

INTERCOOLER FOR VEHICULAR ENGINE

FIELD OF INVENTION

5 The present invention relates to an intercooler. In more particular, the present invention relates an intercooler that utilizes refrigerant flow from an air conditioning system of a vehicle for providing cold air supply to the engine of the vehicle in order to improve the efficiency of the engine.

10

BACKGROUND OF THE INVENTION

Automobile engine uses energy from the mixture of burning fuel and air to produce power. A proper mixture will produce efficient combustion for the power generating
15 process and also efficient fuel consumption for the engine. Through providing a cold air flow into the engine, more oxygen is supplied to burn more fuel that is injected into the engine as cool air has greater density as compared to hot air due to having more oxygen, thereby increasing the combustion and fuel consumption efficiencies, resulting in the generation of greater power.

20

Most engines that are commonly used in cars employ turbochargers or superchargers to pump and force air into the combustion chamber of the engine so that the engine would be able to burn more fuel for generating more power. The application of superchargers or turbochargers is intended to increase the air pressure by compressing
25 the air rather than to obtain denser air with more oxygen. Compressed air discharged from the turbocharger or supercharger is cooled by an intercooler prior to being transferred to the engine as the high pressure air with high temperature causes detonation and damage to the engine.

30 Various types of intercoolers have been introduced in the prior arts. One example of

an intercooler is disclosed in U.S. Patent No. 5547019. The active type of intercooler is used for heating or cooling gases exiting a compression stage of a turbocharger. The intercooler comprises a chamber for receiving the gases from the turbocharger, having a plurality of tubes through which the gases flow and an antifreeze filling the chamber and surrounding the tubes, a thermoelectric heat pump thermally coupled to the chamber and a temperature control means for controlling the temperature of gases flowing through the chamber

Another prior art, U.S. Patent No. 4823868 describes an intercooler on a turbocharged engine that comprises an intercooler core having an inlet, an outlet and a flange peripherally extending therefrom with a plurality of holes spaced around the flange; first and second gaskets positioned on either side of the flange; a housing having a face mateable with the first gasket; an intake manifold having a face mateable with the second gasket; a plurality of cap screws for clamping the housing, gaskets, flange and manifold together to form an air-tight seal therebetween; and a highly compressible intercooler seal positioned about the inlet and outlet and compressed between the intercooler core and an inside surface of the housing about the opening to form a seal therebetween.

As compressed air supplied from the turbocharger or supercharger has high temperature with low density, there is less oxygen in the air to burn the fuel in the engine. The intercooler requires more energy to lower the temperature of the air to be provided to the engine. Such intercoolers that are not engineered well might not be able to generate more energy to cool the compressed air and therefore produce air with insufficient coldness. Air that is not cold enough carries less oxygen for complete or more combustion to occur in the engine, resulting in less power output and affects the performance of the engine.

It is therefore necessary to introduce a system with the use of an intercooler that ensures a cold air flow with rich oxygen to be supplied to the engine for complete

combustion to occur. Such intercooler not only improves the efficiency of the engine by generating greater power and reducing fuel uptake but also enhances the durability of the engine.

5

SUMMARY OF INVENTION

The main aspect of the present invention is to provide an intercooler that utilizes refrigerant flow from an air conditioning system for providing a cold air flow supply
10 to the engine.

Another aspect of the present invention is to provide an intercooler that provides air with rich oxygen to the engine for enhancing the combustion process.

15 Still another aspect of the present invention is to provide an intercooler that improves the efficiency of the engine by generating greater power.

Yet another aspect of the present invention is to provide an intercooler that contributes to the decrease in consumption of fuel.
20

Also another aspect of the present invention is to provide an intercooler which enables regulation of the rate of the cold air flow that is to be transferred to the engine.

