USING OF WASTE HEAT OF INTERNAL COMBUSTION ENGINES

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Abstract: *Article discusses about the use of heat exchangers for stationary combustion engines and cogeneration units. The paper is dedicated to the problem of unused thermal energy in stationary engines. It analyzes possibilities of accumulation of heat energy and its possible application in various fields. The paper deals with the classification of heat exchangers and with the subsequent description of design solutions of heat exchangers types used in given field.*
Keywords: HEAT EXCHANGERS, COGENERATION UNITS, WASTE HEAT, COMBUSTION ENGINES, UNUSED ENERGY

1. Introduction

Nowadays if we omit alternating economic crisis. We can talk about ecological time. Political thinking towards just environmental but also economical, gives new insight into the lifestyle and comfort of man. A great impact just on these aspects has energetic. It is due to the increasing energy demands of human society, on which depends in no small measure the environmental burden and efficiency of energy use.

Possibility how to reduce energy consumption, is the way of savings. Reduction in fuel consumption can be utilized in a direction, which deals with the production of several types of energy, and possibly also of the products from the primary source at the same time. To this category can include cogeneration, trigeneration and polygeneration. Find a use for the heat is not as easy as in the case of electrical energy. But nevertheless is being offered several options, such as use of heat for hot water or direct water heating and its subsequent use for houses or large objects, depending on the performance of the cogeneration unit itself. Another option would be to use the absorption unit to transform heat to cold, making it possible to extend services to the production of cold water, for example for supply of air conditioners.

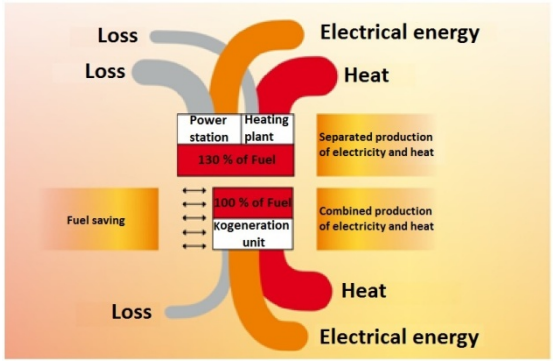

Fig. 1 *Cogeneration principle*

For all these systems the energy transformation is decisive the method how to submit it. For this intention in case of heat is used inseparable part of most of the systems which is called the thermal coupling node. Thereby may be various types of heat exchangers, coolers, condensers etc. The most common devices nowadays belong heat exchangers. In this case, for the generation of thermal energy from the exhaust gas and its subsequent use in other applications.

2. Use of heat exchangers in cogeneration units and stationary internal combustion engines.

For use of stationary internal combustion engine to generate electricity, or in other applications, arises a waste heat [1]. In most cases, this heat is not used in any way, but today´s time more and more forcing producers and consumers to invest in technology that can leverage the potential of unused energy and contribute to cost saving. To this end has started to use exhaust gas heat exchangers. An exhaust heat exchanger is positioned on the exhaust pipe, removing heat flue gases, which could then be used for various applications.

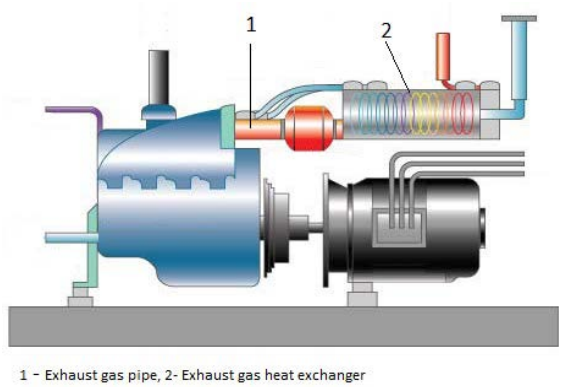

Fig. 2 *Position of exhaust gas exchanger in stationary combustion engine*

Exhaust gas temperature at the start of the exhaust pipe is in the range 500-700 ° C. This means that the exhaust gases offer a great potential for utilization of waste heat. The exhaust gases in the most of cases heat up liquid, which can subsequently be used in several ways.

3. Use of thermal energy from stationary engines

Possibilities of using waste heat are several. The most common include heating domestic hot water and heating. Smaller stationary engines can cover claims of houses alternatively smaller buildings. Using the largest units with up to 2 MW, or combining multiple units into a single source of energy can cover demands for heating and DHW for larger building or complex of several buildings.

