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CHARGE AIR COOLERS

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ABSTRACT

Charge air coolers are specific heat exchangers that are used in particularly stressful environments, such as on internal combustion engines with turbochargers or superchargers. Charge air coolers are located between the turbo charger and the engine air inlet manifold. When the air is compressed by the turbocharger or supercharger, it is also heated, which causes its density to decrease. Cooling the combustion air by a charge air cooler prior to sending it into the engine, the density of the air increases which permits more air to enter the engine and increases the power and efficiency of the engine. Besides, it is very important that providing cooler inlet air can lower the amount of NO_x generated during combustion.

1. INTRODUCTION

Charge air coolers are basically heat exchangers facilitating the heat transfer between two fluids of varying temperatures. Since they operate at more severe environments (on internal combustion engines), they need to be of a more special and durable design.

In diesel engines, charge air coolers are located between the turbocharger which provides a greater supply of combustion air by air compression and the air inlet manifolds. The temperature of the air compressed by the turbocharger increases during this process. The density of the air whose temperature increases due to compression, friction etc. decreases. Increasing the density of the combustion air will increase combustion efficiency. Hence, the temperature of the air should be lowered prior to channelling within the cylinder. The increase in density of the cooling air will lead to an increase in weight of the charge air of the system, which in turn leads to an increase in engine efficiency and in power production capacity. The basic function of charge air coolers is to facilitate the specified cooling function.

The growing emphasis placed on the environmental approach in our day has a substantial impact on legislations addressing control of emissions. This has a bearing particularly on diesel engine applications and the lowering of NO_x levels is becoming ever more crucial.

Charge air coolers, as well as increasing engine efficiency and power also enable lower NO_x levels. Many methods have been developed for reducing NO_x levels and increasing the efficiency of combustion. Placing a cooler for charge air is one method. Lower charge air temperatures lead to lower temperatures for combustion gases and in turn lower NO_x emissions.

2. TYPES OF CHARGE AIR COOLERS:

Charge air coolers are basically manufactured in two types: “Air – Air” (where the first and second fluid is air) and “Water – Air” (where the primary fluid is air and the secondary fluid is water).

Water-air heat exchangers where the primary fluid is air and the secondary is water are manufactured in two main designs which are the finned block and the shell and tube designs.

Figure 1 Some examples of finned block coolers:

(Figure 2) A Typical shell and tube cooler

3. PROPERTIES AND APPLICATIONS OF CHARGE AIR COOLERS:

High capacity Water – Air charge air coolers are widely used particularly in diesel engines found in ships and power plants. (The intercoolers and gas turbine charge air coolers widely used in the automotive field will not be mentioned herewith.)

In diesel engines, charge air coolers are placed between the turbocharger which provides a greater supply of combustion air by air compression and the air intake manifolds.

According to IACS (The International Association of Classification Societies) M 28 ambient air temperature and seawater are taken as 45°C 32 respectively. These figures are observed in tropical ambient conditions. (If feeding is done from a central cooling unit, the water inlet temperature is taken as 36°C.)

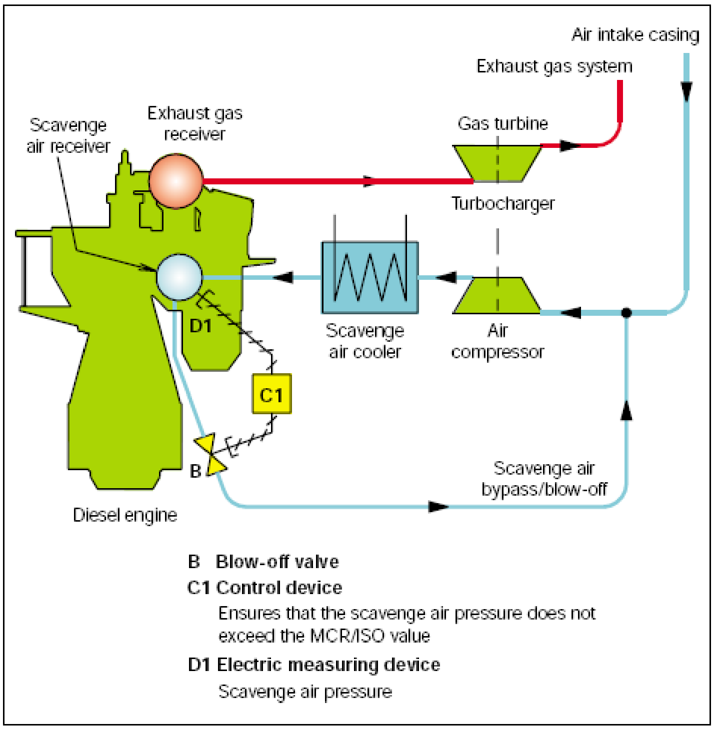


Figure -3 Schematic showing the placement of the Charge Air Cooler

In engine rooms where engines and auxiliary machines are operated, air feeding is done by a ventilation system. Ventilation blowing channels are usually placed close to Turbochargers. For this reason, the inlet air temperature is normally lower than engine room temperature. (The design condition for engine room equipment is 55 °C.) In applications the turbocharger inlet temperature is taken between + 45 °C / -10 °C. In low ambient temperatures, a pre-cooler must be placed on the inlet air.