At least one of the preceding aspects is met, in whole or in part, by the present
25 invention, in which the embodiment of the present invention describes an apparatus for supplying cooled ambient air to an engine comprising, an intercooler having an inlet for receiving ambient air, a heat exchanger section for cooling the ambient air, and an chamber coupled to the heat exchanger section having an outlet for passing the cooled ambient air to the engine, characterized in that air conditioning cycle
30 comprises a refrigerant compressor, a condenser, and an evaporator, connected by

5 piping, a sections of the piping between the evaporator and the compressor serving to carry cooled refrigerant flow through the heat exchanger section, and allowing the ambient air to be cooled by the refrigerant flow.

5

In addition to that, the present invention also describes a system for providing a cold air flow to an engine of a vehicle. The system comprises an air conditioning cycle having a compressor for compressing a refrigerant flow, a condenser for condensing the compressed refrigerant flow; and an evaporator for evaporating the condensed refrigerant flow into gas; characterized in that the air conditioning cycle has a section that passes cold refrigerant from the evaporator through a heat exchanger portion of an intercooler, the intercooler having an inlet for receiving ambient air, an chamber coupled with an outlet being connected to the engine for supplying air cooled by the heat exchanger to the engine.

15

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a diagram of the system that comprises an intercooler connected to an air conditioning cycle for providing a cold air flow to the engine of a vehicle.

20

Figure 2 shows a diagram of the intercooler.

Figure 3 shows a graph of engine speed (RPM) versus time for an engine that receives a cold air flow from a conventional cold air flow producing system and the same engine that receives a cold air flow from the cold air flow producing system of the present invention.

25

Figure 4 shows a graph of car speed versus time of a car which employs an engine that receives a cold air flow from a conventional cold air flow producing system and

30

the same car that uses the same engine which receives a cold air flow from the cold air flow producing system of the present invention.

Figure 5 is a graph and table that show the torque and power generated by the engine that receives a cold air flow from a conventional cold air flow producing system and the same engine that receives a cold air flow from the cold air flow producing system of the present invention.

10 DETAILED DESCRIPTION OF THE INVENTION

The present invention discloses an apparatus for supplying cooled ambient air to an engine (110) comprising, an intercooler (100) having an inlet (112) for receiving ambient air, a heat exchanger section (101) for cooling the ambient air, and an chamber (105) coupled to the heat exchanger section (101) having an outlet (106) for passing the cooled ambient air to the engine (110), characterized in that air conditioning cycle comprises a refrigerant compressor (107), a condenser (108), and an evaporator (109), connected by piping, a sections of the piping between the evaporator (109) and the compressor (107) serving to carry cooled refrigerant flow through the heat exchanger section (101), and allowing the ambient air to be cooled by the refrigerant flow.

Specifically, the apparatus comprises an intercooler (100) connected to an air conditioning cycle of a vehicle comprising a heat exchanger (101) having an array of fins (102) with a plurality of tubes fabricated across the fins (102), an inlet connecting the tubes (103) to an evaporator (109) of the cycle for receiving a refrigerant flow from the evaporator (109), a first outlet (104) connecting the tubes to a compressor (107) of the cycle for discharging the refrigerant flow from the heat exchanger (101) back into the cycle through the compressor (107), and an opening (112) for ambient air to flow into the heat exchanger and past the fins (102); and a chamber (105)

coupled to the heat exchanger (101) having a second outlet (106) connected to an engine (110) of the vehicle; wherein the refrigerant flow passes through the tubes to remove heat from the ambient air for forming a cold air flow to be continuously transferred to the engine (110) through the second outlet (106) of the chamber (105).

5

The air conditioning cycle typically consists of a compressor (107) for compressing the refrigerant flow, a condenser (108) for condensing the compressed refrigerant flow and an evaporator (109) for evaporating the condensed refrigerant flow into a cold gas. The refrigerant flow is supplied to the compressor (107) in the form of a low pressure cold gas. The compressor (107) compresses the refrigerant flow such that molecules of the fluid become closer, increasing its energy and therefore leads to the rise of temperature of the refrigerant flow. The refrigerant flow then enters the condenser (108) in the form of a high pressure and hot gas whereby the condenser (108) condenses the hot gas and converts the gas into a lower temperature gas. An expansion valve (111) could be included between the condenser (108) and the evaporator (109) for changing the high pressure gas to cold temperature liquid entering the evaporator (109) that is received from the condenser (108). The cold liquid is evaporated into cold gas to be provided into the car cabin by a fan.

