HYDRAULIC MACHINE WITH RADIAL CYLINDERS HAVING AN IMPROVED CRANK BEARING

Abstract: The hydraulic machine with radial cylinders, comprises: cylinders (8) fixed to the body (1) in which the cylinders are circumferentially spaced in the rotation plane of a crank (10, 25, 35, 45) rotating with a drive shaft (3) of the machine; distribution members of the hydraulic liquid (7, 9) and at least one bearing with rolling friction having rows of rollers, situated between the crank and the sliding shoes (19) of the connecting rods (20) of said cylinders and it has an outer ring (15, 29, 39) of the rolling bearing held in position by annular support means (41, 51, 14, 18, 28, 31, 38) of the ring and of the rollers; said means being foreseen for an incomplete radial contact (40, 50, 14, 18, 28, 31, 36) of the base of said rollers (11, 12, 37) against said annular side support means; at least one of the annular means (18, 28, 41, 51) being removably applied on the crank (10, 25, 35, 45).
HYDRAULIC MACHINE WITH RADIAL CYLINDERS HAVING AN IMPROVED CRANK BEARING

The invention concerns: a hydraulic machine with radial cylinders having an improved bearing in the crank, i.e. a machine with radial cylinders fixed to its crankcase, advantageously for pressurised hydraulic liquids, in which the respective connecting rod is coupled with the crank through an improved bearing with rolling friction, so as to reduce the parts worked, to simplify the processing and assembly processes, increasing the mechanical performance of the machine and improving its lifetime.

The state of the art, in the specific field of machines with radial cylinders, comprises the hydraulic motors with cylinders oscillating with respect to the body of the motor and with fixed cylinders; these cylinders have connection members of the crank with the piston, like the connecting rods, sliding planes of the base of the piston or sliding shoes of the body of the piston on the crank. It is known that between said sliding shoes and the crank pin a rolling bearing is arranged to reduce the friction and withstand the substantial forces transmitted, consisting of side-by-side rows of rollers between the crank and the outer ring on which the shoes slide.

Moreover, the aforementioned hydraulic machines have said rolling bearing formed from an inner raceway coinciding with the outer surface of the crank pin, from an outer ring on the inner surface of which the rows of rollers are coupled, whereas the shoes of the connecting rods of each piston are able to slide on the outer surface.

The crank pin is equipped with end annular abutments for the side containment of the rollers to avoid drift.
during rolling. For the axial positioning of the outer ring, centrally, between the inner rolling raceways of the rows of rollers an annular projection is made on which the sides of the rollers of the inner rows rest, to avoid the axial drift of the outer ring with respect to the crank pin.

Moreover, the rows of rollers are foreseen in a number equal to the sides of said inner annular projection; thus assembly occurs before the rows of rollers on one side of the annular projection and, then after having correctly positioned the ring with respect to the pin, the remaining rows of rollers are introduced through a side port foreseen in the annular abutment free from the rollers: each roller is introduced individually until the necessary rows of rollers are completed. The side port is opened during assembly and closed after assembly thereof. Said port, although closed by a suitable plug, determines sliding on the base of the rollers of the row nearby, due to the imprecision of the plug in its housing after the port has been closed. It has been found that this operating state damages the rollers and reduces its average operating lifetime.

Furthermore, in the state of the art it is known, from patent US 3908517 A, to have a hydraulic motor with radial cylinders with a roller bearing interpositioned in the crank; the motor also having variable piston displacement. The rollers of the bearing are contained between the flanges with which the crank is equipped; one of them is fixed and made in one piece with the crank and the other is inserted and clamped in the seat of a suitable ring nut; the inner ring of the bearing is also equipped with annular seals acting against the inner faces of said flanges and is radially mobile on the crank, to vary its radius under the pressure of hydraulic fluid coming from ducts inside the drive shaft. The inserted flange is equipped with a
sealing ring at the inner diameter and is secured to the crank, to prevent it rotating. The rollers of the bearing are thus guided in said flanges for their entire bottom face, thus generating incorrect sliding against their inner surfaces, such as to damage the flanges themselves and the lifetime of the bearing. Furthermore, the construction of such a crank is highly mechanically complex without solving the problem of a constructive simplification of the assembly of the roller bearing in the crank and still having the problem of incorrect sliding of the rollers on the inner wall of the flanges. Finally, the mechanical processing operations of the annular projections on the crank pin and inside the ring are complex and expensive and, as stated, require a rather long specific assembly method. Also, the damage to the rows of rollers limit the exploitation of the maximum lifetime of the rollers themselves so as to limit the lifetime of the hydraulic machine itself.

