A temperature control apparatus for an interior of a motor vehicle having a temperature control loop circulating a heat-exchange fluid to a drivetrain component. A thermoelectric heat-pump (Peltier device) is disposed in the vehicle to heat or cool the desired area, and a fluid comfort control loop exchanges heat with the thermoelectric heat-pump and with the drivetrain temperature control loop, increasing the net amount of heating or cooling that can be delivered to the desired location by the thermoelectric heat-pump. The comfort control loop may branch from the drivetrain loop and carry a portion of the heat-exchange fluid carried in the drivetrain loop. Alternatively, the comfort control loop may carry a second heat-exchange fluid that remains separate from the heat-exchange fluid of the drivetrain loop and exchanges heat therewith in a heat exchanger.
Fig. 3
THERMOELECTRIC COMFORT CONTROL SYSTEM FOR MOTOR VEHICLE

TECHNICAL FIELD

[0001] The present invention relates to a comfort control system for a vehicle that includes a thermoelectric heat pump (Peltier device) having a fluid temperature control loop, and specifically to such a system in which energy efficiency is improved by the exchange of heat energy between the temperature control loop and a second fluid temperature control loop that controls the temperature of a drivetrain component.

BACKGROUND

[0002] Electric powered vehicles (including hybrid-electric vehicles, fuel cell vehicles, plug-in electric vehicles, etc.) have one or more drivetrain components that should be maintained within a desired operating temperature range for optimum performance. Examples of such drivetrain components are high-voltage batteries, electric machines (motors, generators, and/or combined devices), and transmissions. Under some operating conditions, a temperature control system is necessary to cool and/or heat the components to maintain them within the desired temperature range.

[0003] It is known to provide a temperature control system in which a fluid (usually a liquid) is circulated to, through, or around the drivetrain component where the fluid removes (or adds) heat energy, and through a heat exchanger to reject (or absorb) heat energy to some other medium, usually ambient air. In this context, the term “heat exchanger” refers to any apparatus that may achieve the desired result of adding and/or removing heat to/from the fluid circulating in the control system. This heat exchange function may be performed by apparatus such as a fluid/heat heat exchanger, a refrigerant cycle heat pump, and a thermoelectric heat pump (also known as a Peltier device).

[0004] Thermoelectric heat pumps are currently used in some automotive vehicles to cool and/or heat a storage compartment in order to store food or drinks at a desired temperature. It is also known to use thermoelectric heat pumps to heat and/or cool seats in the vehicle interior. In such “air conditioned seats,” the seating surface which contacts the seat occupant is typically perforated and a fan circulates air over the cold side of the Peltier cooler and blows the cooled or heated air out of the perforations in the seat skin.

[0005] It has also been proposed to integrate a liquid heat exchanger with a thermoelectric heat pump. In this concept, a liquid working fluid passes through the heat pump. In heating mode, heat is pumped from the working fluid through the thermoelectric device into the passenger comfort air. In cooling mode, heat is rejected from the air into the liquid working fluid.

SUMMARY

[0006] The object of the invention is to improve the overall energy efficiency of a motor vehicle, in particular an electric vehicle, by reducing or eliminating the need to use electric power to run a conventional heater or air conditioning unit to achieve a comfortable cabin temperature.

[0007] According to a feature disclosed herein, an interior temperature control apparatus for a motor vehicle having a temperature control loop carrying a heat-exchange fluid to a drivetrain component comprises a thermoelectric heat-pump disposed in the vehicle, and a comfort control loop exchanges heat with the thermoelectric heat-pump and with the drivetrain temperature control loop. This increases the net amount of heating or cooling that can be delivered to the desired location by the thermoelectric heat-pump, thereby reducing the amount of electrical power that may otherwise be needed to run the climate control system.

[0008] According to another feature disclosed herein, the comfort control loop branches from the drivetrain loop and carries a portion of the heat-exchange fluid carried in the drivetrain loop.

[0009] According to another feature disclosed herein, the comfort control loop carries a second heat-exchange fluid that exchanges heat with the heat-exchange fluid of the drivetrain loop.

[0010] According to another feature disclosed herein, an apparatus for passenger comfort control in a motor vehicle comprises a drivetrain component, a temperature control loop circulating a heat-exchange fluid to the drivetrain component, a thermoelectric heat-pump disposed in a passenger compartment of the vehicle, and a comfort control loop branching from the temperature control loop and carrying a portion of the heat-exchange fluid to the thermoelectric heat-pump.

