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(54) **COOLANT PUMP WITH ELECTRIC MOTOR DRIVE AND MECHANICAL DRIVE**

(71) Applicant: **BorgWarner Inc.**, Auburn Hills, MI (US)

(72) Inventors: **Thomas Buchholz**, Stockach (DE); **Juergen Roth**, Heiligenberg (DE)

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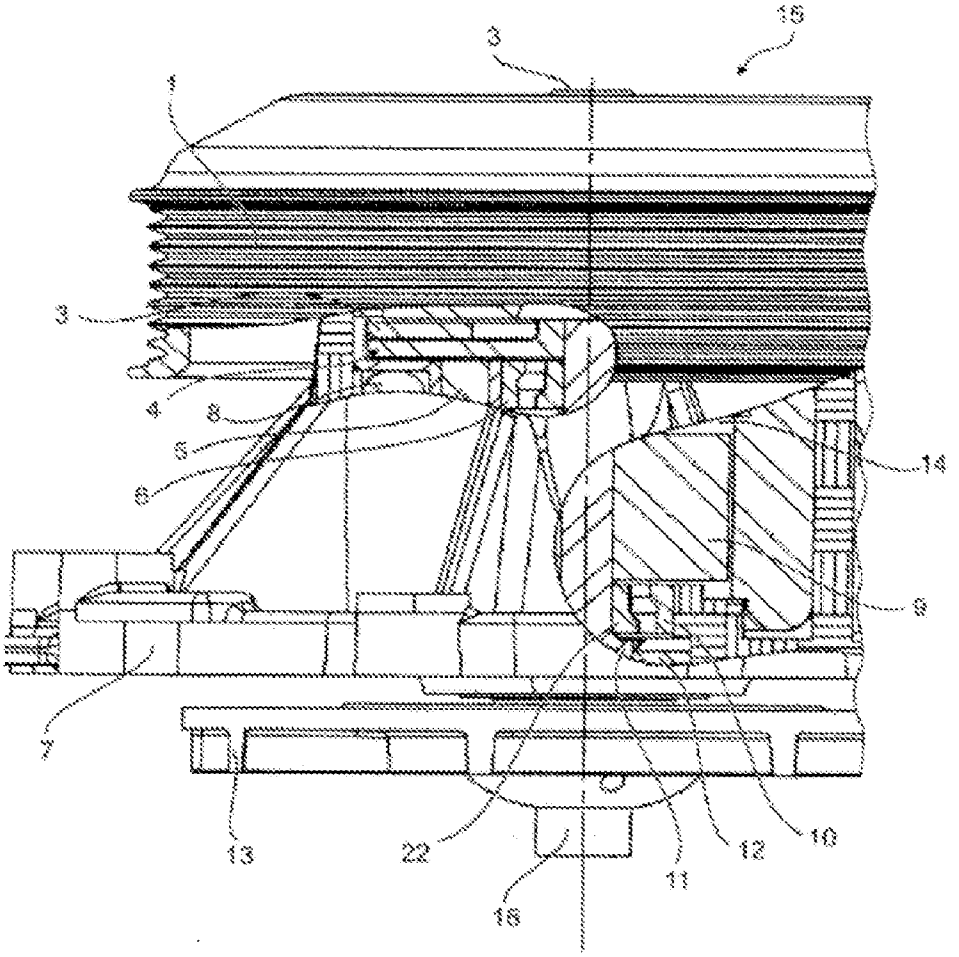
(57) **ABSTRACT**

The invention relates to a coolant pump (**15**) having a pump wheel (**13**) which is arranged on a pump wheel shaft (**3**, **11**); and having a drive device (**1**; **8**, **9**) for the pump wheel (**13**), which drive device has a mechanical drive (**1**) and which drive device has an electric-motor drive (**8**, **9**), wherein the pump wheel shaft is divided into a driving section (**3**) and a driven section (**11**), and an openable and closable clutch (**4**) is arranged between the driving section (**3**) and the driven section (**11**).



