Techniques to Achieve Energy Efficient Heating Substation

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Abstract

Efficient use of energy raises the quality of our own environment and contributing to the global fight to combat climate change. Simply put, energy efficiency means a smaller amount of energy used for the same work - function (heating or cooling, lighting, producing variety of products, drive vehicles, etc.). It should be noted that energy efficiency can not be seen as energy savings, because savings are always entails certain sacrifices, while the efficient use of energy never distort the conditions of work and life. Furthermore, improving the efficiency of energy consumption not only involve the application of technical solutions, but also the existence of educated people who will know how to use it in the most efficient manner possible.

The paper presents what are the techniques for energy-efficient heating substations in relation to the use of devices that are integral parts of one heating substation. An analysis of thermal substation before and after the implementation of energy efficiency measures is presented. Techno-economic analysis of implementation of energy efficient heating substation was performed in terms of electric energy consumption, the costs of the old versions and new ones, and obtained data shows estimated savings at the example of a heating substation.

1 Introduction

Energy efficiency is the top priority for most people. However, what energy efficiency really involves and what the ways of saving energy can be applied is still quite unclear. For this reason, some companies are dealing with the energy savings, determined two approaches to energy efficiency including: passive energy efficiency, and greater extent active energy efficiency. From the point of view of active energy management it is not enough just to install energy-saving equipment, but they can be controlled and to use only as much energy as they need. This aspect of control is actually crucial to achieving maximum energy efficiency [1]-[3].

The term energy efficiency is used in various ways depending on the contest, and also depends on the person using the term. From the standpoint of the profession, energy efficiency is in relation to the energy input and the output of a process. This is a typical engineering approach when analyzing machines, motors, etc.

The energy efficiency of the electric motor is the ratio of mechanical input (work) and output electrical power. The values must be expressed in the same units such as kWh / day as a result, often dimensionless number, conventionally expressed as a percentage.

This approach is represented in industrial plants and buildings for a wide range of equipment including motors, pumps, compressors, electric stoves and water heaters. In many real situations, energy efficiency often has its alternate name. On a national or a higher level is often mentioned term energy intensity. The difference between energy efficiency and energy intensity is that changes in the sector, such as the transition from the production of one product to another, affect the energy intensity regardless of the change in the energy efficiency of the plant, machinery or processes that are involved in the production. There are many of the benefits of increased energy efficiency. They can generally be categorized as financial (economic), environmental and social. For private companies, the most significant benefits of implementing energy efficiency measures are directly related to the financial indicators in the form of lower operating costs. This refers to the typical manufacturing companies as well as suppliers of energy.

2 The concept and role of heat substations in heating system

According to the holder of the heat, district heating systems can be divided into hot water and steam systems. According to the type of consumer and their location they are divided into block heating systems with heat source in a separate facility or heating plant and the industrial and urban systems. Industrial remote systems satisfy needs of the technological processes in production. In addition to commonly used to supply heat to the settlement of prefabricated housing that is being built near industrial facilities. Supplying heat to entire cities, or at least large parts of them, called the system of the city or district heating.

Pipeline, which carries the fluid to the property, which is connected to the remote system, is a primary network. Piping from the substation to the end users and the radiator is a secondary network. Limit location of primary and secondary pipe networks are heat substations, where the primary carrier of heat has to be transformed according to needed of individual

consumers through a secondary network. Equipment compact heat substation consists of mechanical (thermal engineering) part and the power part [3] - [5].
Thermo-technical installation contains all the necessary elements required to operate the substation:

- heat exchanger (indirect connection with consumers),
- pressure regulator and relief valve (with direct connection of customers)
- electric control valve or combined valve,
- ultrasonic flow sensor (part of heat meters),
- catcher dirt and sump.
- circulation pump,
- court or expansion device to maintain pressure
- safety valve,
- sensor for measuring the pressure and temperature of the water

3 Measures to achieve energy efficient heating substation

With increasing awareness of the need for improving energy efficiency in the market have begun to appear different solutions that have found their use in district heating sector and thus also in heating substations. Some of these solutions are comprised in this paper, such as frequency converters, high efficiency electronic pumps, electronic controls, thermostatic valves, balancing valves, etc [6] - [8].

3.1 Frequency converter ACS-800

The frequency converter is used to change the speed of an induction motor according to the technological process [6] - [8]..
It consists of:

- power supply (contactors, fuses)
- AC adapter - DC link
- modulator drive voltage and frequency – output
- controls
- regulator
- protection and limits.

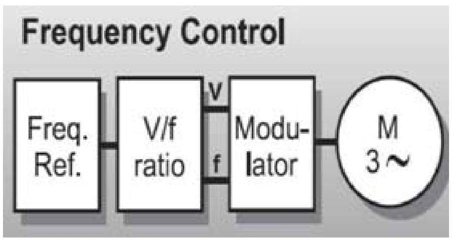

Figure 1 The block diagram of frequency converter

ACS 800 drives that are built on the heating system have the ability to choose the motor control mode as follows: DTC (Direct Torque Control) is suitable for the largest number of examples and SCALAR control mode should be selected in special cases where the DTC mode can not be applied.