[0011] According to another feature disclosed herein, the passenger comfort control apparatus further comprises a HVAC system circulating air through the passenger compartment, and an electronic control unit controlling the HVAC system and the thermoelectric heat-pump. Integrating the control of the thermoelectric heat pump with the HVAC system achieves optimum energy management, thereby minimizing energy usage while maintaining a comfortable passenger environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a schematic system diagram of a thermoelectric comfort control system according to a first disclosed embodiment;

[0013] FIG. 2A is a schematic depiction of a thermoelectric heat pump with fluid a heat exchange fluid loop;

[0014] FIG. 2B is a schematic depiction of a Peltier element of the type used in a thermoelectric heat pump; and

[0015] FIG. 3 is a schematic system diagram of second embodiment of a thermoelectric comfort control system.

DETAILED DESCRIPTION

[0016] As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

[0017] Referring to FIG. 1, a thermoelectric comfort control system for a vehicle includes one or more thermoelectric heat pumps 10 located in, on, or adjacent to a passenger compartment of a vehicle. In the depicted embodiment, thermoelectric heat pumps (TEHP) are located inside a passenger seat 12, one in the seat bottom and one in the seat back. TEHPs may be provided at other locations within a passenger cabin where heating and/or cooling is required, such as beneath a seat, adjacent a foot-well area, behind a body trim...
panel (e.g., headliner or door trim), or behind the instrument panel. Further, TEHPs may be located within or adjacent to a storage compartment in order to heat and/or cool the storage compartment as may be required, for example, to store food or drinks at a desired temperature.

[0018] TEHPs as described herein operate on the well-known Peltier effect in which a DC electric voltage is applied across pairs of n-type and p-type thermoelement to cause an electron flow and result in heat transfer from a "cold side" to a "hot side" of the elements. Reversing the polarity of the DC voltage reverses the flow of electrons and results in a switching of the hot side and cool side. Accordingly, a single TEHP may be used either as a heating device or a cooling device by simply applying the appropriate voltage polarity.

[0019] The following description primarily discusses the situation where TEHPs 10 are used to cool the vehicle interior. This should, however, not be construed to limit the scope of the present invention since, as noted above, TEHPs 10 may easily be operated to heat the vehicle interior if desired.

[0020] A comfort control loop 14 circulates a heat exchange fluid through TEHPs 10. Comfort control loop 14 may comprise hollow pipes or tubes that enter TEHPs and pass across one side of the Peltier devices to allow an exchange of heat energy between the fluid and the Peltier device, and exit the TEHP. In the embodiment depicted in Fig. 1, comfort control loop 14 branches off from a drivetrain temperature control loop 16 and carries a portion of the heat exchange fluid circulating through the drivetrain temperature control loop.

[0021] The amount or portion of heat exchange fluid that is diverted from the drivetrain temperature control loop 16 to circulate through comfort control loop 14 may be regulated by one or more valves 18 that are preferably controlled by an electronic control unit (ECU) 20, the operation of which will be further described below. A pump 19 may be provided to provide additional control over the amount and direction of the flow of fluid through comfort control loop 14.

[0022] Drivetrain temperature control loop 16 exchanges heat energy with one or more drivetrain components 22 and with a heat exchanger 24. In an electrically powered vehicle, drivetrain components 22 may comprise one or more components such as a high-voltage battery, electric motors, generators, and power electronics (such as DC/DC or AC/DC converters). Under most vehicle operating conditions, such drivetrain components will generate excess heat when operating, so that the heat exchange fluid circulating in drivetrain temperature control loop 16 carries heat away from the components. Heat exchanger 24 may comprise one or more of a conventional liquid-to-liquid or liquid-to-air exchanger, a heat pump using a fluid refrigerant cycle, or a thermoelectric (Peltier) heat pump. In any event, the objective of drivetrain temperature control loop 16 and heat exchanger 24 is to heat or cool drivetrain component 22 as is necessary to maintain a desired operating temperature range.

