ELECTRIC OIL PUMP

An electric oil pump is provided including: (i) a pump part housed in a pump part-accommodating portion formed in a metal pump housing; (ii) an electric motor part housed in an electric motor part-accommodating portion formed in the pump housing; and (iii) a drive control part having (a) a control part case fastened to the pump housing and formed of synthetic resin, (b) a control board for supplying a driving current to the electric motor part, and (c) a metal control part cover fastened to the control part case and accommodating the control board. In this pump, the control part cover and the pump housing are covered with an oxide film having corrosion resistance and heat resistance at least at their outer surface, and the pump housing provided with the oxide film is fixed to an automatic transmission casing in a manner to be immersed in a hydraulic oil.
FIG. 2
ELECTRIC OIL PUMP

BACKGROUND OF THE INVENTION

[0001] This invention relates to improvements in an electric oil pump, and more particularly to improvements in an electric oil pump where a drive control part which can supply a driving current to an electric motor part for rotating a pump rotor is disposed adjacent to the electric motor part.

[0002] In recent years, there have been proposed and developed various idling-stop system equipped vehicles or automatic engine stop-start system equipped hybrid vehicles for improved fuel economy. In these vehicles, pumps driven by an internal combustion engine are to stop at the time when the internal combustion engine is stopped, and therefore the presence of a pump-driving source other than the internal combustion engine is needed. In particular, the idling-stop system equipped vehicles, automatic engine stop-start system equipped hybrid vehicles and the like require an oil pump so that a hydraulic mechanism for controlling an automatic transmission can keep ensuring a hydraulic pressure. In view of the above, there has been developed the trend toward the increase of the use of an electric oil pump which imparts a rotational force to a pump rotor by using an electric motor to cause pumping actions.

[0003] As an electric oil pump mounted to an automatic transmission of an automotive vehicle, there has widely been adopted an internal gear pump of a trochoid type. In an internal gear pump, a pump rotor is rotated by a driving rotational shaft driven by a motor, so that an outer rotor having an inner tooth engageable with an outer tooth of the pump rotor is rotated. With this, the volume of a plurality of volume chambers formed between the inner tooth of the outer rotor and the outer tooth of the pump rotor is continuously changed thereby performing intake/discharge of a hydraulic oil. Such an internal gear pump is disclosed in Japanese Patent Application Publication No. 2012-207638 (Patent Document 1) for example.

[0004] A typical electric oil pump is provided including: a drive control part for controlling the passage of electric current through an electric motor; a stator section having a wire and iron core for generating magnetomotive force by the electric current passage from the drive control part; a rotor section disposed in a space defined by the inner periphery of the stator section and having a permanent magnet to be rotated by the magnetomotive force; and a driving rotational shaft fixed to the rotor section by means of press-fitting or the like so as to rotate together therewith.

[0005] Moreover, in the recent electric oil pump, the drive control part for running a controlled driving current into the wire portion is getting fixed integral with the electric oil pump. The reason to provide the drive control part integral with the electric oil pump as mentioned above is for at least one or more purposes of: shortening the length of wiring between the wire portion and the drive control part to reduce the adverse effect of outside noise as much as possible; decreasing a wiring cost; facilitating calibration between the drive control part and a pump part; improving handling property; and the like.

[0006] The above-discussed drive control part is provided composed of: a control part case fastened to the side of the electric motor part and formed of synthetic resin; a control part cover formed of metal and so fixed as to enclose the control part case; and a control board housed in a space defined between the control part case and the control part cover. The reason to employ a control part cover formed of metal as mentioned above is for letting the cover function as a heat sink which can dissipate heat generated from the control board to the outside. Since the control board is equipped with an inverter circuit, a large amount of heat is generated from a switching element comprised of MOSFET that constitutes the inverter circuit. In order to dissipate the heat, a control part cover formed of metal is employed.

[0007] The components of the electric motor part and those of the pump part are accommodated in a pump housing, and the above-mentioned control part case formed of synthetic resin is fastened to the pump housing. The pump housing is formed of metal and fastened to an automatic transmission casing with a fastening bolt. Furthermore, the control part cover and the pump housing, which are formed of metal are electrically connected with each other through a fastening bolt formed of metal, while the automatic transmission casing and the pump housing are also electrically connected with each other by a fastening bolt formed of metal. The reason to make such an arrangement is for letting static electricity escape toward the side of the automatic transmission, because static electricity charged on the control part case or the control part cover can adversely affect an electric element of the control board.