20 The main feature of the present invention is that it utilizes refrigerant in the form of a cold gas flow exiting the evaporation stage of the air conditioning cycle to be supplied to the engine (110) upon being subject to further cooling by the intercooler (100). By connecting the intercooler (100) to the air conditioning system, two continuous running cycles are formed, with one being the air conditioning cycle and another being the intercooling cycle, whereby both cycles utilize the refrigerant flow to run. As depicted in Figure 2, the intercooler (100) comprises two main parts which is the heat exchanger (101) and the chamber (105). The heat exchanger (101) has an inlet (103) connected to the evaporator (109) and a first outlet (104) connected to the compressor (107), whereas the chamber (105) has a second outlet (106) connected to the engine (110). A diagram of the system (200) that is formed by the two cycles is

25
30

illustrated in Figure 1.

The system (200) used for providing the cold air flow to the engine (110) of the vehicle could be summarized as having the air conditioning cycle and an intercooler (100) that is being connected to the cycle for producing the cold air flow through removing heat from ambient air flowing into the intercooler (100) by the refrigerant flow supplied by the cycle. It should be noted that although it is preferred that the intercooler (100) applied in the system comes in the embodiment as described above and shown in Figure 2, other types of intercooler that allows the application of the refrigeration flow to cool ambient air for forming the cold air flow to be supplied to the vehicular engine could also be employed.

As the heat exchanger (101) functions by using the refrigerant flow entering the heat exchanger (101) from the evaporator (109) to remove heat from the ambient air, the intercooler (100) is preferred to have a front mount heat exchanger in which the heat exchanger (101) is mounted at the front of the vehicle such that ambient air from the outside is forced to flow into the heat exchanger (101) via the opening (112) and through the fins (102). A cross flow heat exchanger would therefore be suitable to be employed in the present invention. The configuration of a cross flow heat exchanger having an array of fins (102) with tubes fabricated through the fins (102) allows the ambient air and the refrigerant flow to pass perpendicular to one another. The ambient air enters the heat exchanger (101) through the gaps between each adjacent fin (102) and flows freely with even distribution across the tubes in which the refrigerant flow flowing inside the tubes removes heat of the ambient air. Examples of such heat exchangers (101) are the finned-tube heat exchanger, plate heat exchanger and plate fin heat exchanger, with the finned-tube heat exchanger being the most preferred heat exchanger (101) to be applied in the present invention. The refrigerant flow passes through the tubes of the heat exchanger (101) and returns to the air conditioning cycle via the first outlet (104) back into the cycle through the compressor (107). Such configuration allows the refrigerant flow to be continuously supplied to the

intercooler (100) to cool the ambient air.

Through this heat exchanging process, the ambient air forms a cold air flow with a temperature between -15°C below ambient temperature and -5°C below ambient
5 temperature that is to be transferred to the engine (110) via the chamber (105) after the heat of the ambient air is removed by the refrigerant flow that passes in a direction transverse to the direction of the ambient air. Unlike conventional intercoolers that need to consume more energy in order to lower the temperature of air that is originally hot due to being compressed by a turbocharger or a supercharger, the
10 intercooler (100) of the present invention saves energy while being able to produce an air flow with very low temperature as it utilizes the refrigerant flow which has a low temperature of about -5°C to 0°C from the air conditioning cycle to cool the ambient air. The cold air flow has high density due to having more oxygen contained in it. This is because the lower the temperature of the air flow, the more oxygen the air flow
15 contains. Hence, the cold air flow produced from the intercooler (100) of the present invention is useful in bringing efficient combustion process inside the engine (110).

