; 715_B) by adjacent integral parts of the material (116₁; 316; 416; 516; 816; 820; 821) overlying each other in face to face contact.
2. A tilting pad thrust bearing arrangements as claimed in claim 1 characterised in that the shim member (112₁; 212₁; 412₁; 512₁; 812_C) is substantially planar and the fulcrum ridge (115; 116; 415; 515; 812_C) comprises a tab (116₁; 316; 416₁; 516; 820, 821) cut from, and folded out of, the plane of the shim member to lie against, and parallel to, an adjacent portion of the shim member.
3. An arrangement as claimed in claim 1 or claim 2 characterised in that the fulcrum ridge (815; 817) is formed by at least one pleat (814; 816) of the shim material.

This Sheet Has Been Replaced





- 15 -

**THIS SHEET HAS BEEN
REPLACED**

4. An arrangement as claimed in any one of claims 1 to 3 characterised in that the fulcrum ridge (824; 826) is formed by folding the shim material against opposite faces (822; 823) of the shim member to define a fulcrum ridge having a thickness at least three times thickness of the shim material.
5. An arrangement as claimed in any one of the preceding claims characterised in that the shim material is of steel of no greater than 0.5 mm thickness.
6. An arrangement as claimed in any one of the preceding claims characterised in that each bearing pad (202₁; 302₁) of the array is secured to the associated shim member (212₁; 312₁) and the shim member is secured with respect to the annular body 106 of the carrier means such that the shim means is prevented from moving circumferentially and radially with respect to the annular body and bearing pads.
7. An arrangement as claimed in claim 6 characterised in that the shim member (212₁; 312₁) associated with each pad (202₁; 302₁) extends in a generally circumferential direction from said fulcrum ridge (215₁; 315₁) and is secured to the carrier body (106) at a position (219_{1A}; 319_{1A}) between the bearing pad and an adjacent pad of the array.
8. An arrangement as claimed in claim 6 or claim 7 characterised in that the shim members (212₁; 312₁) are secured by a plurality of spot welds.
9. An arrangement as claimed in any one of claims 1 to 5

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

WO 97/21935

PCT/GB96/02969

- 16 -

characterised in that each bearing pad (102₁; 202₁; 302₁; 402₁; 502₁) of the array is coupled to the carrier body (106), to inhibit relative motion in at least circumferential and radial directions, by at least one locating member (122; 430, 431; 530, 531; 61; 62) extending through the shim means (112; 412₁; 512₁; 612).

10. An arranged as claimed in claim 9 characterised in that each bearing pad (402₁; 502₁) is discrete and coupled to the carrier body (106) by way of a pair of locating members (430; 431; 530; 531; 61; 62) extending between the bearing pad and the annular body and spaced apart along the fulcrum ridges of the shim member associated with the pad.
11. An arrangement as claimed in claim 9 characterised in that locating members (62) form an interference fit in the bearing pad and clearance fit in the carrier body and shim means.
12. An arrangement as claimed in any one of claims 10 or claim 11 characterised in that the locating members comprise curled spring pins (430, 431; 530, 531; 62) forming an interference fit in an aperture (435, 433) of the bearing pad.
13. An arrangement as claimed in claim 10 characterised in that the locating members comprise curled spring pins (430, 431; 530, 531) forming an interference fit in both an aperture of the bearing pad and of the carrier body and are spaced from the ends of the fulcrum ridge (415₁; 515₁).
14. An arrangement as claimed in any one of the preceding claims

This Sheet Has Been Replaced





- 17 -

characterised in that the shim (112₁, 112₂; 212₁, 212₂; 412₁, 412₂) members associated with the individual bearing pads of the array are joined to each other as a unitary annular shim member ring (112; 212; 412).

15. An arrangement as claimed in any one of claims 10 to 13 characterised in that each shim member (812₃) is discrete and of limited circumferential extent with respect to the associated bearing pad and the fulcrum ridge (826) comprises a coiling of the shim material thereabout against opposite faces.