SUMMARY OF THE INVENTION

[0009] However, drawbacks have been encountered in the above discussed conventional oil cooler. More specifically, this kind of electric oil pump is usually mounted inside an engine compartment of an automotive vehicle, so that its metal portions are liable to corrosion due to rainwater or saltwater intruding into the engine compartment. In particular, corrosion tends to develop at a contact surface between a control part case and a control part cover and a contact surface between the control part case and a pump housing thereby allowing the intrusion of rainwater or saltwater also into a space accommodating a control board and into the electric motor part in due course. Hence there is a fear that the electric element on the control board and the wire in the electric motor part cause a short to be broken down.

[0010] Additionally, the pump housing is formed of aluminum or aluminum alloy, and mounted in such a manner as to reside in the interior of the automatic transmission to be immersed in a hydraulic oil. The reason why the pump housing is mounted in the interior of the automatic transmission is in order to reduce the automatic transmission in axial length or outer dimension itself as much as possible. Additionally, the pump housing is to be exposed to the hydraulic oil, and therefore formed of aluminum or aluminum alloy. For example, if the pump housing is formed of synthetic resin, the synthetic resin is to swell up by the hydraulic oil so that the pump housing cannot keep its functions.

[0011] Though the pump housing is formed of aluminum or aluminum alloy as discussed above, the temperature of the hydraulic oil gets increased as an automotive vehicle travels, and the heat of the hydraulic oil is to be transmitted to the drive control part through such a wellthermal conductive pump housing. Consequently, there arises a fear that the drive control part cannot be normally operated by the influence of the heat.

[0012] An object of the present invention is to provide a novel and improved electric oil pump which can prevent a
space housing a control board and an electric motor part from water intrusion while inhibiting the heat of the hydraulic oil from transmitting to the drive control part.

An aspect of the present invention resides in an electric oil pump comprising: (i) a pump part housed in a pump part-accommodating portion formed in a metal pump housing; (ii) an electric motor part housed in an electric motor part-accommodating portion formed in the pump housing; and (iii) a drive control part comprising (a) a control part case fastened to the pump housing and formed of synthetic resin, (b) a control board for supplying a driving current to the electric motor part, and (c) a control part cover fastened to the control part case and accommodating the control board, wherein the pump housing is fixed to a casing of an automatic transmission in a manner to be immersed in a hydraulic oil, and wherein the control part cover and the pump housing are covered with an oxide film having corrosion resistance and heat resistance at least at their outer surface, and the pump housing provided with the oxide film is fixed to the casing of the automatic transmission in a manner to be immersed in the hydraulic oil.

According to the present invention, an oxide film having corrosion resistance and heat resistance is formed at least on the outer surface of the control part cover (formed of metal) and the outer surface of the pump housing (also formed of metal); with this, interfaces among the control part cover, a control part case and the pump housing are protected from corrosion. Moreover, since the outer surface of the pump housing to be exposed to the hydraulic oil is covered with the oxide film having corrosion resistance and heat resistance, the pump housing is so improved in heat resistance as to inhibit a drive control part from receiving the influence of the heat of the hydraulic oil.

**BRIEF DESCRIPTION OF THE DRAWING**

Fig. 1 is an overall perspective view of an embodiment of an electric oil pump according to the present invention;

Fig. 2 is a vertical cross-sectional view of the electric oil pump of Fig. 1;

Fig. 3 is an exploded perspective view of the electric oil pump of Fig. 1; and

Fig. 4 is a cross-sectional view of fixing parts among a control part cover, a control part case and a pump housing.

**DETAILED DESCRIPTION OF THE INVENTION**

Referring now to the accompanying drawings, an embodiment of an electric oil pump according to the present invention will specifically be discussed; however, the invention is not limited to the illustrated embodiment, and modifications and variations of the illustrated embodiment will occur to those skilled in the art.