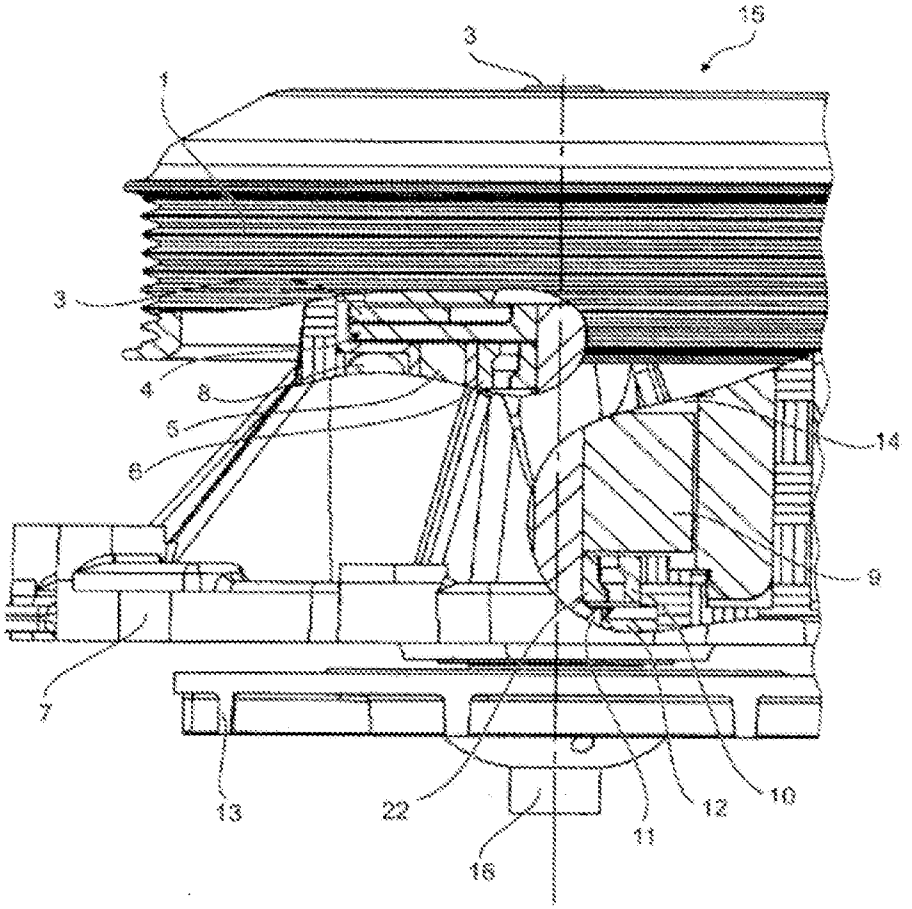


FIG. 1

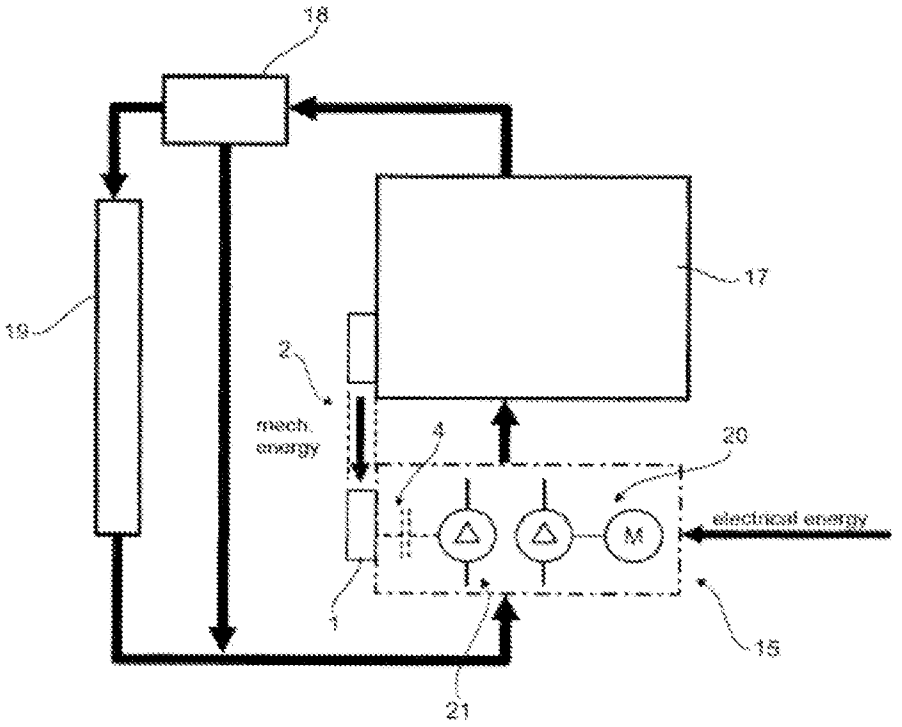


FIG. 2

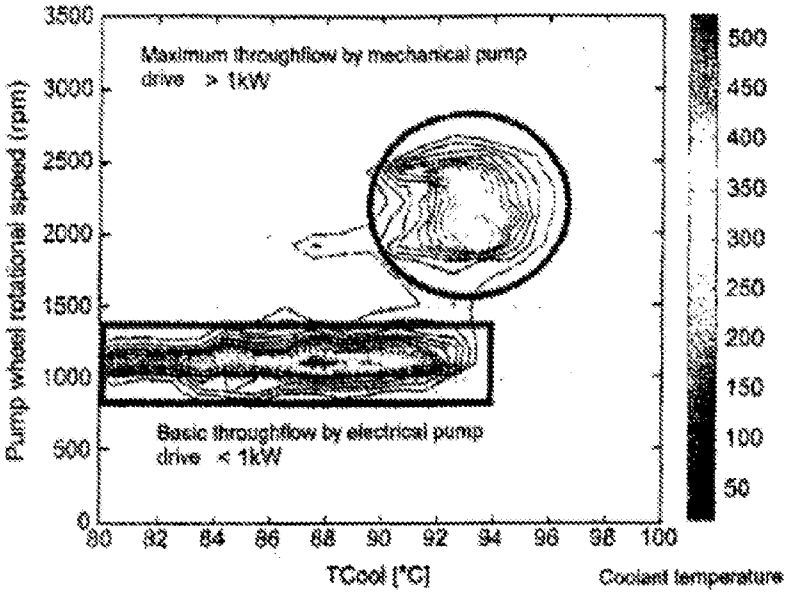

Maximum throughflow by mechanical pump drive > 1kW
Basic throughflow by electrical pump drive < 1kW
Pump wheel rotational speed (rpm)
TCool [°C]
Coolant temperature

FIG. 3

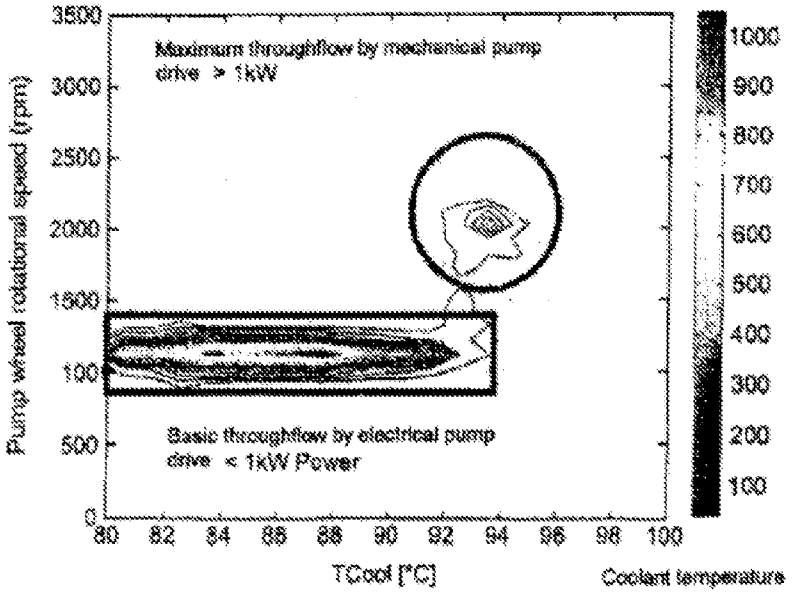

Maximum throughflow by mechanical pump drive > 1kW
Basic throughflow by electrical pump drive < 1kW Power
Pump wheel rotational speed (rpm)
TCool [°C]
Coolant temperature

FIG. 4

COOLANT PUMP WITH ELECTRIC MOTOR DRIVE AND MECHANICAL DRIVE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation of U.S. patent application Ser. No. 12/937,746, filed on Feb. 6, 2011. This application is also related to U.S. patent application Ser. No. 14/517,914 and U.S. patent application Ser. No. 14/517,916, both filed on Oct. 19, 2014.

