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Waste Heat Used for Heating Instead of Natural Gas

Technical paper

In beverage industry, due to the necessary cooling of water and soft drinks for further carbonization during production, there is releasing of freon condenzation heat on cooling compressors (chillers). Amount of heat gained on a such way is so abundant that there is real potential for further use in several ways.
Here is described use of that waste heat made by condenzation of freon for heating of water, which has been used as a working fluid in a low-temperature system, of 40/50 type, for ambient heating, as opposite to the current usual hot-water distribution system, of 90/70 type, and belonging fittings. The very process of heat convection on the ambiental air has ben done through channel climate units, which are used in summertime for air conditioning of the same ambiental space.
Natural gas yearly consumption was lowered for € 13.000 using this energy efficient system (total heat recovery), and return on investment is under five years, according to complete project value of € 350.000.

Key words: *energy source, waste heat, energy efficiency, energy renewal, industry, total heat recovery*

Introduction

Today, energy needed to compensate the heat losses during heating season most commonly derives from combustion of fossil fuels in boiler houses and power plants, and by its further transformation into warmth delivered further to heating bodies, whereby a certain space is heated up to the required conditions of comfort.

As fossil fuels are non-renewable in their nature, the question is raised on their substitution by other sources that could be used as energy source for heating space at a required time.

In industrial plants for the production of carbonated mineral water and carbonated drinks, due to the technological process of cooling mineral water and drinks for further carbonization, heat generated by freon's condensation is inexorably rejected from chillers. Heat, being one of the media in energy transformation in the left-hand cycle, is found in large amounts that can be recovered for certain purposes.

One of these is heating of water, as a heat carrier, which can be used as a work fluid in low-temperature heating systems of facilities or working areas.

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Company energy situation

In the plant of company "Knjaz Miloš" in Arandjelovac, Serbia, natural gas is the main energy source for producing heat energy. Heat energy obtained by its combustion is consumed for two essential purposes:

– for creating and maintaining the technological processes in the factory, and
– for heating the facilities and rooms for a variety of purposes.

Technological processes proceed throughout the entire year and in this case do not demonstrate any dependence on season or time of day, while consumption of gas for heating is determined by duration of the heating season, *i. e.* current climate demands, where the plant and accompanying facilities are situated.

The structure of gas consumption (2,052,691 m^3) in 2008 is (presented by fig. 1):

– technological needs: 1,297,024 m^3 (63%), and
– heating: 755,667 m^3 (37%).

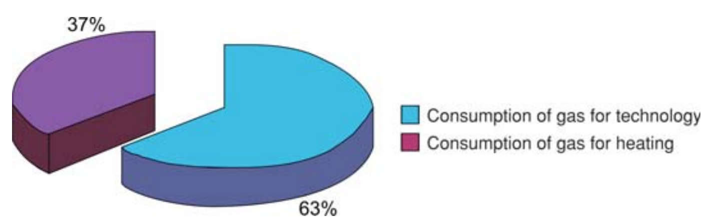

Figure 1. Share in gas consumption in 2008

In terms of money, natural gas costs in 2008 amounted to 56,810,037.62 RSD, or by annual mean rate of exchange of 81.43 RSD to one Euro: 697,654.89 €.

The structure of gas consumption per location within the plant in 2008 (fig. 2):

– Warehouse	113,350 m^3, (6-15%)	
– PET production	196,473 m^3, (10-26%)	69,765.49 €
– Glass & baloon production	151,133 m^3, (7-20%)	
– Glass 5 & glass syrup room	37,783 m^3, (2-5%)	13,953.10 €
– Flower growing plant	30,227 m^3, (1-4%)	
– Others	226,700 m^3, (11-30%)	
Together PET production with glass 5 & glass syrup room:		83,718.59 €

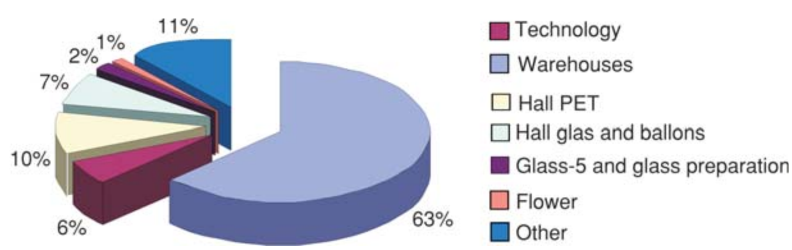

Figure 2. Structure of gas consumption in 2008
(full color figure is available in electronic version)

The structure of gas consumption (1,871,089 m^3) in 2009 is (fig. 3):
– technological needs: 1,280,985 m^3 (68%),
– heating: 590,104 m^3 (32%).