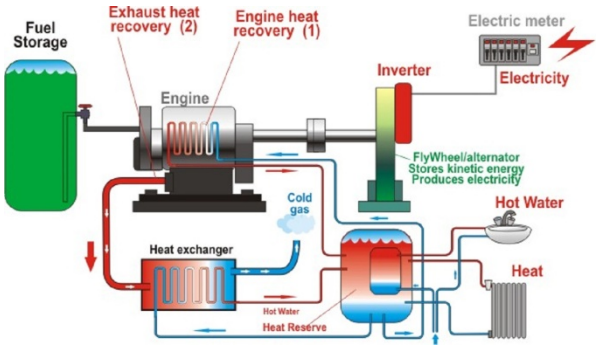

Fig. 3 *Cogeneration unit with supply of heating water and hot domestic water*

A further possibility is the use of waste heat to accumulate in the storage tanks, and its subsequent use, if needs. In the Nordic countries, the use of waste heat necessary to ensure of the right engine function. Heat is used for heating of intake air and in a case of engine shutdown for maintaining the operating temperature for the purpose to avoid cold starts. With the similar principle is already dealing automakers like BMW with their technology Efficient Dynamics. Automakers already knows for a long time, that the heating of combustion engine in winter requires more fuel and the engine also produces larger amounts of emissions. Thus the engine is warmer, thus there is less friction and decreases consumption and CO2 emissions [2]. BMW engineers have calculated that the warmed engine after start in the winter consumes about 10% less fuel than a cold engine.

The heat exchanger which heats the fluids and shortens warm-up phase of the engine is already commonly used in gasoline engines. The faster the heated oil in the gearbox and the engine is at operating temperature, the lower the energy losses by friction and fuel consumption. For diesel engines, BMW sees the potential saving in heating the interior. Modern units are already so efficient that the waste heat from them is unable to heat cabin. Therefore, in vehicles with diesel engines is started mounted auxiliary electric heater with 1000 W power, which in winter increases fuel consumption by an average of 1 l per 100 km. In this regard can help heated interior by heat exchanger. Attachments electric heaters will thus become superfluous. The heat exchanger, like in gasoline engines may also participate in faster heating of diesel engine to operating temperature.

4. *Heat exchanger*

Device used for targeted transfer heat energy from the one heat medium to another one, according to the second law of thermodynamics, is called a heat exchanger [3]. These facilities include a large group and can be found in many sorts of systems without us realizing it. According to the purpose and primarily according to the action, which takes place in the heat exchanger can be divided into the condensers, evaporators, coolers, regenerative heat exchangers etc. Another division is quite normal according to the method of heat transfer, ie whether there is contact between the media etc.

Heat exchangers are divided into:

- Recuperative - media are separated by a solid impermeable wall and not coming into contact
- Regenerative - occurs periodically substituted flow heating and cooling media in the defined area.
- Contact - media come together for some time in contact without chemical reaction, and then are separated.
- Mixing - media are in a certain place mixed and continuing as a mixture.

The most commonly used type of heat exchanger is recuperative. This group primarily include tubular and plate heat exchanger. From the point of view flow is the most common counter-flow design, which results in better heat distribution than in parallel flow design.

• *Tube heat exchanger*

In this type of exchanger, heat exchange takes place between the tube and the tubular-space. Tubular space normally consists of pipes or tubes of circular cross section, but we can meet with cross-sections of other shapes such as oval, square etc. To reduce the dimensional parameters of tubular exchangers can use all sorts of ways to increase the area of the pipe from the side of the pipe as well as the tubular space. For this purpose are used, for example ribs.

Tube heat exchangers can be divided according to the construction on:

- With shaped tubes
- With straight pipes
  - Tube in tube
  - Tube in the shell

Design with shaped tubes represent different tube axis arranged in the shape of a helix, spiral etc., located in the shell.

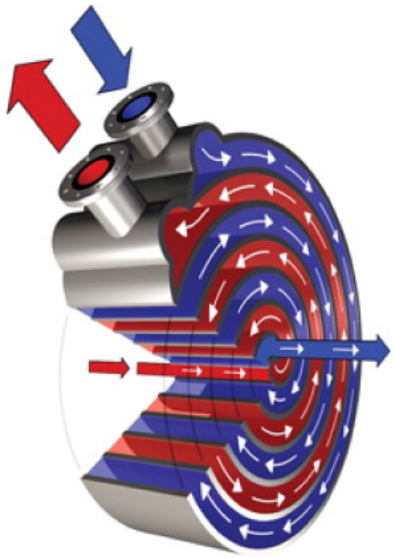

Fig. 4 *Spiral tube heat exchanger*

Exchangers in design tube in tube are among the simplest device in the above category. It´s occurred like dismountable and non-dismountable which are exclusively for pure thermal media.