TECHNICAL FIELD

[0002] The present invention relates to coolant pumps which have both a mechanical mode of operation and an electric mode of operation.

BACKGROUND OF THE INVENTION

[0003] A coolant pump of said type is known from DE 102 14 637 A1.

[0004] To be able to realize different driving operation states of a vehicle with said coolant pump, which has both an electric-motor drive and also a mechanical drive, a planetary drive is provided which can be driven by the electric motor and/or by the mechanical drive.

[0005] Said design is however complex with regard to its mechanical construction and is susceptible to faults.

[0006] It is therefore an object of the present invention to create a coolant pump, the design of which coolant pump is simplified in relation to the prior art and the operation of which coolant pump is efficient and fail-safe.

SUMMARY OF THE INVENTION

[0007] As a result of the pump wheel shaft being divided into a driving section and a driven section which is separate from said driving section, and as a result of the provision of a clutch which is arranged between the driving section and the driven section and which can be opened in order to separate said two sections and which can be closed in order to connect the two sections, it is possible in an extremely simple manner for the pump wheel to be driven both by the electric-motor drive and also by the mechanical drive, in each case independently.

[0008] The present invention is based on the concept of providing two pump types, such that the mechanical pump takes over the function of the electric pump in order to boost the pump power for operating conditions for which the electric pump would be too weak. In this way, it is also possible to obtain a fail-safe function for the electric pump, since it is possible according to the invention to couple in the mechanical pump if an interruption occurs in the electrical energy supply for the electric pump.

[0009] In principle, the following implementations of the invention are possible:

[0010] Although it is fundamentally possible to operate both pump types in parallel, it is particularly preferably provided according to the invention that the electric pump and the mechanical pump are connected in series, with a regulated clutch performing the function of coupling in the mechanical pump, for example on the basis of pressure measurements or monitoring of the electrical energy supply.

[0011] In the case of a sequential arrangement of the mechanically operated pump and the electrically operated pump, it is preferably possible, for both pumps to use a single pump wheel.

[0012] It is also possible according to the invention, as a result of a downsizing of the coolant pump, for said coolant pump to be adapted both for the utility vehicle field and also for the passenger vehicle field, wherein in the case in particular of the passenger vehicle field, the warm-up behavior of the engine can be improved by precise adjustment of the basic coolant flow.

[0013] In hybrid vehicles, the concept according to the invention may also provide a coolant flow when the engine is stopped. The coolant flow is required for the functioning of the alternator/generator and for the battery. The coolant flow which is required may accordingly be provided by the combination according to the invention of the electric pump and of the mechanically driven pump, without an auxiliary pump being required, as in the prior art.

[0014] This yields the following advantages:

[0015] More fail-safe design of the entire system, since it is possible, when the electric-motor drive is deactivated, for the pump wheel to be actuated solely by means of the mechanical drive. The decoupling from the mechanical drive takes place by means of an actuation of the clutch. In the rest position of the clutch, the pump wheel shaft is driven by the mechanical drive.

[0016] Two operating principles for actuating a driving side, wherein the two driving sides can be decoupled entirely from the driven side, or the two driving sides can be decoupled only individually from the driven side.

[0017] In-line concept for coupling/decoupling with electric-motor drive. The electric-motor drive, which is preferably designed as a brushless direct-current motor, is arranged on the driven side of the pump wheel shaft. The mechanical drive and also the electric-motor drive may, connected by the clutch, be arranged in alignment on the same axis of the coolant pump, and drive only a single pump wheel.

[0018] The concept of the coolant pump according to the invention is compatible with different coolant pump designs.