3.2 Wilo - Stratos PICO highly-efficient pump

With energy savings of up to 90% compared with the old unregulated pump Wilo-Stratos PICO is more frugal than any other pump of the A-Class, according to standard European Committee. This is possible by using an unique 3-watt technology. Practically pump will repay itself in the first year of operation.

3.3 Electronic controller Eltec TP-05

Electronic controller TP-05 is very important to achieve energy efficient heating substation. The regulator, as the name implies, regulates the operation of the substation according to predefined settings [6] - [8].

Electronic controller consists of:
- five analog inputs (pressure sensors, valves openness ...)
- ten digital inputs (alarm pumps, pulse inputs etc.)
- eight temperature inputs (PT1000)
- digital outputs

3.4 Pumps with variable flow

Pumps with variable flow like Wilo Stratos and Grundfos Alpha have incorporated a variable speed drive (VFD - Variable Frequency Drive), which changes the speed of rotation of the engine, and thus changing the flow of the pump. The pumps are equipped with electronic that on the basis of the measured number of revolutions of the motor pumps and electricity that drives the motor and given parameters of pipeline pump regulates the rpm and maintains the working point of the pump. Some of the advantages of variable flow pumps:

- reducing electricity consumption 70% to 90%
- optimized flow through heating body
- replacement of circulating pumps by one pump when there are more thermostatically controlled heating circuits
- greater efficiency condensing boilers
- longer service life of pumps and zonal regulated valves
- less noisy pump operation
- easier selection and dimensioning pumps

4 Comparison of the results in relation to the different techniques to achieve energy effiviency

A complete analysis of the application frequency regulated drive effects are done for pump water network in Tuzla power plant based on the assumption that regulation is made for two new operating points, so that after the control engine is running with 75% and 60% power.

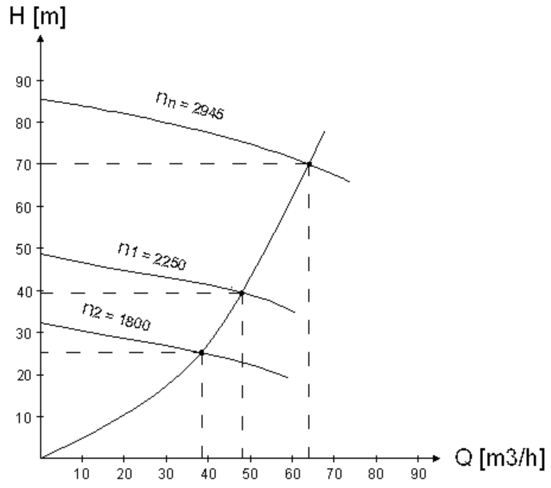

Figure 2 Pump characteristic curve with the new operating points

Operating parameters of pump aggregates, assumed arbitrarily due to the impossibility of performing experimental measurements, and corresponds to the computational values from the equations regarding to the theory of similarity work of turbo-machines:

$$\frac{Q}{Q_0} = \frac{n}{n_0} \; ; \frac{H}{H_0} = \left(\frac{n}{n_0}\right)^2 \tag{1}$$

$$\frac{P}{P_0} = \left(\frac{n}{n_0}\right)^3 \tag{2}$$

$$P_P = \frac{\rho \cdot Q \cdot H \cdot g}{\eta_P} \tag{3}$$

$$P_m = \frac{P_P}{\eta_m} \tag{4}$$

where are:
g – the acceleration of gravitation,
η_p, η_m – level of efficiency pump and motor,
P_p, P_m – power of the pump and motor,
H – Effort of the pump
Q- Volumetric flow pumps
n- speed pumps

The difference or savings in the power demand of electric drives and savings in the consumption of raw water gives input to the economic analysis of the effects of reconstruction. Saving electricity due to the reduction of engine power pumping units is:

$$\Delta P = 12719 + 17248 = 29967W = 2{,}997kW \tag{5}$$

$$\Delta E = \Delta P \cdot TI = 29967 \cdot 3500 = 104884500 Wh$$

$$= 104884{,}5\, kWh,$$

Average annual energy savings is $\Delta E \approx 104\,884{,}5$ kWh.

Table 1 The parameters of the pump before regulation

No frekvency regulation			
Number of rpm	Effort of the pump	Flow	Power of the motor
n [rpm/min]	H [m]	Q [m^3/h]	P [kW]
2945	70	64	22

Table 2 The parameters of the pump after frequency regulation and achieved energy savings

Number of rpm	Effort of the pump	Flow	Power of the motor	Power saving	Water saving
n [rpm/min]	H [m]	Q [m^3/h]	P [W]	ΔP [W]	ΔQ [m^3/h]
2250	39,38	48	9281	12719	16
1800	25,20	38,4	4752	17248	25,6

5 Analysis of own electricity consumption of heating substations and economic indicators justification of investments

5.1 Application of frequency converter

By applying the frequency converter on the drive pumps substation "Korzo" 1" some positive results are achieved. By monitoring electricity consumption, which is carried out in the specified substation, corresponding results obtained are presented in the Table 3 –Table 6.
It is considered the heat exchange substation of nominal power of 2800 kW engaged in heat and power is 1908 kW.