An electric oil pump is, for example, a pump to be mounted for automatic transmission of a vehicle having an idle stop function. The automatic transmission refers to a belt-type continuously variable transmission (hereinafter referred to as CVT) equipped separately with a mechanical pump driven by an engine. In the embodiment of the present invention, the electric oil pump is used as a hydraulic pressure supply source for automatic transmission and therefore fixed to a casing for automatic transmission.

At the time of stopping the engine under an idle stop control, the mechanical pump cannot ensure a hydraulic pressure. Additionally, if a leak from a friction fastening element or a pulley in the belt-type CVT, a certain period of time is required for ensuring a hydraulic pressure necessary for a restart so as to cause drivability deterioration. In view of the above, an electric oil pump capable of discharging a hydraulic pressure regardless of the running state of the engine is provided in addition to the mechanical pump to ensure such an amount of a hydraulic pressure as to compensate for the leak from the friction fastening element or the pulley, thereby improving the drivability at the time of running the engine and at the time of restarting the vehicle.

Fig. 1 is a perspective view of an electric oil pump, showing an overall configuration thereof. Fig. 2 is a cross-sectional view of the electric oil pump of Fig. 1. Electric oil pump 10 is constructed from electric motor part 10A, drive control part 10B fixed adjacent to electric motor part 10A, and pump part 10C driven by electric motor part 10A. Incidentally, the members illustrated in Fig. 1 other than these parts will be explained with reference to Figs. 2 and 3.

Electric motor part 10A is provided including at least rotor section 16 and stator section 18 as shown in Figs. 2 and 3, and enclosed in electric motor part-accommodating portion 24 provided to one side of metal pump housing 20 formed of aluminum alloy or the like.

Additionally, the above-mentioned pump housing 20 is formed having, at the other side, pump part-accommodating portion 22 which can accommodate pump part 10C. Pump part 10C is composed of at least pump rotor 12 having an external gear, and outer rotor 14 having an internal gear. Pump rotor 12 and outer rotor 14 are housed in the above-mentioned pump part-accommodating portion 22 provided at the other side of pump housing 20. Drive control part 10B is constituted of at least control part case 44, control board 46 accommodated in control part case 44, and control part cover 48 to be fixed onto control part case 44 to enclose control board 46.

Pump cover 34 constituting pump part 10C is fastened to pump housing 20 with fastening bolt (or pump cover-fastening bolt) 60A. Likewise, control part case 44 and control part cover 48, which are constituting drive control part 10B, are jointly fastened to pump housing 20 at the side close to electric motor part 10A with fastening bolt (or control part case-fastening bolt) 62A. More specifically, control part case 44 and control part cover 48 are jointly fastened, at least at one point, to pump housing 20 with fastening bolt 62A. Furthermore, control part case 44 and control part cover 48 are fastened to each other at five points with fastening bolts (or control part cover-fastening bolts) 64A.

The structure of electric oil pump 10 will be explained in detail by reference to Fig. 2. Electric oil pump 10 is provided to include: pump part 10C composed of pump rotor 12 having an external gear and outer rotor 14 having an internal gear; and electric motor 10A composed of rotor section 16 joined with pump rotor 12 and stator section 18. Stator section 18 is wound with wire 18A, and an end of the wire 18A is drawn into drive control part 42.

Pump part 10C and electric motor 10A are housed in electric motor part-accommodating portion 24 provided at one end surface of pump housing 20 and pump part-accommodating portion 22 provided at the other end surface of pump housing 20, respectively. More specifically, the pump...
housing 20 is formed having: pump part-accommodating portion 22 which can accommodate outer rotor 14 rotatably therein at the side of the other end surface; electric motor part-accommodating portion 24 which can support stator section 18 fixedly at its inner periphery and at its opening defined at the one end surface while accommodating rotor section 16 and the like therein; and bracket 26 axially outside the electric motor part-accommodating portion 24, the bracket 26 being attachable to automatic transmission casing 52. Incidentally, pump housing 20 is a metal product formed of aluminum alloy.