Rate of the air flow is dependable on the size of the chamber (105). According to the Bernoulli's principle and Reynolds number equation, the flow rate is inversely
20 proportional to the dimensions of the chamber (105). The larger the chamber (105), the lower the flow rate will be whereas the smaller the chamber (105), the higher the flow rate will result in. Thus, the incorporation of the chamber (105) in the intercooler (100) is for regulating the rate of the air flow.

25 A high flow rate of the air flow decreases the efficiency of heat transfer from the chamber (105) into the engine (110) whereas a low flow rate leads to accumulation of more heat in the air flow and thus produces an air flow that is not cold enough to be supply to the engine (110) for generating efficient power. Therefore, to achieve an optimum flow rate for the cold air flow into the engine (110), the size of the chamber
30 (105) plays an important role. The Bernoulli's principle and Reynolds number

equation are used to determine the size of the chamber (105). The Reynolds number is defined in Equation 1. Due to the most effective heat transfer for the air flow being a laminar flow, the Reynolds number must be less than 10, 000. A turbulent flow is not desired in the chamber (105) as turbulence causes lose in energy.

5

$$Re = \frac{\rho v D_H}{\mu} = \frac{v D_H}{\nu} = \frac{Q D_H}{\nu A} \quad \text{---- (1)}$$

where

D_H = hydraulic diameter of the chamber, its characteristic travelled length, L (m)

10 Q = volumetric flow rate (m³/s)

A = cross-sectional area of the chamber (m²)

v = mean velocity of the object relative to the cold air flow (m/s).

μ = dynamic viscosity of the cold air flow (Pa·s or N·s/m² or kg/(m·s)).

ν = kinematic viscosity, $\nu = \mu / \rho$, (m²/s).

15 ρ = density of the cold air flow (kg/m³)

With the chamber (105) being in a square or rectangular shape, the characteristic dimension of the chamber (105) is as represented in Equation 2.

$$D_H = \frac{4A}{P}. \quad \text{---- (2)}$$

where

A = cross-sectional area of the chamber (m²)

P = wetted perimeter = the total perimeter of all walls of the chamber that are in

25 contact with the cold air flow.

Pressure along a streamline is calculated as static pressure + dynamic pressure = total pressure which could be represented in Equation 3 to Equation 5 according to the

Boyle's principle.

$$P_s + \frac{\rho V^2}{2} = P_t \quad \text{---- (3)}$$

$$5 \quad \left(P_s + \frac{\rho V^2}{2} \right)_1 = \left(P_s + \frac{\rho V^2}{2} \right)_2 \quad \text{---- (4)}$$

By substituting Equation 5 into Equation 4, Equation 6 is obtained.

$$p = \rho gh \quad \text{---- (5)}$$

$$10 \quad g \cdot h_1 + \frac{P_1}{\rho} + \frac{V_1^2}{2} = g \cdot h_2 + \frac{P_2}{\rho} + \frac{V_2^2}{2} \quad \text{---- (6)}$$

where

$$15 \quad h = h_1 - h_2 \quad \text{---- (7)}$$

$$V_1 = \left(\frac{A_2}{A_1} \right) \cdot V_2 \quad \text{---- (8)}$$

V_2 could be derived into Equation 12 by substituting Equation 7 and Equation 8 into Equation 6.

$$20 \quad V_2 = \sqrt{\frac{2}{\left(1 - \frac{A_2^2}{A_1^2}\right)} \cdot \left(\frac{P_1 - P_2}{\rho} + g \cdot h\right)} \quad \text{---- (9)}$$

$$V_2 = \sqrt{2 \cdot g \cdot h} \quad \text{---- (10)}$$

$$25 \quad V_2 = c \sqrt{2 \cdot g \cdot h} \quad \text{---- (11)}$$

$$V_2 = \sqrt{\frac{2 \cdot (P_1 - P_2)}{\rho}} \quad \text{---- (12)}$$

By substituting Equation 12 into Equation 1, the dimension of the chamber (105) could be determined in order to obtain a desired or optimum flow rate for the cold air flow that enters from the chamber (105) into the engine (110).