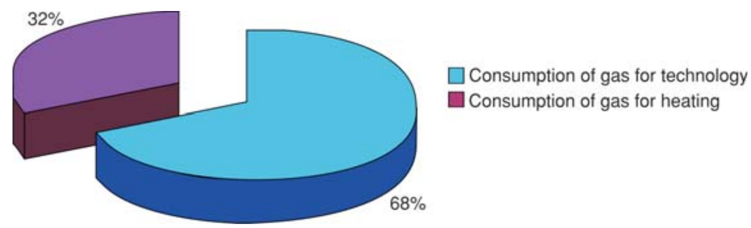

Figure 3. Share in gas consumption in 2009

In 2009 gas costs amounted to 58,461,010.91 RSD, or if calculated by mean annual exchange rate of 93.93 RSD to one Euro, it is 622,389.13 €.

The structure of gas consumption per location within the plant in 2009 (fig. 4):

– Warehouse	88,516 m^3, (5-15%)	
– PET production	153,427 m^3, (8-26%)	49,791.13 €
– Glass & baloon production	118,021 m^3, (6-20%)	
– Glass 5 & glass syrup room	29,505 m^3, (2-5%)	12,447.78 €
– Flower growing plant	23,604 m^3, (1-4%)	
– Others	177,031 m^3, (9-30%)	
Together PET production with glass 5 & glass syrup room:		62,238.91 €

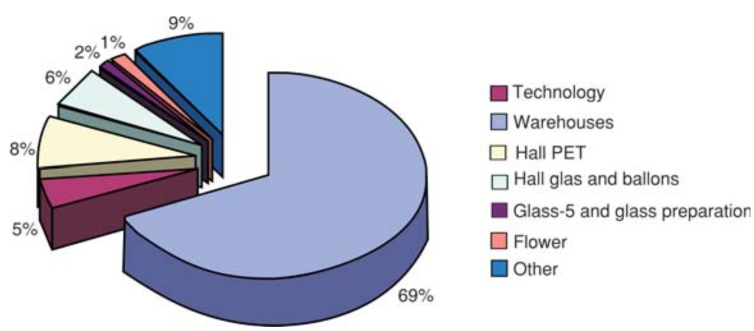

Figure 4. Structure of gas consumption in 2009
(full color figure is available in electronic version)

Production process

The production plants, *i. e.* lines, are supplied with mineral water from the wells located 400 m below the ground, where the average temperature of water is 340 °C, having value of 26 °C at the moment of its arrival to the plant through the pipeline.

A constituent part of one of numerous technological processes, which is the production of carbonated mineral water or carbonated refreshing drinks, is cooling of mineral water and soft drinks at acceptably low temperature to make the carbonization process stable. Taking into account a comparatively high water temperature for the observed process, it was necessary to perform cooling in two phases. The first is lowering the temperature from the mentioned 26 °C to 16 °C, and the second is further lowering the temperature.

The traditional method of lowering temperature uses standard cooling compressors, so-called chillers, where heat of the water or some other treated product is transmitted through the cycle itself in a chiller to the atmospheric air. It has been done via waste heat generated by freon condensation on the chiller condenser. This heat cannot be used any more.

Unlike the above-mentioned, the choice in this case were the cooling compressors that had the capacity of total energy recovery due to mounted heat exchangers "cooling fluid-water" on the condenser side. The aim was to carry out freon's condensation in the mentioned exchanger and to heat water in this way to the outlet temperature of about 50-55 °C. Due to the way of design and construction stated by the manufacturer of cooling machines, one portion of condensation heat still remains unused, and it is wasted out by the air used for cooling the condenser.

The idea of the project

The idea is to utilize waste heat from the chillers in a useful and acceptable way as a form of substitution for the existing sources of energy generated in some processes or treatments.

Simple measurements carried out in January 2006 in one Belgrade's company, indicated that at the outside air temperature of –10 °C the thermometer placed in the outlet air flow at 700 mm above the fan located on the condenser top, shows the temperature of +18 °C. This was one of the prime movers for this project.

That was the guiding thought in decision-making on the purchase of accessory cooling capacities, because cooling compressors, existed in that time, did not possess the option for total heat energy recovery, hence this was a winning solution. Namely, it is obvious that a large amount of hot air is rejected from cooling compressors as waste heat and goes into the atmosphere, so the problem posed was how it was possible to use that heat.