[0028] The above-mentioned pump housing 20 is mounted in such a manner as to reside in the interior of the automatic transmission to be immersed in a hydraulic oil. The reason why pump housing 20 is mounted in the interior of the automatic transmission is in order to reduce the automatic transmission in axial length or outer dimension itself as much as possible. Additionally, pump housing 20 is formed of aluminum or aluminum alloy because it is to be exposed to the hydraulic oil. If pump housing 20 is formed of synthetic resin, the synthetic resin is to swell up by the hydraulic oil so that pump housing 20 cannot keep its functions. This is the reason why pump housing 20 is formed of aluminum or aluminum alloy.

[0029] As shown in FIG. 2, automatic transmission casing 52 is formed with pump-accepting recess CA in its interior. In the state where pump housing 20 is accommodated in the pump-accepting recess CA, the outer periphery of pump housing 20 is filled with the hydraulic oil. The hydraulic oil is adapted to circulate by the pumping action.

[0030] On the upper surface of the fixing bracket 26 formed as a part of pump housing 20, control part case-fixing section 54 formed as a part of control part case 44 is mounted. The control part case-fixing section 54 is pierced with metal bush 56 at both ends of which are annularly opening, by insert molding. Fastening bolt 58A is provided to pierce bush 56 and fixing bracket 26 and then screwed into automatic transmission casing 52, thereby fastening electric oil pump 10 to automatic transmission casing 52. A similar bracket is also provided at two other positions of pump housing 20, though not shown, thereby fastening electric oil pump 10 to automatic transmission casing 52 by the same structure.

[0031] Inside pump housing 20, there is provided a bearing portion 30 for rotatably supporting driving rotational shaft 28 which connects pump rotor 12 to rotor section 16. This bearing portion 30 takes on such an arrangement that the inner peripheral surface thereof rotatably supports the outer peripheral surface of the medial region of driving rotational shaft 28. Incidentally, the medial region refers to a region between pump rotor 12 and rotor section 16 and therefore not limited to the midpoint of driving rotational shaft 28.

[0032] Moreover, bearing portion 30 is formed at bulkhead 31 provided for dividing pump part-accommodating portion 22 and electric motor part-accommodating portion 24 from each other. The bearing portion 30 is the so-called plain bearing and formed with a certain length of crevice between the inner peripheral surface of bearing portion 30 and the outer peripheral surface of driving rotational shaft 28. A hydraulic oil on the discharge side (or the higher pressure side) is adapted to be introduced into this crevice through oil introduction passage 33. Furthermore, seal member 32 for sealing driving rotational shaft 28 is provided on the upper side of driving rotational shaft 28 and bearing portion 30.

[0033] Pump cover 34 is provided with: discharge port 36 cylindrically prolonged to communicate with an outlet of pump part 10C; and intake port 38 communicating with an inlet of pump part 10C. Seal ring 40 is attached to the tip end of the outer periphery of discharge port 36.

[0034] Control part case 44 constituting drive control part 42 is fixed onto pump housing 20 at the side of electric motor part-accommodating portion 24 in a manner to enclose electric motor part-accommodating portion 24. Incidentally, drive control part 42 as shown in FIG. 2 and drive control part 105 as shown in FIG. 1 are the same, though their reference numerals are different.

[0035] Drive control part 42 is constituted of: control part case 44 attached to pump housing 20 and formed of synthetic resin; control board 46 accommodated in control part case 44; and metal control part cover 48 formed of aluminum alloy and fixed onto control part case 44 to enclose control board 46.

[0036] Control board 46 is provided with an inverter circuit which can supply a controlled electric current to wire 18A wound around stator section 18 of electric motor part 10A. Connector terminal 50 is disposed between control part case 44 and control part cover 48 to supply a controlled signal or electric power to an electric element mounted on the control board 46.

[0037] Control part cover 48 is adapted to function as a heat sink for dissipating heat generated from the electric element of control board 46 to the outside, and therefore formed of metal. Since control board 46 is thus provided with the inverter circuit, a large amount of heat is generated from a switching element comprised of MOSFET that constitutes the inverter circuit. In order to dissipate the heat, control part cover 48 formed of metal is used.