Table 3 Consumption in the typical months in a higher and a lower daily rate and total consumption after installation of frequency converter 31.05.2007.

PERIOD	HIGH TARIFF	LOWER TARIFF	SUM kWh
31-Aug-07	13	19	32
31-Dec-07	4153	4317	8470
31-Jan-08	4488	5633	10121
29-Feb-08	4211	4523	8734

Table 4 Consumption in the typical months in a higher and a lower daily rate and total consumption after suffering frequency converter 22.11.2008.

PERIOD	HIGH TARIFF	LOWER TARIFF	SUM kWh
31-Dec-08	6106	7841	13947
31-Jan-09	5822	8018	13840
28-Feb-09	5203	6954	12157

Table 5 Consumption in the typical months in a higher and a lower daily rate and total consumption with the new built-in frequency converter 28.05.2009

PERIOD	HIGH TARIFF	LOWER TARIFF	SUM kWh
31-Dec-09	3911	4339	8250
31-Jan-10	4522	6172	10694
28-Feb-10	3943	5310	9253

Table 6 Consumption in the typical months in a higher and a lower daily rate and total consumption after re-suffering converter 10.10.2011

PERIOD	HIGH TARIFF	LOWER TARIFF	SUM kWh
31-Aug-11	15	21	36
31-Dec-11	5994	8070	14064
31-Jan-12	5188	6868	12056
29-Feb-12	5135	6788	11923

From the presented tables it is evident that the energy consumption in the summer negligible compared to the periods of the winter months, which is logical because the pump as the largest consumers of electricity in the substation, work during winter months [9]. Heating season in Tuzla lasts from the beginning of October until the end of the fourth month next year. Therefore, the following analysis and spent observing eight complete heating seasons and this season of 2006/2007 do 2013/2014. Temperature characteristics of selected heating season were approximately equal with characteristic of average high temperatures of winter period.
From the previous table it can be seen that the consumption of electricity is reduced in the season which the pump plant was built with frequency regulator (converter).
Realized savings at the level of the season amounted to 11165 (kWh) or consumption was reduced by 16.41% compared to the season without frequency regulator. Using an automatic speed control speed according to set parameters of pressure and temperature it is possible to avoid unnecessary energy consumption caused by increased improper handling of individuals.

6 Conclusion

Using modern smart technology to optimize the efficiency of the system for energy management currently offers the greatest opportunities for improving energy efficiency and reducing operating costs, while ensuring significant reduction in CO2 emissions. Through detailed energy audit and analysis of specific indicators of technologies used for industrial systems it is possible identify the causes of irrational energy consumption, in order to find the best balance between system management, and user devices. Setting energy-efficient motor and frequency inverter is one of the easiest measures to achieve energy efficiency.
Responsible and rational approach of using modern devices can contribute to reducing their energy consumption which directly reflects on the necessary financial resources of the company.

Literature

[1] Europan Commision Directorate-General JRC, Institute for perspective Technological Studies:"Best available Techniques in the Energy Efficiency", July, 2007.

[2]David Boomer, Head of Energy Efficinecy and Climate Change, UK, „Energy Efficieny", 2008.

[3] Projekat:"Razvoj i unaprjeđenje konkurentnosti malih i rednjih preduzeća na polju povećanja energetske efiksnosti"„Izgradnja pravnog okruženja u BiH za energijsku efikasnost u zgradarstvu", Privredna komora kantona Sarajevo.

[4] Vladimir Stevanović, Bransilav Živković, Blaženka Maslovarić, Sanja Prica, Maja Todorović, Radislv Galić„Termohidraulički proračuni sistema daljinskog grejanja u cilju povećanja energetske efikasnosti transporta toplote" JKP „Beogradske elektrane", Beograd.

[5] E3 International,"Technical Study of Energy Efficiency Opportunities in the District Heating System in Oradea, Romania"

[6] Catalogue, :OEM High Efficinecy Circulation Pumps, Willo Pumpen Inteligenz

[7] „Frekventni regulatori" ccd.uns.ac.rs/aus/auenerg/auenerg_doc/ac/Poglevlje%20., http://www.carbontrust.com/media/13063/ctg070_variable_speed_drives.pdf

[8] Janus Wollerstand, :"District Heating Substations, Performanc, Operation and Design, Doctoral Thesis, 1997.

[9] Projekt CARDS 2004 Potpora nastavku približavanja hrvatskog zakonodavstva pravnoj stečevini EU na području zaštite okoliša: „Uputa o najboljim raspoloživim tehnikama-Energetska efikasnost".