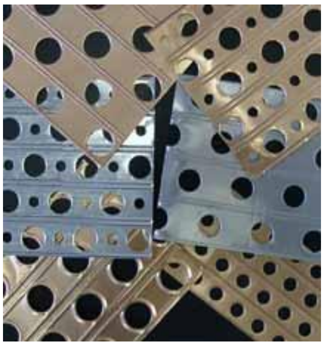
In most applications, the cooling water is obtained from the sea or a central water cooling unit. Since coolers operate under high temperatures and with sea water, the construction and materials used must be selected from high quality materials capable of withstanding the severe conditions.

Typically a charge air cooler cools the air at high speed from 200°C down to 45°C. It is important to achieve the capacity required at high speed. Special high speed and high pressure coolers operating under even higher turbocharger outlet temperatures are also used.

It should be considered that damaged or leaking cooler will cause power loss, increase emissions and fuel consumption and will damage the engine by increasing exhaust temperature; also it should be considered that charge air coolers causing pressure losses above the engine's design specifications will engender problems in the engine at high speeds.

Main materials of Finned Block Charge Air Coolers:

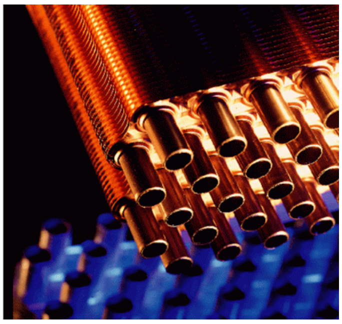
Fins:



Many materials and forms for fins can be used in charge air coolers depending on the place of application and operating temperature. Aluminum, Copper, Tin Plated Copper are commonly used materials. Most charge air coolers today, operate at temperatures below 250 °C - 300 °C. Since durability drops at temperatures higher than 150°C, Aluminum is not recommended as a material over this temperature. In uses above 150°C and on the whole, copper and tin plated copper is preferred.

(Figure-4)Various Fin Forms

Tubes:



In applications, Cu/Ni 90/10 (or the alternative 70/30 Cu Ni), Aluminum-Brass alloy is generally used as tube material. Applications involving stainless tubes are also found. While tube diameters vary with design, cylindrical pipes are the preferred form of tube. An efficient heat transfer between Tube and Fins requires excellent mechanical connection (firm contact between the Tube and fins). This process is handled hydro-mechanically in the Tube Blowing Machine. Tube thicknesses may vary depending on design specifications.

(Figure-5) Finned Block

Side-Middle mirrors and frame:

For applications, carbon steel and Rolled Naval Brass are widely used materials for side panels and middle mirrors respectively. Stainless steel can also be used for applications if desired. The construction must be well designed for the robustness and resistance to vibration of the unit.

(Figure-6)The cooling unit

Evaluation:

FRİTERM has been actively engaged in product development with the objective of meeting the requirements of the energy sector since 2001. Friterm which has experience on Turbine Charge Air Cooler units also runs product development on charge air coolers used for Diesel Engines and manufactures replacement coils or on demand finned block units of replacement coils. A decision has been made to invest in stainless steel tube coils has also been made.

REFERENCES

[1] ASHRAE Technical documents
[2] MAN B&W Technical document “Influence of Ambient Temperature conditions on main Engine Operation”
[3] Vestas air coil, AMI Exchangers Ltd., AKS Heat transfer, JM heat exchangers web pages
[4] Friterm A.Ş Technical Documents

BIOGRAPHY OF THE AUTHOR:

Hasan ACÜL was born in Ayvalık in 1976. He graduated from the Mechanical Engineering Department of the Yıldız Technical University in 1999. Before and after completing his major degree, he worked in engineering capacity in sales, field office, production and R&D departments of various firms operating in the Heating, Cooling and Air Conditioning sectors. He is currently employed by FRİTERM A.Ş. as the Department Head of Research and Development; continues his postgraduate studies in Science and Technology Strategies at the Gebze Institute of High Technology and is a member of the board of directors for the Kartal district division of the Chamber of Mechanical Engineers. Hasan Acül is married and has one daughter.