[0038] In electric oil pump 10 having an arrangement as mentioned above, the start and the end of wire 18A wound around stator section 18 constituting electric motor part 10A are connected with an input terminal (not shown) and a neutral terminal (not shown) attached to control part case 44, respectively, through a through hole (not shown) formed in control part case 44 of drive control part 42 fixed adjacent to electric motor part-accommodating portion 24. Accordingly, a driving signal controlled by the inverter circuit is supplied to wire 18A to rotate rotor section 16 of electric motor part 10A, thereby finally rotating pump rotor 12 to produce the pumping action.

[0039] Electric oil pump 10 having such an arrangement is mounted inside an engine compartment of an automobile vehicle as mentioned above, so that corrosion is developed at a contact surface between control part case 44 and control part cover 48 and a contact surface between control part case 44 and pump housing 20 due to rainwater or saltwater intruding into the engine compartment thereby allowing the intrusion of rainwater or saltwater also into a space accommodating control board 46 and into electric motor part-accommodating portion 24. Soon, the electric element on control board 46 and wire 18A in electric motor part 10A often cause a short to be broken down.

[0040] This corrosion is considered to develop through a mechanism as below. Now the mechanism will be explained, on the assumption that a crevice defined between plastic control part case 44 and aluminum alloy control part cover 48 is subjected to an intrusion of saltwater and thus crevice corrosion is caused at the interface.

[0041] At the interface, an anode reaction where Al dissolves (Al→Al³⁺+3e⁻) and a cathode reaction (O₂+2H₂O+...
When the anode reaction is so progressed as to increase the number of $\text{Al}^{3+}$, $\text{Cl}^-$ comes to migrate thereto from the periphery so that the concentration of $\text{Cl}^-$ in the crevice is also increased. Simultaneously, $\text{Al}^{3+}$ causes hydrolysis to start releasing $\text{H}^+ (\text{Al}^{3+} + 3\text{H}_2\text{O} \rightarrow \text{Al} (\text{OH})_3 + 3\text{H}^+)$ thereby reducing pH. Thus corrosion of aluminum at the interface is accelerated through these reactions.

In order to prevent control part cover 48 and pump housing 20 exposed to outside air from corrosion, an embodiment of the present invention was presented in such a manner as to form an oxide film having corrosion resistance and heat resistance on the outer surfaces of control part cover 48 and pump housing 20 which are brought into contact with control part case 44.

As the oxide film having corrosion resistance and heat resistance, an embodiment of the present invention was arranged to form a film of aluminum oxide on the outer surfaces of control part cover 48 and pump housing 20 (both of them are formed of aluminum alloy) to prevent corrosion by conducting anodic oxidation treatment thereon. By having formed a film of aluminum oxide, it becomes possible to suppress the above-mentioned reactions.

The anodic oxidation treatment is carried out by previously shaping control part cover 48 and pump housing 20 into their respective final forms, masking regions not needed to form an oxide film (a film of aluminum oxide), immersing control part cover 48 and pump housing 20 in an electrolytic cell charged with an acidic electrolyte solution such as sulfuric acid, and then causing electrolysis where control part cover 48 and pump housing 20 serves as anode, thereby forming an oxide film comprised of aluminum oxide on the surface of aluminum or aluminum alloy.

By forming a film of aluminum oxide, it becomes possible to solve the above-mentioned problem that corrosion is developed at a contact surface between control part case 44 and control part cover 48 and a contact surface between control part case 44 and pump housing 20 due to rainwater or saltwater intruding into the engine compartment thereby allowing the intrusion of rainwater or saltwater also into a space accommodating control board 46 and into electric motor part-accommodating portion 24 soon.

Additionally, there is another problem of the temperature of a hydraulic oil. More specifically, pump housing 20 is accommodated in pump-accepting recess CA filled with a hydraulic oil. As an automotive vehicle travels, the temperature of the hydraulic oil gets increased, so that the heat of the hydraulic oil is to be transmitted to drive control part 42 through pump housing 20 formed of aluminum or aluminum alloy. Consequently, there arises a fear that drive control part 42 cannot be normally operated by the influence of the heat.

An electric oil pump according to an embodiment of the present invention significantly receives changes in temperature environment since it is used in an automatic transmission of an automotive vehicle. When the hydraulic oil has low temperatures, the hydraulic oil exhibits high viscosity and therefore the electric current that flows through an electric motor for driving the pump becomes small and the amount of heat generated from the electric motor is decreased; however, the intense heat of the hydraulic oil is transmitted to drive control part 42 from all around the surfaces of pump housing 20, thereby adversely affecting drive control part 42.

