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UTILIZATION OF GAS HEAT PUMPS FOR HEATING AND AIR CONDITIONING IN SMALL AND MEDIUM SIZED ENTERPRISES

9.1 INTRODUCTION

Small and medium sized enterprises (SMEs) have seriously varying demands for heating and/or cooling necessary for their proper operation. Some of them have demand comparable with large-scale production plants. Although technologies applied by them can't always be the same due to e.g. lack of space, infrastructure etc., use of innovative methods to meet demands can be based on various new technologies, among which the VRF (VRF – Variable Refrigerant Flow) gas heat pump is of great importance.

SME sector has been highlighted by the European Union as very important for economy, which is reflected in the EU regional development policy as well as in Small Business Act for Europe [4]. SME sector is the base of all modern European economies [8]. Its role is visible through influence on European regional economy, thus actions of authorities in favor of inspiring and supporting development of SMEs should be an answer to requirements of this sector.

Contribution of the SME sector to the GDP of Poland is significant. In terms of structure of the enterprise input, SMEs generate every other zloty (47.3%), whereas the smallest companies account for nearly every third zloty (29.4%) generated. The share of medium-sized enterprises is three times smaller (10.1%) as compared to microenterprises, and the contribution of small enterprises is nearly four times lower (7.8%) [7].

For this reason, promotion of innovative methods in this sector ought to be of enormous importance for their further development. Nevertheless, generation of electricity and thermal energy in Poland is presently based in over 93% on hard and brown coal. What's more, energy intensity per capita is very high and will probably result in an increase of energy consumption in power and heat production in the near future [3]. Therefore it is necessary to diversify sources of primary energy in favor of natural gas. These assumptions are part of energy and environment policy of Poland as well as European Union [1, 2, 6, 9]. Following from these assumptions, major infrastructural investments are planned for better accessibility to natural gas and increase of its share in final energy production.

In the office buildings, hotels and similar facilities now under construction, air conditioning becomes a standard, and it is common, that such buildings have independent heating, air conditioning and ventilation systems, that are driven by electricity. Necessity of air conditioning during daytime in the summer increases peak load. Such high demand for electricity requires operation of more generation units and also gives increase to the air pollution.

Similar situation of peaks in consumption of electricity took place in 1980s in Japan and was connected to strong economic growth, causing a rise in energy use. For this reason, Japanese Government has ordered and financed scientific program with goal of developing new solutions allowing production of the required amount of heating/ cooling energy, associated with reduction of both electricity consumption and pollution of natural environment. In few years, such a new technology has been developed – Gas Heat Pumps (GHP), relying on the use of gas-driven engine in heat pump system working in Variable Refrigerant Flow (VRF) mode. Gas heat pumps allow combining heating and cooling as well as hot water production in a single installation using natural gas or LPG, which reduced electricity consumption in peak hours. In addition, the design, construction and operation costs of heating and air-conditioning systems were reduced.

9.2 GAS HEAT PUMP TECHNOLOGY BY GHP AISIN

Developed by AISIN Group, the GHP technology involves the use of an internal combustion engine fueled by gas to drive the compressor unit working in the high-performance heat pump system with variable refrigerant flow (VRF). The heat produced by the engine is used in this system as a source of supply of the heat pump cycle in the heating mode, while in the cooling mode it allows to eliminate the losses associated with the process of defrosting the evaporator, that occur in traditional electrical heat pump systems. The internal combustion engine applied in the GHP AISIN technology differs from the constructions used in the automotive industry. It was designed at the TOYOTA Research and Development Center specifically for use in the GHP AISIN gas heat pumps. This engine works in the Miller cycle, which is characterized by a shortened compression stroke and lower compression pressure, and thus lower temperature. This design allows for a significant increase in engine performance and a reduction in NO_x emissions, compared with traditional Otto cycle internal combustion engine. AISIN GHP engine can be powered by natural gas or LPG. High efficiency of this heat pump system is in addition increased through the use of engine speed modulation and electromagnetic clutches for compressors, depending on the current system load. In the GHP AISIN heat pump uses the R410A refrigerant of the latest generation, which allows for the most effective liquefaction and evaporation in the heating and refrigeration cycle.