Such a state of the art is susceptible to improvements with regard to the possibility of making a machine for hydraulic liquids that allows a simple construction of the crank, has a reduced number of parts and with less processing and assembly operations, reducing the processing and assembly costs increasing its performance and the lifetime of the machine.

From the above there is clearly the need to solve the technical problem of making: a machine with radial cylinders for hydraulic liquids in which between the crank and the connecting rods of the cylinders there is a coupling with a reduced number of parts; moreover, which allows, with the same performance with respect to known types, the reduction of the mechanical and assembly
processes; finally, which allows damage to the parts sliding in the crank itself to be avoided, also achieving an increase in the mechanical performance.

The invention solves the aforementioned technical problem, by adopting: a hydraulic machine with radial cylinders, comprising cylinders fixed to the body in which the cylinders are circumferentially spaced in the rotation plane of a crank rotating with a drive shaft of the machine; distribution members of the hydraulic liquid and at least one bearing with rolling friction having rows of rollers, arranged between the crank and the sliding shoes of the connecting rods of said cylinders; characterised in that it comprises an outer ring of the rolling bearing held in position by annular support means of the ring and of the rollers; said means being foreseen for an incomplete radial contact of the base of said rollers against said side annular support means; at least one of the annular means being removably applied on the crank.

Moreover, in a further embodiment, by adopting said side annular support means held by at least one axial stop ring.

Furthermore, in a further embodiment, by adopting said removable annular support means consisting of at least one ring or fifth wheel equipped, on the side intended to come into contact with the bases of the rollers, with a shoulder with a diameter such as to engage the rollers of the interfacing row for a band of smaller size than the radius of the roller.

Moreover, in a further embodiment, by adopting said removable annular support means consisting of at least one ring or fifth wheel with a diameter such as to engage the rollers of the interfacing row for a band of smaller size than the radius of the roller.
Furthermore, in a further embodiment, by adopting fixed annular support means, on the end of the crank opposite the removable means, consisting of at least one shoulder for supporting an outer ring of the rolling bearing, and a shoulder with a diameter such as to engage the rollers of the interfacing row for a band of smaller size than the radius of the roller.

Moreover, in a further embodiment, by adopting said annular support means equipped with at least one inner axial stop ring positioned to contain the rows of rollers in which in the contact between said stop ring and the bases of the rollers an axial support ring is positioned; in at least one of the ends of the crank an outer axial stop ring is foreseen, in contact with the base of the rollers of the interfacing row of rollers between which a support ring is arranged.

Moreover, by adopting, in a further embodiment, the outer ring of the rolling bearing equipped with the inner axial stop ring positioned with any number (but not zero) of rows of rollers between it and one of the ends of the crank; there is a support ring on both sides of said inner stop ring.

By adopting, furthermore, in a further embodiment, on the opposite end of the crank to that of the outer axial stop ring, an axial abutment integral with the crank itself.

By adopting, moreover, in a further embodiment, an inner axial stop ring present on each end of the outer ring of the bearing with rolling friction and having, situated between said ring and the bases of the rollers of the side-by-side rows, a support ring.

Finally, by adopting, in a further embodiment, an outer axial stop ring present on each end of the crank and having, situated between said ring and the bases of the
rollers of the side-by-side rows, a support ring.

An embodiment of the invention is illustrated, purely as an example/ in the four attached tables of drawings in which Figure 1 is a schematic section of a hydraulic motor made according to the invention on the axial plane of the drive shaft containing a cylinder; Figure 2 is a schematic cross section of the complete motor containing all of the cylinders; Figure 3 is a cross section, like Figure 2, limited to the crank and enlarged; Figure 4 is an axial section, like Figure 1, limited to the crank and enlarged; Figure 5 is an axial section, similar to the previous one, in which a simplified assembly is illustrated; Figure 6 is an axial section, like Figure 1, limited to the crank and enlarged, of an embodiment of the present invention equipped with a containment fifth wheel for supporting the end wheels and the outer ring; Figure 7 is an axial section, analogous to the previous figure, in which an assembly is illustrated that is simplified, but that avoids the containment fifth wheel making contact with the bearing of the main journal.