In order to suppress the amount of heat to be transmitted from all around the surfaces of pump housing 20 immersed in the hydraulic oil, an embodiment of the present invention was arranged to conduct the anodic oxidation treatment on all the surfaces of pump housing 20 intended to be brought into contact with the hydraulic oil. An improvement in heat resistance can be expected by forming a film of aluminum oxide on the surfaces as discussed above. The oxide film comprising aluminum oxide is about one-thirds of pure aluminum in thermal conductivity and therefore sufficiently functions as a heat shield film.

Incidentally, an oxide film comprising aluminum oxide is formed with fine pores at its surface. These fine pores cause a deterioration of corrosion resistance. Hence sealing treatment is performed for sealing these fine pores. Sealing treatment is performed in a manner to increase the volume of the oxide film by heating the film in boiling water or steam thereby sealing the fine pores. Though the sealing treatment is mainly carried out for enhancing the corrosion resistance, the heat resistance is also improved. Therefore, in the case of shielding heat generated from the hydraulic oil as in the embodiment of the present invention, it serves as a particularly effective treatment.

When performing the anodic oxidation treatment, control part cover 48 and pump housing 20 are previously shaped into their respective final forms, then regions not needed to form an oxide film (a film of aluminum oxide) are masked, then control part cover 48 and pump housing 20 are immersed in an electrolytic cell charged with an acidic electrolyte solution such as sulfuric acid, and then electrolysis where control part cover 48 and pump housing 20 serves as anode is initiated thereby forming an oxide film comprising aluminum oxide on the surface of aluminum or aluminum alloy.

Control part cover 48 and pump housing 20 having final shapes are immersed in an electrolytic cell to cause electrolysis therein as mentioned above; therefore, a threaded box portion of pump housing 20 into which fastening bolt 62A is screwed thereby electrically connecting control part cover 48 with pump housing 20 is simultaneously insulated by the oxide film, so that it becomes impossible to let static electricity escape through fastening bolt 62A.

In addition, a through hole of pump housing 20 into which fastening bolt 58A is inserted thereby electrically connecting automatic transmission casing 52 with pump housing 20 is also simultaneously insulated by the oxide film, so that it becomes impossible to let static electricity escape through fastening bolt 58A.

As a countermeasure, masking with rubber plug or the like is conducted on the threaded box portion of pump housing 20 into which fastening bolt 62A for electrically connecting control part cover 48 with pump housing 20 is screwed and a portion defining the through hole of pump housing 20 where fastening bolt 58A for electrically connecting automatic transmission casing 52 with pump housing 20 is inserted, so as not to form the oxide film comprising aluminum oxide on these portions.
The configuration of electric oil pump 10 will concretely be explained by reference to FIGS. 3 and 4. FIG. 3 is an exploded perspective view showing electric oil pump 10 of FIG. 2 from above and slightly diagonally, while FIG. 4 is an enlarged cross-sectional view showing cross sections of fixing parts among control part cover 48, control part case 44, and pump housing 20.

Since the components of electric oil pump 10 had specifically been discussed by reference to FIG. 2, FIG. 3 will be referred to for explanation about a method of fixing pump cover 34, pump housing 20, control part case 44, and control part cover 48.

As shown in FIG. 3, pump housing 20 is formed having, at its one side, pump part-accommodating portion 22 in which pump rotor 12 having an external gear and outer rotor 14 having an internal gear are accommodated. Pump part-accommodating portion 22 in which pump rotor 12 and outer rotor 14 are housed is enclosed by pump cover 34, and tightly fastened with fastening bolt 60A screwed into threaded hole 603 formed in pump housing 20.

Furthermore, pump housing 20 is formed having, at the other side, electric motor part-accommodating portion 24, in which at least rotor section 16 and stator section 18 are housed. In this state control part case 44 is fastened to pump housing 20 in a manner to enclose electric motor part-accommodating portion 24.