9.3 OPERATING IN HEATING MODE

During operation of the heat pump in heating mode the refrigerant R410A is heated using the heat from the cooling system of the internal combustion engine, which in this case acts as a lower source of heat, if compared with traditional systems

of ground-source heat pumps. When R410A refrigerant is heated, it evaporates, and the vapors of low performance go to the compressor, where they are compressed and their temperature rises. Heated and compressed, the refrigerant goes to the internal unit, where heat is transferred into the room, followed by its condensation. The refrigerant then goes back to external units, where it is heated using the heat of the engine, evaporates and goes to the compressor, and then repeats the entire cycle. The principle of operation of gas heat pump GHP AISIN in heating mode is presented in Figure 9.1.

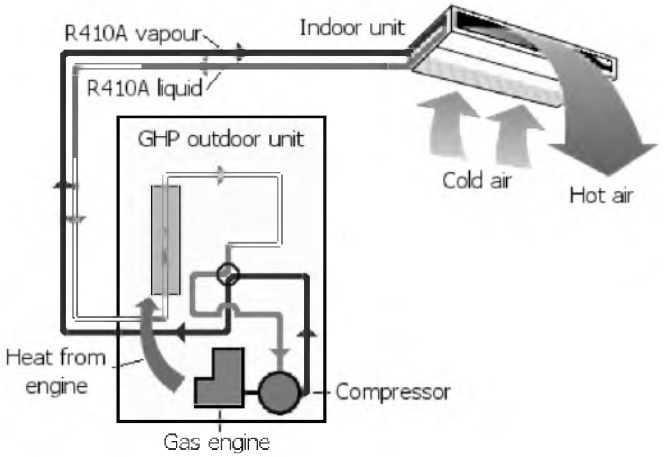

Fig. 9.1 Operation principle of gas heat pump GHP AISIN in heating mode

9.4 OPERATION IN COOLING MODE

During operation in cooling mode, heat pump refrigerant R410A goes to the internal units, where it is vaporized and at the same time picks up heat from the air conditioned spaces, so that the vapor of low performance goes to the compressor.

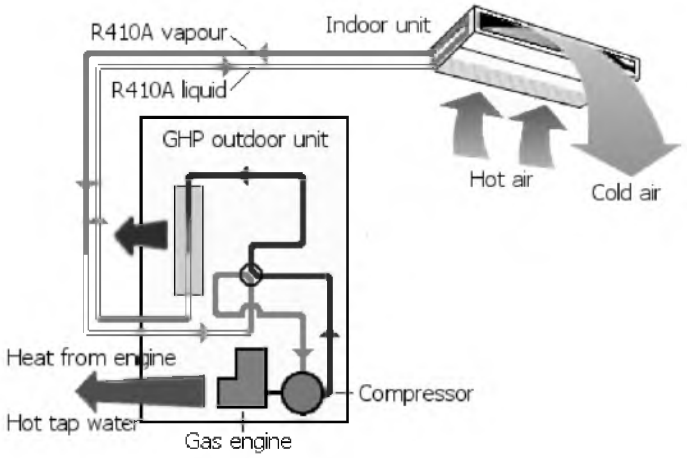

Fig. 9.2 Operation principle of gas heat pump GHP AISIN in cooling mode

Compressed refrigerant goes to the heat exchanger, where it is condensing and putting heat into the ambient temperature outside the building. Liquefied refrigerant then goes back to the internal units, where it evaporates, and the entire cycle is repeated. The heat, generated by the engine in this mode, can be used for production of domestic hot water. The principle of operation of gas heat pump GHP AISIN in cooling mode has been presented in Figure 9.2.

9.5 REDUCTION IN ENERGY CONSUMPTION AND OPERATING COSTS

Application of gas internal combustion engine in the heat pump GHP AISIN allows to get a specific thermal power/cooling, passed into the building at a lower cost in comparison with electric heat pumps EHP.