In Figures 1 to 4 it is possible to see the body 1 of the motor, in which the drive shaft 3 is rotatably coupled through the support 4 and rotatably coupled with the cover 5 with the support 6. The drive shaft is connected to the distributor of the hydraulic liquid 7 for feeding the cylinders 8 through the ducts 9. The drive shaft has a crank 10 with its middle plane aligned with the plane containing the cylinders 8 of the motor; rows of rollers 11 roll directly on the surface of the crank; the two most inner rows 12 are divided by an inner axial stop ring 13, known by the trade name seeger, and by a support and containment ring or fifth wheel 14, for each side, to avoid sideways drift of the rollers in the passage of the part missing in the axial stop ring 13 and allow it to slide
correctly. The axial stop ring 13 allows the outer ring 15 on which it is mounted to be positioned axially, with respect to the crank 10. Indeed, the rows of rollers 11, on the outside, are in contact with the outer base of the rollers on one side with the annular projection 16 and on the other side with an outer axial stop ring 17 and with a support ring or fifth wheel 18. The outer ring 15 carries, so that they can slide on it in a known way, the shoes 19 of the connecting rods 20, in turn connected with the spherical feet 21 to the respective piston 22 of each cylinder 8. The rings 23 hold, in a known way, said shoes 19 in contact with the outer surface of said outer ring 15.

In Figure 5, moreover, in a second embodiment, a drive shaft 24 is equipped with a crank 25 on the surface of which recesses are made, at the ends of said crank, for housing outer stop rings 26 with a support ring or fifth wheel 28 interposed between it and the side-by-side row of rollers, for the side containment of the bases of the rollers in the missing part in the axial stop ring, advantageously of the seeeger type and without eyelets a the end, i.e. with reduced radial bulk. Similarly, on the outer ring 29, similar to the previous one 15, recesses are made for housing inner axial stop rings 30 with a support ring or fifth wheel 31 interposed between them and the rows of rollers 27, for the side containment of the bases of the rollers in the missing part in the axial stop ring and to allow it to slide correctly. Thus, the number of intermediate rows of rollers 32 can be whatever, in order to complete the filling in width of the rolling surface of the crank 25.

In Figure 6, moreover, in a third embodiment, a drive shaft 3 is equipped with a crank 35 on which at one end 33 of said crank, a shoulder 36 is foreseen between it and the side-by-side row of rollers 37, a support shoulder 38, for the side containment of the outer ring 39 of the rolling
bearing, being foreseen on said end of the crank. The outer ring 39 is positioned axially to the crank 35 through a support ring or fifth wheel 41, on which a shoulder 40 is foreseen for the side containment of the bases of the rollers of the opposite end row 37 and to allow it to slide correctly. Thus, the number of intermediate rows of rollers 32 can be whatever, in order to completely fill the width of the rolling surface of the crank 35. Moreover, the fifth wheel 41 is located side-by-side on the outside of the main bearing 4 of the crankshaft 3, on which it can slide, with it being foreseen for it to be coupled with the crank with diameter 42 with clearance.

In Figure 7, moreover, in a further embodiment, a drive shaft 3 is equipped with a crank 45 on which, at one end 33 of said crank, a shoulder 36 is foreseen between it and the side-by-side row of rollers 37, and a support shoulder 38, for the side containment of the outer ring 39 of the rolling bearing, is also foreseen on said end of the crank. The outer ring 39 is positioned axially to the crank 45 through a support ring or fifth wheel 51, on which a shoulder 50 is foreseen for the side containment of the bases of the rollers of the opposite end row 37 and to allow it to slide correctly. Thus, the number of intermediate rows of rollers 32 can be whatever, in order to completely fill the width of the rolling surface of the crank 45. Moreover, the fifth wheel 51 is side-by-side on the outside of an outer stop ring 46, housed in the recess 47 made between the crank 45 and the main bearing of the shaft 3 opposite the end 33 of said crank.