Control board 46 is firmly fastened to control part case 44 with fastening bolts 66A, and additionally enclosed by control part cover 48 fixed to control part case 44. In this arrangement, fastening bolt 64A is piercedly inserted into the fixing hole formed in cover-fixing section 643 of control part case 44 and screwed into a threaded hole formed in case-fixing section 64C of control part case 44, thereby fastening control part case 44 and control part cover 48 to each other.

Moreover, control part cover 48 and control part case 44 are jointly fastened to pump housing 20 with fastening bolt 62A. In this arrangement, fastening bolt 62A is piercedly inserted into a fixing hole formed in cover-fixing section 623 of control part case 44 and a through hole formed in case-fixing section 62C of control part case 444 and screwed into threaded hole 62D formed in pump housing 20, thereby fastening control part cover 48, control part case 44, and pump housing 20 to each other.

Pump cover 34, pump housing 20, control part case 44, and control part cover 48 are fastened by the above-mentioned fixing method. Then, a method of fixing pump housing 20, control part case 44, control part cover 48, and automatic transmission casing 52 according to the embodiment of the present invention will be discussed in detail.

An embodiment of the present invention is based on the premise that pump housing 20 and control part cover 48 shaped into final forms and then immersed in an electrolytic cell has previously been subjected to anodic oxidation treatment but the surfaces of threaded box portions into which fastening bolts for conducting static electricity are to be screwed are masked with rubber plug or the like so as not to form the oxide film comprising aluminum oxide thereon. Additionally, pump part-accommodating portion 22 and a space for housing seal member 32 are also masked with a masking member, and therefore the oxide film comprising aluminum oxide is not formed thereon.

As shown in FIG. 4, control part cover 48 is fixed on the upper surface of control part case 44 formed of synthetic resin. Control part cover 48 is formed of aluminum alloy, and therefore the surface thereof is covered with oxide film 66 formed of aluminum oxide produced by anodic oxidation treatment. Control part case 44 is formed integral with threaded metal bush 68 (formed of aluminum) into which fastening bolt 64A is to be screwed, by insert molding. This threaded metal bush 68 is disposed corresponding to the threaded hole of case-fixing section 64C illustrated in FIG. 3.

Fastening bolt 64A is piercedly inserted into the fixing hole formed in cover-fixing section 643 of control part case 48 and screwed into threaded metal bush 68, thereby tightly fastening control part cover 48 and control part case 44 to each other. The fixing hole of cover-fixing section 643 has an inner diameter larger than the outer diameter of a threaded portion of fastening bolt 64A, and the inner peripheral surface of fixing hole of cover-fixing section 643 had been covered with a rubber plug and therefore not covered with oxide film 66. With this, fastening bolt 64A and aluminum alloy that resides inside control part cover 48 are electrically connected with each other.

On the other hand, pump housing 20 is fixed on the bottom surface of control part case 44 formed of synthetic resin. Pump housing 20 is also formed of aluminum alloy, and therefore the surface thereof is covered with oxide film 66 formed of aluminum oxide produced by anodic oxidation treatment. Fastening bolt 62A which can fasten control part case 44 and control part cover 48 jointly to pump housing 20 has the function of leading static electricity charged on the outer surface of control part cover 48 to aluminum alloy that resides inside control part cover 48.

Fastening bolt 62A is piercedly inserted into the fixing hole formed in cover-fixing section 623 of control part case 44 and the through hole formed in case-fixing section 62C of control part case 44, and screwed into threaded hole 62D formed in pump housing 20. The fixing hole formed in cover-fixing section 623 of control part case 48 has an inner diameter larger than the outer diameter of a threaded portion of fastening bolt 62A, and the inner peripheral surface of the fixing hole of cover-fixing section 623 had been covered with a rubber plug and therefore not covered with oxide film 66. With this, fastening bolt 62A and aluminum alloy that resides inside control part cover 48 are electrically connected with each other.

The through hole formed in case-fixing section 62C of control part case 44 is defined by an annularly-shaped metal bush 70 (formed of aluminum) through which fastening bolt 62A pierces, the metal bush 70 being formed integral with control part case 44 by insert molding. Metal bush 70 has the function of receiving a load that control part case 44 formed of synthetic resin is to receive at the time when fastening bolt 62A is screwed thereinto, to prevent the breakdown of control part case 44. Metal bush 70 also has an inner diameter larger than the outer diameter of the threaded portion of fastening bolt 62A.