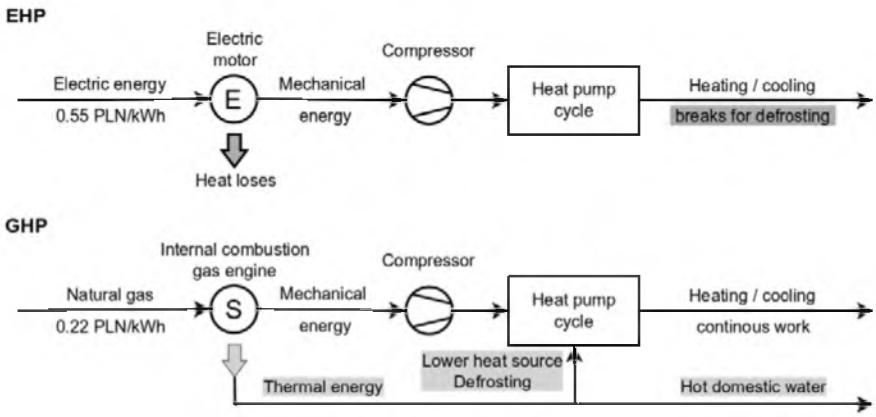

Fig. 9.3 Energy utilization in electric (EHP) and gas (GHP) heat pump systems

Cost of electricity (0.5 PLN/kWh) is greater than the cost of energy obtained from burning gas (0.18PLN/kWh). Therefore, if the energy contained in the gas is delivered to the process in which it is effectively transformed into heat/cooling, it is possible to obtain significant savings in operating costs. Such a highly-efficient gas fuel conversion into useful energy takes place in the GHP devices, where it is used in addition to heat from the cooling system of internal combustion engine and the heat contained in combustion gases (Fig. 9.3). That system allows to reduce operating costs up to 40%, compared to traditional technologies.

9.6 WORK WITHOUT INTERRUPTION FOR DEFROSTING

Because of the use of heat from the cooling system of the internal combustion engine, GHP AISIN does not require work in the reverse flow of the refrigerant (required for the necessary defrosting and proper operation), as it is in the case of electric heat pump EHP (Fig. 9.4).

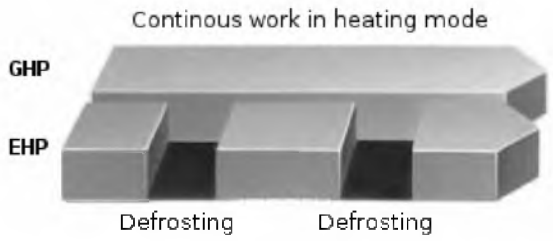

Fig. 9.4 Difference in continuity of operation for gas (GHP) and electric (EHP) heat pumps in heating mode

In addition, TOYOTA high efficiency gas combustion engine allows for very rapid heating of the premises, even at the lowest outside temperatures.

9.7 ENVIRONMENTALLY-FRIENDLY TECHNOLOGY

Application of GHP AISIN devices in HVAC systems means reducing the amount of primary fuel, that must be used to produce a given quantity of energy required to ensure thermal comfort inside the building. Natural gas is the cleanest source of energy currently used in the combustion process, because of the high calorific value of natural gas and LPG as well as the composition of exhaust gases, compared to the pollution caused by burning coal in conventional power plants if one takes into account the entire cycle of generating electricity in the power plant fueled with coal together with the transmission of this energy to the end user. When the later is compared with the installation of GHP AISIN, where clean burning process of gas is carried out directly to the place of use of the generated energy, the volume of CO_2 emissions into the atmosphere in the AISIN GHP technologies is nearly 50% less than in traditional technology.

High gas utilization efficiency (GUE) of the AISIN GHP technology means that this solution is very effective and allows to reduce primary energy demanded by building for heating/cooling and leads to reduction of greenhouse gas emissions, The R410A refrigerant, applied within the GHP AISIN, is characterized by close to zero impact on the ozone layer and is recognized as the best for use in air conditioning systems. Reduction in energy consumption and CO_2 emissions and the use of R410A refrigerant also allow to apply for a very favorable loan for the purchase of gas technology for the protection of the environment, financed by the National and Regional Environmental Protection Funds.

9.8 LONG LASTING OF GHP AISIN DEVICES

GHP AISIN devices are made in Japan in factories of AISIN, which is part of TOYOTA Group. Excellent quality of their parts and precision of manufacturing and assembling assure their durability and reliability. Special construction of gas engines allows for many years of performance at a minimal costs of maintenance. Exchange of spark-plugs, wedge-belts and motor oil top-up is usually required after 5 years of operation or every 10000 hours of running time, while oil exchange needs to be done once for 15 years. Quality of workmanship in gas heat pumps GHP AISIN ensures continuous operation of installations and significantly reduces maintenance costs.

9.9 APPLICATIONS

Because of different power outputs of external GHP AISIN units (which can be joined into the larger groups) and possibility to utilize the gained heating/cooling energy in different arrangement of internal units and ventilation switchboards (Dx, AWS, AHU, HWK), GHP systems can be used in a broad scope of investments. Among the most common uses of GHP AISIN the following locations should be pointed out:

- hotels,
- banks,
- office buildings,
- car showrooms,

- research institutes,
- apartment buildings,
- entertainment centers,
- hospitals,
- schools,
- small- and medium-sized manufacturing plants.