[0023] ECU 20 may receive signals or inputs from a variety of sensors and controls. Examples of such sensors include: cabin temperature sensor(s) 26; exterior temperature sensor(s) 28; and sensor(s) 32 monitoring conditions of drivetrain components 22, heat exchanger 24, or drivetrain temperature control loop 16. Inputs may be made by a vehicle occupant using a climate control panel 30. Such inputs may include desired temperature, fan speed, direction of air flow, or simply "heat" or "cool." ECU 20 controls the condition of valve(s) 18 and/or pump 19 to regulate the direction and/or flow rate of heat exchange fluid to TEHPs 10. ECU 20 preferably also controls the electric voltage/current/polarity applied to the Peltier elements within TEHPs 10. By monitoring and/or controlling the basic parameters of the temperature and volume flow rate of the heat exchange fluid traveling through comfort control loop 14 and the voltage and polarity of the current applied to the Peltier devices and TEHPs 10, ECU 20 controls the amount or level of heating and/or cooling supplied to vehicle interior and any occupants.

[0024] Heat transfer from/to TEHPs 10 may be enhanced by one or more fans or other air movement devices (not shown) integrated with or located adjacent to the TEHPs to circulate air over the occupant/cabin side of the Peltier device. ECU 20 may also control the on/off condition and/or the speed of the fans.

[0025] ECU 20 may also control other vehicle comfort control systems, such as an HVAC system 36, and may have one or more automatic climate control operating modes. HVAC system 36 comprises apparatus for circulating heated, cooled, or otherwise conditioned air through the vehicle interior, such as a conventional air conditioning system and/or vehicle heater. Alternatively ECU 20 may be connected with a separate control device (not shown) for HVAC system 36 so that the two systems may operate in a coordinated manner.

[0026] As shown schematically in Fig. 2A, a possible embodiment of a TEHP 10 includes Peltier elements 50 arranged on opposite sides of a multi-tube conduit 52. Conduit 52 is part of comfort control loop 14 and conducts heat exchange fluid in a direction into/out of the page. Fins 54 extend outwardly from Peltier elements 50 in both directions (up and down, as viewed in Fig. 2A), and the entire structure is contained in an air flow housing 56. A fan 48 (or other air movement device) is positioned to force air (usually ambient air from the passenger cabin or other interior compartment of the vehicle) through air flow housing 56 and over fins 54. The air flow exits TEHP 10 and passes into the portion of the vehicle interior that is being warmed or cooled by the system.

[0027] Fig. 2B shows, again in schematic form, an example of a Peltier element 50. Each Peltier element comprises a p-type element 50a and a n-type element 50b electrically connected with one another and with a DC voltage source as shown. When the indicated polarity is applied, the side of element 50 in contact with conduit 52 (see Fig. 2A) becomes the hot side and the opposite side, in contact with fin 54, becomes the cold side.

[0028] On a warm day, when vehicle occupants are most likely to be using TEHPs 10 in a cooling mode, heat energy from the hot side of the Peltier elements passes to the heat exchange fluid in the comfort control loop 14 as it circulates through the TEHPs. Thus, the fluid carries heat out of the passenger compartment and travels to/through heat exchanger 24 along with the rest of the heat exchange fluid circulating through the drivetrain temperature control loop 16. Also on such a warm day, drivetrain components 22 will usually generate excess heat that must be removed by the drivetrain loop 16 in order to maintain the drivetrain components within the desired operating temperature range. So heat exchanger 24 will be operating in a mode to cool the fluid circulating in drivetrain loop 16. If heat exchanger 24 is a heat pump (refrigerant cycle or Peltier), it will be operated in a cooling mode, which is compatible with the need to cool the fluid reaching the heat exchanger from the comfort control loop 14.
Under colder ambient conditions, vehicle occupants are likely to be using TEHPs 10 in a heating mode, in which heat exchange fluid circulating though comfort control loop 14 passes over the cold side of the TEHPs. The fluid therefore exits TEHPs 10 cooler than when it entered and must gain heat energy before returning to the TEHPs. Under all but very cold ambient conditions, this need for heat energy will be met by the excess heat generated by drivetrain components 22. Under very cold conditions, drivetrain components 22 may need to be warmed by the drivetrain temperature control loop 16 in order to stay within the desired operating temperature range. In this case, heat exchanger 24 will operate in a mode to warm the fluid circulating in drivetrain loop 16, and the branching comfort control loop 14.

The direction in which the fluid flows through comfort control loop 14 may be controlled (using a bi-directional pump 19 or any other appropriate means) as necessary to divert working fluid from powertrain loop 16 at the location best suited for operation of the system. The flow direction may depend on many factors, such as ambient temperature, fluid temperatures, drivetrain component temperatures, commanded function of the TEHP, etc.