The assembly of the bearing with rolling friction in the crank 10 according to the invention takes place as follows. After having positioned the outer ring 15 near to the crank 10 the rollers of the two rows 11 and 12 are introduced from the side of the annular projection 16 of
said crank; then a support ring 14 and the inner axial stop
ring 13, with the appropriate instruments, are introduced
in succession into the middle plane recess of the outer
ring 15, followed by a second support ring 14. Thus, after
having positioned the assembly on the crank 10, the
successive rows of rollers 12 and 11 can be introduced,
until the completion of said rows. The closing of the
bearing takes place through the support ring 18 close to
the base of the rollers of the row 11, still free, in turn
held by the outer axial stop ring 17 housed in the
appropriate recess on the surface of the crank 10. Then,
the group of the crank with the bearing with rolling
friction can be mounted in the usual way in the body 1 of
the hydraulic machine.

Similarly, the assembly of the bearing of Figure 5
occurs with the greater freedom of being able to choose
which axial stop ring 26 or 30 to mount last.

In the further embodiments of Figures 6 and 7 the rows
of rollers, end 37 and intermediate 32, are mounted in
succession from the shoulder 36 and held with the support
fifth wheel or ring 41 or 51. Both of these last two
embodiments respect the prescribed lateral sliding of the
rollers of the end rows 37 for a height band that is
smaller than the radius of the roller itself, against the
shoulder, 40 of Figure 6 and 50 of Figure 7, respectively.

The operation of the machine for hydraulic liquids
with radial cylinders according to the invention takes
place in the known way for the hydraulic part, whereas for
the bearings with rolling friction in the crank 10, 25 it
has a substantial improvement, since the rollers are
constantly guided at the base in all of the rows of rollers
through the respective support ring 14 or 18 and through
the annular projection 16 of the crank. In the embodiment
of Figure 5 the guide of the rollers at the base of the
most outer rows 27 takes place in the contact with the
support rings 28 or 31.

Thus the inner axial stop ring 13 acts as a projection for stopping the drift of the outer ring 15 with respect to the middle plane of the crank 10, allowing correct operation of the shoes 19 on the outer surface of said outer ring.

The presence of the support rings 14, 18, 28 or 31 allows the bases of the rollers to also be rested on the discontinuity of the stop rings, known by the trade name seeger, without jeopardizing its correct operation and consequently making the bearing itself last longer.

The position of the axial stop ring 13 can be varied from what has been depicted in the figures; indeed, if a different number of rows of rollers has to be foreseen the stop ring can be positioned with an number (but not zero) of rows of rollers between it and the ends of the crank. The movement of the stop ring is only possible by foreseeing the recess in the suitable point on the inner diameter of the ring 15 between the outer rolling raceways of the rows of rollers 11 or 12. Indeed, as shown by Figure 5, the inner axial stop ring 13 can be replaced with an axial stop ring 30 at each end: in this way the outer rows of rollers 27 and the inner ones 32 can occupy the entire axial generatrix of the rolling surface of the rollers in the crank 25, completely exploiting its length.

From tests carried out it has been noted that, since the distribution of the contact between the rollers and the raceways is greater, for the same power transmitted by the hydraulic machine, the rotation speed is much greater.

Moreover, the embodiments of Figures 6 and 7 are extremely cost-effective and easy to apply, taking care to make the support rings or fifth wheels 41 and 51 from hardened material with high mechanical strength and
suitable for the sliding of the bases of the rollers.

The advantages obtained by this invention are: the bearing with rolling friction in this way has a longer lifetime, having the rolling bodies (rollers) correctly guided with axial abutment; moreover, the performance of the axial abutment is much quicker and simpler that what occurred previously: now it is much easier to make a recess at the sides of the raceways of the rollers than the processing of the integral axial projection of the prior art. The group of the rows of rollers 11 and 12 can be pre-assembled before the definitive movement on the outer surface of the crank 10: before this operation was prevented by the double axial support projection present in the crank of the prior art.

Last but not least, the possibility of exploiting the length of the crank 10, 25 more or completely, allows the stresses transmitted by the rollers 11, 12, 27 or 32 on the crank to be distributed on a larger contact zone, increasing the mechanical performance of the crank mechanism and finally increasing its average lifetime. Indeed, already with the elimination of the annular projection at the inner diameter of the ring, with the outer rolling raceways of the rollers, the contact zone between the rollers and the raceways is increased; in the embodiment of Figure 5 the contact zone has the maximum length equal to that of the crank.