[0019] The coolant pump according to the invention can provide hydraulic energy when the internal combustion engine is at a standstill, if the coolant pump is for an internal combustion engine of a passenger vehicle. Post-operation cooling can take place via the main pump wheel by means of drive by means of the electric motor.

[0020] Sequential operating logic can be obtained with the coolant pump according to the invention, since the pump wheel can be driven either by the electric motor or by the mechanical drive.

[0021] The bearings on the driving side and on the driven side can be arranged in alignment on the same axle, wherein all of the inner rings rotate.

[0022] It is possible to recover electrical energy from the electric-motor drive (generator operation) when the pump wheel is being driven exclusively by the mechanical drive. From an energetic aspect, this is particularly expedient in the overrun mode of the internal combustion engine.

[0023] The provision of sufficient cooling power for most operating states by decoupling the mechanical drive and operation by means of the electric motor.

[0024] As a result of the quadratic power characteristic curve of a coolant pump, the electric motor provides a basic volume flow, wherein the maximum delivery power for maxi-

mum cooling power takes place by coupling the mechanical drive (without electric-motor pump).

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Further details, advantages and features of the present invention can be gathered from the following description of an exemplary embodiment on the basis of the drawing, in which:

[0026] FIG. **1** shows a sectioned illustration through an embodiment of a coolant pump according to the invention;

[0027] FIG. **2** shows a schematic construction of a cooling circuit of an internal combustion engine having the coolant pump according to the invention; and

[0028] FIGS. **3** and **4** show two statistical distribution plots of the pump wheel rotational speed in relation to the engine speed for two transient driving cycles.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] FIG. **1** shows a sectioned illustration through an embodiment of a coolant pump **15** according to the invention. The coolant pump **15** has a pump wheel **13** which is arranged on a pump wheel shaft. The pump wheel shaft is divided into a driving section **3** and a driven section **11**. In the illustrated embodiment, the driving section **3** is formed as a flange, to which a mechanical drive **1**, in the form of a belt pulley in this example, is rotationally fixedly connected. In the illustrated embodiment, the arrangement composed of a flange **3** and a belt pulley **1** is mounted in a housing **7** by means of a bearing (not shown).

[0030] The mechanical drive **1** may be connected to an internal combustion engine of a motor vehicle, wherein in the illustrated embodiment, it is possible to use a belt drive, of which, however, only the belt pulley **1** is shown in order to simplify the illustration.

[0031] The driven section **11** of the pump wheel shaft is mounted in the housing **7** by means of two bearings **5** and **10**, and at its free end **16**, supports the pump wheel **13**. Here, the free end **16** of the driven section **11** is sealed off with respect to the housing **7** by means of a seal **12** which is arranged between the pump wheel **13** and the bearing **10**.

[0032] As is also shown in FIG. **1**, the driven section **11** and the driving section **3** of the pump wheel shaft can be connected by means of a clutch **4** which is arranged between the two sections **3** and **11**. The clutch **4** may for example be embodied as an electromagnetic clutch with a coil **5**.

[0033] An electric-motor drive is also assigned to the driven section **11** of the pump wheel shaft, which electric-motor drive is arranged, with its rotor **9** and a stator **8** which surrounds said rotor **9**, in alignment with the lo mechanical drive **3** on the driven section **11**. Here, as shown in FIG. **1**, the rotor **9** and the stator **8** are held in a housing **7**.

[0034] Finally, a Hall effect device **14** is arranged between the rotor **9** and the bearing **6**.

[0035] With said design of the coolant pump **15** according to the invention, it is possible for the pump wheel **13** to be completely separated from the mechanical drive **1** by opening the clutch **4**. Here, the electric-motor drive, which is preferably embodied as a brushless direct-current motor, is arranged on the side of the driven section **11** of the pump wheel shaft, in order to be able to provide a regulable coolant flow in a predeterminable power range, which is completely independent of the rotational speed of the motor to which the coolant pump **15** is connected, when the driven section **11** is separated from the driving section **3** by the opened clutch.