Fig. 5 *Shell & tube heat exchanger*

In general the tube exchanger with jacket is the most commonly used heat exchanger , where the main structure consists of a tube bundle placed in the shell of a cylindrical shape. These exchangers are manufactured at many different versions, depending on the configuration of inlet and outlet orifices, pipes, construction attachment of different thermal dilatation of tubes and plastics etc. This type of heat exchanger typically includes partitions that perform two basic functions. Aretation of tubes resulting in a reduction of bending and vibration and also primarily direct the flow of media that is purposely altered to the cross-flow that increase the intensity of heat transfer. The system also has the disadvantage that, with the inclusion of partitions create higher pressure drop.

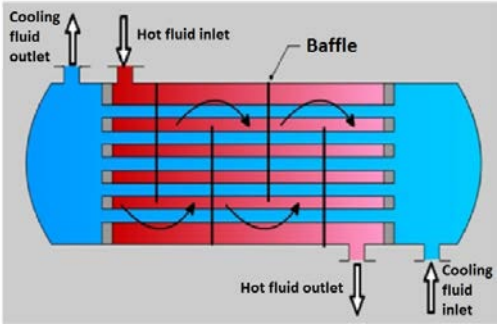

Fig. 6 *Tube heat exchanger with baffles*

Tube heat exchangers are characterized by good heat resistance and affordable price. However, their disadvantages are small compactness and high weight. The case of the pipes with small diameter, in which is the aqueous medium dirty it´s expected gradual decrease of the cross-section pipe up to its complete clogging.

Fig. 7 *Real construction of tube heat exchanger with baffles*

- ***Plate heat exchanger***

Plate heat exchangers are based on a patent that has already been registered in 1878 by German inventor Albrecht Dracke. This principle, when one liquid cooling another liquid and liquids are flowing on both sides of group thin metal plates , became the basis for the construction of the heat exchanger - commercial plate pasteurizer Alfa Laval.

For more than 130 years was plate heat exchangers developed and structurally modified to devices that are used in thousands of different applications in all industries. Plate heat exchanger was previously designed for heating and cooling of the milk, but now is commonly used for heating and cooling in industrial processes and it is the basis of air-conditioning in buildings or it provides heating of hot water for hundreds of millions of people.

This type of heat exchanger is characterized with a row lying plates which bear shaped reinforcements create turbulence of heat transfer medium and enlarge the heat-conveying surface. The heat transfer medium, as shown in the figure flows between the slabs of small thickness, whereby the heat is transmitted between substances mainly convective. Plate heat exchangers can be sorted into dismountable and non-dismountable. Non-dismountable exchangers are usually occur in the brazing or welding design, which can also be used in case of the aggressive heat transfer medium. For plate heat exchangers is a clear advantage of their higher performance per unit area, therefore low weight and small size which is for the same performance about 5 times smaller than in tubular heat exchangers. However, the benefits are offset by higher prices and demanding production technology.

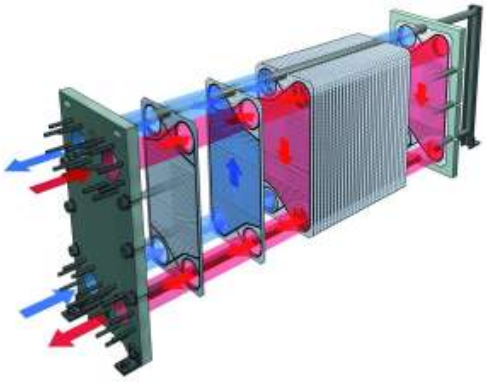

Fig. 8 *Plate heat exchanger*

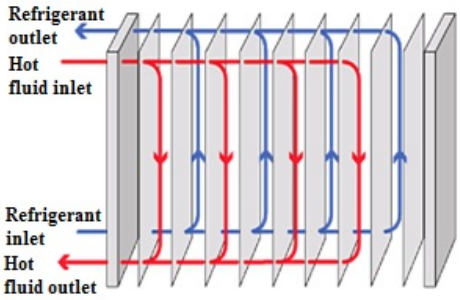

Fig. 9 *Fluid flow in plate heat exchanger*

5. Conclusion

Nowadays, everyone looking for ways to save the largest amount of funds. Hence arise technology with which we can use energy from waste heat for other applications. Exhaust gas heat exchangers are increasingly appearing in conjunction with stationary combustion engines and automotive industries. Use of this technology to many manufacturers interesting solution as fuel economy and reduce emissions. The rate of fuel savings and overall efficiency of the plant will require yet another survey, which I will dedicate next steps in my work.

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