In the practical embodiment the materials, the sizes and the details can be different to those indicated, but technically equivalent to them, without for this reason departing from the legal scope of the present invention. Thus, even if less advantageously, an integral axial abutment, replacing an inner axial stop ring 30, can be made in an end of the outer ring 15, 29 of the bearing with rolling friction.
Claims

1. Hydraulic machine with radial cylinders, comprising cylinders (8) fixed to the body (1) in which the cylinders are circumferentially spaced in the rotation plane of a crank (10, 25, 35, 45) rotating with a drive shaft (3) of the machine; distribution members of the hydraulic liquid (7, 9) and at least one bearing with rolling friction having rows of rollers, situated between the crank and the sliding shoes (19) of the connecting rods (20) of said cylinders, characterised in that it comprises an outer ring (15, 29, 39) of the rolling bearing held in position by annular support means (41, 51, 14, 18, 28, 31, 38) of the ring and of the rollers; said means being foreseen for an incomplete radial contact (40, 50, 14, 18, 28, 31, 36) of the base of said rollers (11, 12, 37) against said annular side support means; at least one of the annular means (18, 28, 41, 51) being removably applied on the crank (10, 25, 35, 45).

2. Hydraulic machine, according to the previous claim 1, characterised in that it has said annular side support means held by at least one axial stop ring (13, 17, 26, 30, 46).

3. Hydraulic machine, according to one of the previous claims 1 or 2, characterised in that it has said removable annular support means consisting of at least one ring or fifth wheel (41, 51) equipped, on the side intended to come into contact with the bases of the rollers, with a shoulder (40, 50) with a diameter such as to engage the rollers of the interfacing row (37) for a band of smaller size than the radius of the roller.
4. Hydraulic machine, according to one of the previous claims 1 or 2, characterised in that it has said removable annular support means consisting of at least one ring or fifth wheel (14, 18, 28>31) with a diameter such as to engage the rollers of the interfacing row for a band of smaller size than the radius of the roller.

5. Hydraulic machine, according to one of the previous claims 1 or 2, characterised in that it has said fixed annular support means, on the end (33) of the crank (35, 45) opposite the removable means, consisting of at least one shoulder (38), for supporting the outer ring (39) of the rolling bearing, and a shoulder (36) with a diameter such as to engage the rollers of the interfacing row (37) for a band of smaller size than the radius of the roller.

6. Hydraulic machine, according to one of the previous claims 1, 2 or 4, characterised in that it has said fixed annular support means equipped with at least one inner axial stop ring (13, 30) positioned to contain the rows of rollers (11, 12, 27, 32) in which in the contact between said stop ring (13, 30) and the bases of the rollers an axial support ring (14, 31) is positioned; in at least one of the ends of the crank (10) an outer axial stop ring (17, 26) is foreseen, in contact with the base of the rollers of the interfacing row of rollers (11, 27) between which a support ring (18, 28) is arranged.

7. Hydraulic machine, according to the previous claim 6, characterised in that it has the inner axial stop ring (13) positioned with any number (but not zero) of rows of rollers (11, 12) between it and one of the ends of the crank (10); there is a support ring (14) on both sides of said inner stop ring (13).
8. Hydraulic machine, according to one of the previous claims 6 or 7, characterised in that it has an axial abutment (16) integral with the crank (10) on the opposite side of the crank itself to that of the outer axial stop ring (17).

9. Hydraulic machine, according to the previous claim 6; characterised in that an inner axial stop ring (30) is present on each end of the outer ring (29) of the bearing with rolling friction and has, situated between said ring and the bases of the rollers of the side-by-side rows (27), a support ring (31).

10. Hydraulic machine, according to the previous claim 7; characterised in that it has an outer axial stop ring on each end of the crank and it has, situated between said ring and the bases of the rollers of the side-by-side rows, a support ring.
**A. CLASSIFICATION OF SUBJECT MATTER**

INV. F04B1/04 F04B9/04

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of Box C

See patent family annex

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Date of the actual completion of the international search

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## INTERNATIONAL SEARCH REPORT

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