[0036] For this purpose, the rotor **9** of the electric-motor drive is arranged directly on the driven section **11** of the pump wheel shaft, as can be seen from FIG. **1**. The stator **8** is integrated, around the same axis of the housing **7**, in the housing **7** around the rotor **9**, as can likewise be seen from FIG. **1**.

[0037] The electric-motor drive **8**, **9** can be regulated by means of a commutated signal from an electronic regulating device (not illustrated in any more detail in FIG. **1**). If the driven side **11** is separated from the driving side **1**, **3**, the pump wheel **13** can be driven solely by the electric-motor drive **8**, **9**. Here, it is provided that sufficient hydraulic output power is provided in order to provide the required coolant flow for all normal operating conditions of the engine which is connected to the coolant pump **15**. To obtain a maximum available coolant flow, the driven section **11** can be connected to the driving section **1**, **3** of the pump wheel shaft by means of the clutch **4**. In said case, the pump wheel **13** is driven solely by the mechanical drive **1** when the electric motor **8**, **9** is deactivated. If appropriate, the electric motor **8**, **9** may be activated.

[0038] FIG. **2** illustrates a schematic construction of a possible cooling circuit of an internal combustion engine **17** which uses the coolant pump **15** according to the invention. In said schematically highly simplified illustration, the pump which is driven by an electric motor is denoted by the reference symbol **20** and the mechanically driven pump is denoted by the reference symbol **21**. The two pumps, which are arranged in series, may be connected via the clutch **4** to a belt drive **2** and via the belt pulley **1** to the engine **17** for the provision of the required mechanical drive energy. In the illustrated embodiment, the coolant circuit also has a thermostat **18** and a cooler **19**, the interaction of which is shown by the plotted arrows, in which regard reference is made explicitly to the graphic illustration of FIG. **2**.

[0039] FIGS. **3** and **4** show data of two transient driving cycles, in which regard reference is made to FIGS. **3** and **4** with the curves and entries plotted therein.

[0040] In addition to the above written disclosure of the invention, reference is hereby explicitly made to the graphic illustration of said illustration of said invention in FIGS. **1** to **3**.

What is claimed is:

1. A method for operating a dual mode coolant pump for a vehicle engine, said coolant pump comprising an impeller shaft having a driving section and a driven section, an impeller member at one end of said shaft for circulating coolant in said engine, an electric motor drive for rotating said impeller shaft at said driven section, a mechanical drive for rotating said impeller shaft at said driving section, a clutch mechanism for engaging and disengaging said mechanical drive from said impeller shaft, and a control system for activating and deactivating said mechanical drive and said electric motor drive, said method of operating said coolant pump comprising:

activating said electric motor drive and deactivating said mechanical drive for pumping coolant through said engine during a first range of impeller rotation speed;

activating said mechanical drive and deactivating said electric motor drive for pumping coolant through said engine during a second range of impeller rotation speed;

said second range of impeller rotation speed being greater than said first range of impeller rotation speed.

2. The method as set forth in claim **1** wherein said first range of impeller rotation speed is from about 1000 rpm to about 1500 rpm.

3. The method as set forth in claim **1** wherein said second range of impeller rotation is from about 1000 rpm to about 2500 rpm.

4. The method as set forth in claim **1** wherein said electric motor is a brushless DC motor.

5. The method as set forth in claim **1** wherein said mechanical drive comprises a pulley.

6. The method as set forth in claim **1** wherein said clutch mechanism is an openable and closeable clutch.

7. The method as set forth in claim **1** wherein said mechanical drive is engaged on the basis of pressure measurements.

8. The method as set forth in claim **1** wherein said mechanical drive is engaged on the basis of monitoring of supply of electrical energy.

9. The method as set forth in claim **1** wherein said first range of impeller rotation speed comprises coolant temperature from about 80° C. to about 94° C.

10. The method as set forth in claim **1** wherein said second range of impeller rotation speed comprises coolant temperature from about 90° C. to about 96° C.

11. The method as set forth in claim **1** wherein an auxiliary coolant pump is not required for the vehicle engine.

12. The method as set forth in claim **1** further comprising the step of recovering electrical energy from the electric motor drive when said mechanical drive is exclusively activated.

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