CONCLUSIONS

Structure of primary sources of energy in Poland, where hard coal is a major energy resource, shows a need for development of modern, high-productive gas technologies. This is important for reduction of natural resources consumption as well as for natural environment protection. This problem is most important in small- and medium-sized enterprises (SMEs), for which energy management decides about development prospects. Diversity of energy management in such enterprises depends on their scope of activity, access to energy carriers and energy policy. For this reason, implementation of up-to-date methods of energy supply should be very important for SME development.

GHP AISIN gas heat pumps technology is an example of such highly-efficient primary energy conversion from gas to useful heating/cooling energy, and delivering them directly to the designed facility. GHP AISIN gas heat pumps technology, which is now available in Poland, is complete from both technique as well as technological point of view and is, at present, the most efficient solution for broad scope of uses in places, where demand for heating, air conditioning and domestic hot water exists.

Solutions used in GHP AISIN technology provides many benefits, which are visible at every stage of investment completion:

- design:
  - demand for one only project for both heating and air-conditioning,
  - reduction in piping required,
  - grouping of equipment in one location (roof or next to the building)
  - greatly reduced or even no need for boiler room,
  - possibility to use different system of supplying the building with energy (Dx, AWS, air system or their combination),
  - possibility of using the hot water produced in HWK system in a capacity, that allows to abandon alternative energy sources, such as solar panels;
  - option to join units into bigger systems,
  - high quality of design from the architectural point of view;
- installation:
  - reduction in labor and material costs due to only one installation being necessary for heating, air-conditioning and hot water production,
  - easiness of assembly of the GHP equipment, piping and internal collectors,
  - no need for additional ground works, necessary in ground-coupled heat pump systems,

- simplification of work management of media distribution from a single source;

- use:
  - reduction of energy consumption,
  - reduction of gaseous emissions to the atmosphere,
  - convenient and self-induced use of heat and/or cold generated in the system,
  - suitable control of internal collectors and of the entire system,
  - high durability and reliability of GHP installations,
  - possible extended warranty (up to 5 years),
  - possibility of connecting GHP system to remote monitoring and visualization of working parameters and conditions.

In the next few years, large number of ongoing as well as planned investments in Poland, will cause an increased energy demand for heating, air-conditioning and ventilation. Taking into account the limitation in electricity supply for newly-designed buildings, it seems necessary to consider implementation of new technologies, efficiently converting accessible sources of primary energy. This shows the profit from using gas heat pump technology GHP. Furthermore, also the energy priorities of both the European Union and Poland are an argument showing the possible broad scope of use and development of GHP technology, which is a very attractive solution when compared to those currently in use.

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UTILIZATION OF GAS HEAT PUMPS FOR HEATING AND AIR CONDITIONING IN SMALL AND MEDIUM SIZED ENTERPRISES

Abstract: *In the article, an innovative method of space heating and cooling in small and medium sized enterprises is presented. Principles of the gas heat pump technology (GHP), its advantages and influence, limiting the impact on the natural environment, as well as decreasing primary fuel resources and reducing costs of using the energy in enterprises are discussed. Various types of locations, where presented technology gives results, are indicated.*

Key words: *Space heating and cooling, gas heat pumps, natural environment, energy management, SME, GHP*

INNOWACYJNA METODA ZAOPATRYWANIA MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTW PRODUKCYJNYCH W CIEPŁO I ENERGIĘ ELEKTRYCZNĄ

Streszczenie: *W artykule przedstawiono innowacyjną metodę zaopatrywania w energię cieplną i elektryczną małych i średnich przedsiębiorstw. Omówiono zasady mikrokogeneracji gazowej MCHP XRGI, jej zalety, wpływ na ograniczenie oddziaływania na środowisko naturalne oraz ograniczenie kosztów użytkowania energii w przedsiębiorstwach. Przedstawiono również instrumenty wsparcia dla inwestorów oraz użytkowników instalacji z wykorzystaniem MCHP XRGI.*

Słowa kluczowe: *Energia cieplna, energia elektryczna, mikrokogeneracja, środowisko naturalne, gospodarka energią, ŚMP, MCHP XRGI, instrumenty wsparcia*

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