It should be noted that the calculations are based on a condition where the cold air flow is incompressible and inviscid as well as flows steadily without any addition of heat and the height difference of the chamber (105) and engine (110) is negligible as it does not affect the flow rate of the cold air flow.

With an optimum flow rate, the cold air flow is kept low with negligible changes due to engine speed. The rich oxygen content in the cold air flow is retained and fed into the engine air intake (110) via the second outlet (106) of the chamber (105) for burning with the fuel in order to enhance the combustion process in the engine (110) for generating more power for the vehicle.

Although the description above contains many specifications, it is understood that the embodiments of the preferred form are not to be regarded as a departure from the invention and it may be modified within the scope of the appended claims.

Example

Example 1

25

A test is conducted on a car that runs on a 2500 cc Turbo Diesel non commonrail engine to determine the difference in engine speed in the unit of revolution per minute (RPM) of an engine that receives a cold air flow from a conventional cold air flow producing system having an intercooler that lowers the temperature of an air flow

compressed by a turbocharger or a supercharger; and an engine that obtains a cold air flow from the cold air flow producing system of the present invention having an intercooler which uses the refrigerant flow from an air conditioning system.

- 5 An average RPM over time is plotted in accordance with results from four test runs of each system. It could be seen from Figure 3 that the engine reaches the maximum speed in a shorter time when the system of the present invention is installed in the car compared to the engine that receives cold air flow from the conventional system. The air flow produced from the present invention contributes to the enhancement of the engine speed by increasing the combustion rate in the engine.
- 10

Example 2

- 15 The speed of the car that is respectively installed with the conventional system that supplies cold air flow to the engine and the system of the present invention is tested. Figure 4 shows that the car that is installed with the system of the present invention travels in higher speed than the same car which is installed with the conventional system when the same volume of fuel is applied, indicating that the system of the present invention provides more energy to the car.
- 20

Example 3

- 25 Comparison of the torque and power generated by engine receiving cold air flow from the conventional cold air flow producing system and the system of the present invention is shown in Figure 5. The test concluded that the system of the present invention is capable of generating a greater torque and power compared to the conventional system.

CLAIMS

- 5 1. An apparatus for supplying cooled ambient air to an engine (110) comprising:
an intercooler (100) having
- an inlet (112) for receiving ambient air,
- a heat exchanger section (101) for cooling the ambient air, and
- an chamber (105) coupled to the heat exchanger section (101) having
- 10 an outlet (106) for passing the cooled ambient air to the engine (110);
- characterized in that air conditioning cycle comprises a refrigerant compres-
sor (107), a condenser (108), and an evaporator (109), connected by piping, a
sections of the piping between the evaporator (109) and the compressor (107)
serving to carry cooled refrigerant flow through the heat exchanger section
- 15 (101), and allowing the ambient air to be cooled by the refrigerant flow.
2. An apparatus according to claim 1, wherein the intercooler (100) has a front
mount heat exchanger (101) for receiving the ambient air from the outside the
heat exchanger (101).
- 20
3. An apparatus according to claim 1, wherein the heat exchanger (101) is a
cross-flow heat exchanger (101).
4. An apparatus according to claim 1, wherein the heat exchanger (101) is any
- 25 one of a finned-tube heat exchange, a plate heat exchanger or a plate fin heat
exchanger.

5. A system (200) for providing a cold air flow to an engine (110) of a vehicle comprising:

5 an air conditioning cycle having a compressor (107) for compressing a refrigerant flow, a condenser (108) for condensing the compressed refrigerant flow; and an evaporator (109) for evaporating the condensed refrigerant flow into gas;

10 characterized in that the air conditioning cycle has a section that passes cold refrigerant from the evaporator (110) through a heat exchanger (101) portion of an intercooler (100), the intercooler (100) having an inlet (112) for receiving ambient air, an chamber (105) coupled with an outlet (106) being connected to the engine (110) for supplying air cooled by the heat exchanger (101) to the engine (110).