The characteristics of chosen cooling compressors are such that, apart from the basic function of cooling, they deliver the total of 880 kW of energy in the temperature regime 40-50 °C at outside air temperature of –15 °C.

Perception of the plant's needs for heat energy led to conclusion that the most expedient solution would be to use the mentioned heat obtained from freon's condensation, for heating production lines "PET 1", "PET 4", "PET 2", "PET 3", and "Cans", because they are situated in a unique and indivisible common area of 5000 m^2. The idea was to use for that purpose channel air-conditioning units anticipated for low-temperature regime. The advantage of such a choice is that by using identical units of identical infrastructure, the same area could be air-conditioned during the summer regime of operation.

On the other hand, the most modern section of the plant – production lines "Glass 5" and "Glass Syrup Room" – are situated on the opposite end of the plant having already installed accessory heating system via channel air-conditioning units required for heating the space in the low-temperature regime. These lines are the only production lines equipped with such type of heating/cooling system used for air-conditioning of space during summer, because of the character of the production technology applied due to high heat gains during filling very products.

However, the system applied in production lines Glass 5 and Glass syrup room uses classical hot water heating system of the 90/70 regime, like any plain industrial heater heating system, and its advantage comes to the fore actually out of the heating season when it is used for cooling the space.

The subject of the project

The subject of this project is making such installation that would enable use of waste heat recovery for heating the mentioned workshops "PET 1-4" and "Cans", because these five production lines are situated in the unique and inseparable air volume, *i. e.* in the same area, which represents an advantage in the realization of the heating project for this air volume.

Due to organizational and financial causes, the project is divided into three phases:

– *Phase 1* – building the heating substation at the so-called group of "water plant" chillers, where the first stage of water cooling is performed, from 26 to 16 °C, intended for receiving and further transport of warm water , as well as building the heating system, the so-called CIP, for washing and disinfection in the water plant itself;
– *Phase 2* – erecting of pipeline carrying bridge and mounting and installation of pipeline from the substation at the water plant to the main production building;
– *Phase 3* – installing the distributing substation, channel air-conditioning units for heating indoor space of production lines and belonging piping for hot water distribution.

Functional scheme of the water cooling system with the accessory total heat recovery system and the three anticipated phases of the project realization are shown in fig. 5.

Phase 1 was successfully completed. It was of importance to prove that there is a sufficient amount of heat, which eliminated all doubts about the project. Having substation installed, the heat was used to preheat the water for washing and sanitation. Here, a certain amount of energy was saved, because water temperature for CIP is 80-85°C, however, in this way the preparation water was constantly kept at 50 °C, whereby steam consumption was reduced to additional water heating from 50 to 80 °C, instead of being used over the entire temperature interval from 15-17 °C to 80 °C.

Phase 2 followed Phase 1, as a logical sequence of events, whereby the plant at water plant was physically connected with main production building itself. The piping of 150 meters in one way length was laid, with both distribution and return pipelines lined with thermal insulation.

The costs of the first two phases amounted to cca. 100,000 € realized within two years, because each phase was an item by itself in annual capital expenditures.

Phase 3 is the last, but the most expensive part of the project, for its anticipated price of 250,000 €. To realize this phase, apart from distributing substation and piping, it is necessary to install a new heating distribution system consisted of channel air-conditioning units that are used only in Glass 5 and Glass syrup room, in parallel with the existing plain heater heating system in the 90/70 regime which is used in the entire plant.