The threaded region of fastening bolt 62A is screwed into the threaded region of threaded hole 62D of pump housing 20, thereby firmly fastening control part case 44 and control part cover 48 to each other with fastening bolt 62A between the head of fastening bolt 62A and threaded hole 62D of pump housing 20. The threaded region of threaded hole 62D of pump housing 20 had been covered with a rubber plug and therefore not covered with oxide film 66. With this, fastening bolt 62A and aluminum alloy that resides inside pump housing 20 are electrically connected with each other.
[0069] As indicated in FIG. 4 by a thick arrow, at least static electricity charged on the outer surface of control part cover 48 is adapted to flow from threaded hole 62D of pump housing 20 to aluminum alloy that resides inside pump housing 20. With this, static electricity can ensure its conductive passage at least as far as pump housing 20.

[0070] Then, electric oil pump thus establishing the static electricity-conductive passage is mounted on automatic transmission casing 52 at automobile manufacturers; at this time, the embodiment of the present invention uses pump-fastening bolt 58A for fastening electric oil pump 10 to automatic transmission casing 52. A threaded region of threaded hole 58C formed in pump housing 20 had been masked with a rubber plug and therefore not covered with oxide film 66. Accordingly aluminum alloy that resides inside pump housing 20 and fastening bolt 58A also serve as a static electricity-conductive passage.

[0071] Pump-fastening bolt 58A is screwed into threaded hole 58C and additionally screwed into screw-fixing portion 52B of automatic transmission casing 52, thereby tightly fastening pump housing 20 to automatic transmission casing 52. Pump-fastening bolt 58A and automatic transmission casing 52 are electrically connected with each other as a matter of course, so that static electricity on control part cover 48 runs through passages as indicated by a thick arrow in FIG. 4 thereby finally escaping into automatic transmission casing 52.

[0072] As discussed above, the present invention provides an electric oil pump with such an arrangement as to accommodate a pump housing in a recess formed in an automatic transmission and filled with a hydraulic oil while forming an oxide film having corrosion resistance and heat resistance at least on the outer surface of a control part cover (formed of metal) and the outer surface of the pump housing (also formed of metal).

[0073] According to the present invention, an oxide film having corrosion resistance and heat resistance is formed at least on the outer surface of the control part cover (formed of metal) and the outer surface of the pump housing (also formed of metal); with this, interfaces among the control part cover, a control part case and the pump housing are protected from corrosion. Moreover, since the outer surface of the pump housing to be exposed to the hydraulic oil is covered with the oxide film having corrosion resistance and heat resistance, the pump housing is so improved in heat resistance as to inhibit a drive control part from receiving the influence of the heat of the hydraulic oil.

[0074] The entire contents of Japanese Patent Application 2015-050113 filed Feb. 19, 2015 are herein incorporated by reference. Although the invention has been described above by reference to certain embodiments and examples of the invention, the invention is not limited to the embodiments and examples described above. Modifications and variations of the embodiments and examples described above will occur to those skilled in the art, in light of the above teachings. The scope of the invention is defined with reference to the following claims:

What is claimed is:
1. An electric oil pump comprising:
   a pump part housed in a pump part-accommodating portion formed in a metal pump housing;
   an electric motor part housed in an electric motor part-accommodating portion formed in the pump housing;
   and
   a drive control part comprising: a control part case fastened to the pump housing and formed of synthetic resin; a control board for supplying a driving current to the electric motor part; and a metal control part cover fastened to the control part case and accommodating the control board,

   wherein the pump housing is fixed to a casing of an automatic transmission in a manner to be immersed in a hydraulic oil,

2. An electric oil pump as claimed in claim 1, wherein the pump housing and the control part cover are formed of aluminum alloy, and the oxide film comprises aluminum oxide and formed on the outer surface of the pump housing and the outer surface of the control part cover by anodic oxidation treatment.

3. An electric oil pump as claimed in claim 2, wherein the oxide film comprising aluminum oxide is subjected to sealing treatment.

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