FIG. 3 shows a second embodiment of a thermoelectric heat pump comfort control system in which heat is exchanged between the comfort control loop 114 and the drivetrain temperature control loop in a manner different from the embodiment of FIG. 1. In this second embodiment, drivetrain components 122 are oil-cooled components such as, for example, a mechanical transmission or an electric machine (generator, motor, or integrated motor/generator). The cooling oil is circulated through a primary drivetrain loop 116a to an oil-to-coolant heat exchanger 124a by a pump 23.

A secondary drivetrain cooling loop 116b contains a second heat exchange fluid that circulates through oil-to-coolant heat exchanger 124b and a second fluid-to-air heat exchanger 124b. Comfort control loop 114 also passes through the oil-to-coolant heat exchanger 124a under pressure provided by a pump 28 controlled by ECU 20. The heat exchange fluid circulating in comfort control loop 114 remains physically separate from both the primary and secondary drivetrain control loops 116a and 116b and may exchange heat with either or both of the fluids (oil and/or coolant) carried in those loops, depending on the interior configuration of oil-to-coolant heat exchanger 124a. In this second embodiment, as with the first embodiment of FIG. 1, the comfort control loop exchanges heat with the drivetrain temperature control loop in order to increase the amount of heat that is possible to efficiently transfer into (or out of) the desired portion of the vehicle cabin using thermoelectric heat pumps.

While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

What is claimed is:

1. Apparatus for improving the energy efficiency of a motor vehicle comprising: a drivetrain component; a temperature control loop circulating a heat-exchange fluid to the drivetrain component; a thermoelectric heat-pump disposed in a vehicle; and a comfort control loop exchanging heat with the thermoelectric heat-pump and with the drivetrain temperature control loop.

2. The apparatus of claim 1 wherein the comfort control loop branches from the drivetrain loop and carries a portion of the heat-exchange fluid.

3. The apparatus of claim 2 wherein the portion of the fluid carried by the comfort control loop is regulated by at least one valve.

4. The apparatus of claim 3 wherein the at least one valve is controlled at least in part by an automatic climate control system.

5. The apparatus of claim 1 wherein the comfort control loop carries a second heat-exchange fluid that exchanges heat with the heat-exchange fluid of the drivetrain loop.

6. The apparatus of claim 5 wherein the comfort control loop and the drivetrain loop exchange heat in a heat exchanger.

7. The apparatus of claim 1 wherein the drivetrain component is at least one of a battery, a fuel cell, an electric motor, a power electronics unit, and a mechanical transmission.

8. The apparatus of claim 1 wherein the thermoelectric heat-pump is located in a passenger seat.

9. The apparatus of claim 1 wherein the drivetrain temperature control loop comprises a heat exchanger through which the heat-exchange fluid flows.

10. The apparatus of claim 9 wherein the heat exchanger is a second thermoelectric heat-pump.

11. A system for improving the energy efficiency of a motor vehicle comprising: a drivetrain component; a temperature control loop circulating a heat-exchange fluid to the drivetrain component; a thermoelectric heat-pump disposed in a passenger compartment of the vehicle; and a comfort control loop branching from the temperature control loop and carrying a portion of the heat-exchange fluid to the thermoelectric heat-pump.

12. The system of claim 11 wherein the drivetrain component is at least one of a battery, a fuel cell, an electric motor, a power electronics unit, and a mechanical transmission.

13. The system of claim 11 wherein the portion of the fluid carried by the comfort control loop is regulated by a valve.

14. The system of claim 13 wherein the valve is controlled by an automatic climate control system.

15. The system of claim 11 wherein the heat exchanger is a second thermoelectric heat-pump.

16. Apparatus for improving the energy efficiency of a motor vehicle comprising: a drivetrain component; a temperature control loop circulating a heat-exchange fluid to the drivetrain component and including a drivetrain heat exchanger; a thermoelectric heat-pump disposed in a passenger compartment of the vehicle; and a comfort control loop exchanging heat with the drivetrain temperature control loop and with the thermoelectric heat-pump.
19. The apparatus of claim 18 further comprising:
a HVAC system circulating air through the passenger compartment; and
an electronic control unit controlling the HVAC system and
the thermoelectric heat-pump.

20. The apparatus of claim 18 wherein the comfort control loop branches from the drivetrain temperature control loop
and carries a portion of the heat-exchange fluid.

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