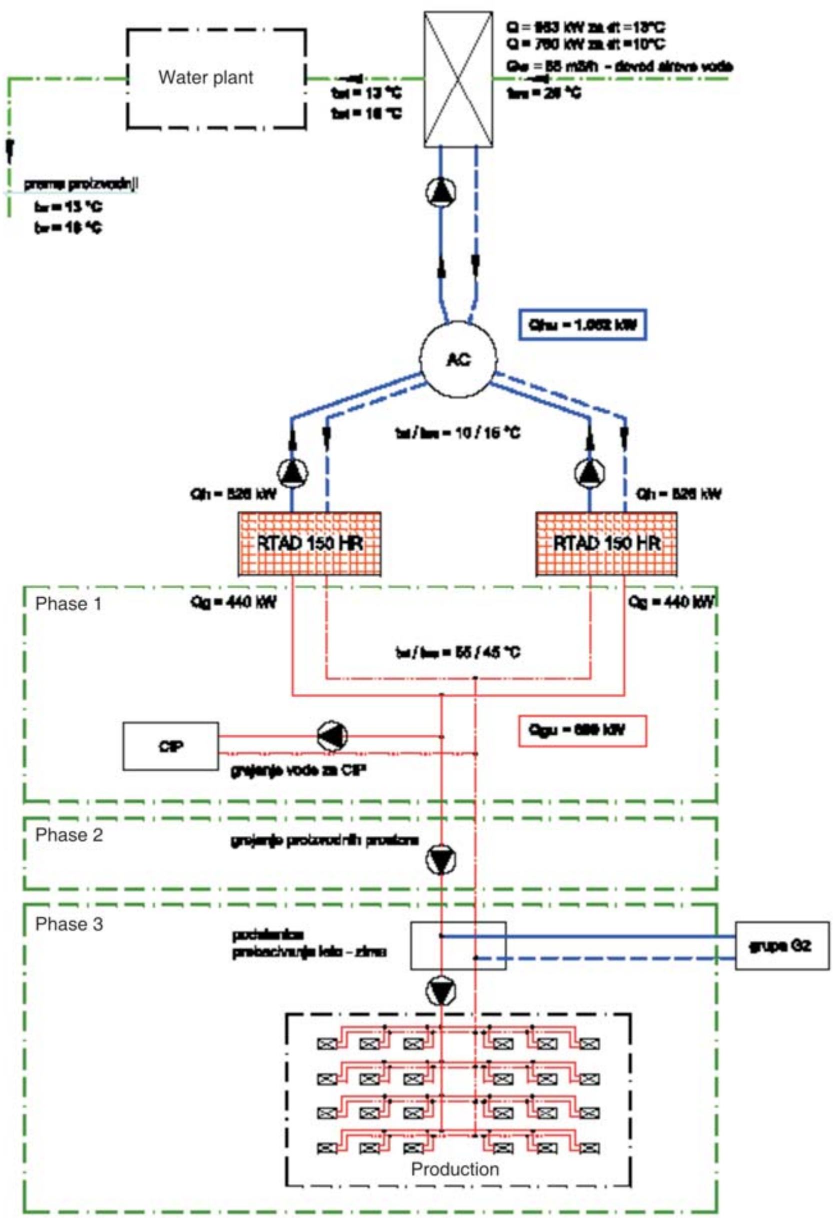

Figure 5. Functional scheme
(full color figure is available in electronic version)

Discussion

Present temporary economic crisis and reduction in investments have not frozen Phase 3 to the full, because there was found a solution to gain benefit from the project, and all this regarding the invested financial means.

Namely, at the end of hot water piping (that connects the substation at the water plant with main production building) and finishes inside the building, a valve junction point was built where is made its connection and junction, respectively, with a piping for cold water distribution that is used for cooling Glass 5 and Glass syrup room during summertime, and starts from a group of old-type cooling units, the so-called group "G2".

This way, during the heating season in winter, hot water is delivered to the mentioned two production lines through the same piping and the same channel air-conditioning units in identical way as anticipated by the original idea and for the production lines PET 1-4.

In the heating season 2010/2011, heating of the mentioned lines was exclusively performed in this way, whereby gas savings amounted to cca 13,000 €.

Conclusions

When the anticipated project costs (cca 350,000 €) are viewed and compared with average annual heating costs for production lines PET 1-4 together with Glass production lines (cca 73,000 €: in 2008 –83,718.59 € and in 2009 –62,238.91 €), the expected returning period of investment through gas price *i. e.* heating costs, is less than 5 years.

On expiration of the time period for investment return, it is realistic to expect that total annual gas consumption in the plant will decrease by 10% and the amount of gas needed for heating by 25%, respectively.

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Апстракт

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Коришћење отпадне топлоте за грејање уместо сагоревања природног гаса

У производној индустрији минералних вода и напитака, услед неопходног поступка хлађења производа због даље карбонизације, на расхладним компресорима долази до ослобађања отпадне топлоте услед кондензације фреона. Та количина топлоте је толика да се ствара могућност њеног коришћења у даље конкретне сврхе и за реалне намене.

У овом раду је описано коришћење те отпадне топлоте настале кондензацијом фреона за загревање воде која се употребљава као радни флуид у нискотемпературском систему типа 40/50 за грејање радних простора, за разлику од постојећег класичног topловодног развода типа 90/70 и његове припадајуће арматуре. Сам процес грејања обавља се преко каналских клима јединица, које се лети користе за климатизацију истог простора.

Годишња потрошња гаса за грејање је коришћењем овог енергетски ефикасног система смањена за 13.000 €, а процењено време повратка целокупне инвестиције (око 350.000 €) је испод пет година.

Кључне речи: *извор енергије, отпадна топлота, енергетска ефикасност, обнављање енергије, индустрија*

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