Possibilities for Improving Energy Efficiency at Water Utility Sector

Gjelosh Vataj, and Zenel Sejfijaj

Abstract—Energy efficiency plays an important role in all water sectors. Energy is one of the largest operating costs for water system. For water utility systems, energy is needed for transports of raw water, water treatment process, water storage and distribution. Energy usage can vary based on water source, treatment type, facility age, storage capacity, topography, and system size, which encompasses volume produced and service area. Water Companies are well known with importance of reducing energy consumption and costs as a means to optimize overall system performance and to provide a safe water supply. But managing staff of the water system and operators may not be fully aware of the options available to them to manage their energy budget or to identify, prioritize and fund energy improvement projects. By applying energy efficiency, water utility sectors can build a successful energy management program and achieve energy savings. This paper discusses energy issues facing public water utility sector, steps that responsibility personnel can take to understand and reduce their energy use and costs, and funding resources for energy efficiency. Main focus in this paper is to perform possibilities for increasing energy efficiency of the Pumping Station in Milloshevë which supply with raw water Treatment Plant in Shkabaj, Kosovo.

Index Terms—Energy Efficiency, Pumping Station, Drinking Water System, Bill.

I. INTRODUCTION

The primary goal of the water industry has always been environmental stewardship to meet all applicable water quality standards. The industry has focused on earning and maintaining public trust by protecting the health and welfare of its communities. For this reason, new, innovative and alternative technologies are approached cautiously within the industry. Likewise, incorporating energy efficient technologies and concepts into treatment processes is usually not a priority. This challenge is often compounded by a general lack of knowledge about energy use and energy billing. Energy costs are sometimes viewed as uncontrollable a business cost that cannot be questioned or changed. However, if operation and management personnel become familiar with how their facility uses energy and is billed for it, they can find ways to manage and reduce energy costs [1-2]. The focus on Energy Water guide was developed to support the industry because of the industry’s enormous potential to reduce energy use without compromising water quality standards. Through the program, water personnel have learned that energy use can be managed, with no adverse effects on water quality. Most locations that have implemented energy saving practices have also found improved control and treatment as an additional benefit. The improvements are often economically attractive, compared to their industrial counterparts, water facilities typically see shorter paybacks on energy efficiency projects due to longer hours of operation. These facilities are necessary public infrastructure and therefore, have stable financial commitment for long-term viability. The objective of this paper is to provide information and resources to assist water company management and their staff in identifying and implementing opportunities to reduce energy use. Case study is Pumping Station in Milloshevë managed by Regional Water Company “PRISHTINA”.

II. DESCRIPTION OF STUDY

The Regional Water Company “PRISHTINA” assumes a population growth for the service area from 554,000 inhabitants up to 938,000 in 2040. The total water demand increases from currently 49 Mio m3 to 66 Mio m3 in 2040, Fig. 1.

In order to fulfil this water demand, it was necessary to build New Water Treatment Plant “SHKABAJ” which will enable water supply beyond 2030. The location of the water source, the Gazivoda Lake, the Iber Channel and the proposed location of the raw water intake at Mihaliq as well as the WTP Shkabaj are presented in Fig. 2.
A. Pump design

Pump is a device used to convert mechanical energy to pressure energy for the movement of fluid respectively water from source to destination. The main pump components are: pump, electric motor, piping to carry fluid, valves to control flow in system, Fig. 3.

The pump is horizontally mounted incorporating a high efficiency mixed flow impeller designed to handle large flows against low to medium heads. The pump manufactured has respected the following EN Standard materials:

- Impeller: Austenitic Stainless Steel
- Shaft: Stainless Steel
- Shaft Sleeves: Stainless Steel
- Casing (Split Axially): Cast Iron
- Case Wear Rings: Zinc Free Bronze
- Bearings: Ball, Grease Lubricated
- Stuffing Box: Cartridge Mechanical Seal

- Coupling: Maintenance Free Flexible Spacer

The pump unit is mounted on a substantial channel section baseplate, extended to incorporate a maintenance free metal membrane spacer coupling between pump and driver with motor alignment jacking screws, Fig. 4. The pump casing is internally coated with a Water Industry approved coating system, while externally it should be coated with a 2-pack epoxy system.

The type of installed pumps complies with the characteristics listed in Table I.

| Characteristics                  | Unit       | Value       |
|----------------------------------|------------|-------------|
| Number of units                  |            | 3           |
| Liquid                           | Water      |             |
| Pumping Temperature              | deg C      | Ambient     |
| Specific Gravity                 |            | 1.0         |
| Flow                             | l/s        | 343.75      |
| Differential Head                | m          | 84          |
| Suction Pressure                 | m          | Assume Flooded |

TABLE I: PUMP CHARACTERISTICS RAW WATER PUMPS

- Application Requirements
- Number of units: 3
- Liquid: Water
- Pumping Temperature: Ambient
- Specific Gravity: 1.0
- Flow: 343.75 l/s
- Differential Head: 84 m
- Suction Pressure: Assume Flooded

- Pump Range: Axial Split Case
- Speed (nominal): 1470 Rpm
- Efficiency: 86.6%
- Power absorbed at coupling: 327.08 kW
- * NPSH Required: 84.00 m
- Suction pump diameter: 400 mm
- Discharge pump diameter: 300 mm
- Flange drilling: PN16
- Rotation (viewed on drive end): CW

- Driver Details
- Rating: 450 kW
- Motor Speed (Nominal): 1485
- Electrical supply: 400/3/50

The required static head is 601 masl – 552 masl = 49 m this is the difference between terrain level at the offtake and the terrain level at the WTP. The friction losses for the gravity pipe from Mihaliq offtake to the Miloshevo pump station are maximum 14.15 m and the friction losses for the pumping main from Miloshevo pump station to Shkabaj WTP are maximum 7.02 m. This is pumped to the water level in the inlet and distribution chamber, which is 609.5 masl i.e. approx. 610 masl which is 9 m above the terrain plus 5 m as a reserve.

The drive motor is a 450 kW, 4 pole machine, designed for use on a 400 V, 3 phase, 50Hz supply, and with a frequency inverter. The machine is an IE2 design, with IP55 enclosure and would be fitted with thermistors and anti-condensation heaters.

The pump-sets have been selected and sized to meet the Stage 2 duty conditions. Two duty pumps will meet the
Stage 1 flow rates as per Table II. Future Stage 2 pumps would be identical machines, including impeller trim diameters.

| Parameter | Total flow rate [l/s] | Pump flow rate [l/s] | Head [m] | Efficiencies [%] | Power [kW] |
|-----------|----------------------|----------------------|----------|------------------|------------|
| Stage 1   | 321                  | 321                  | 64.3     | 86.4             | 234.2      |
| Min Flow  | 770                  | 385                  | 69.5     | 85.5             | 306.9      |
| Max Flow  | 573                  | 286.5                | 64       | 85.9             | 209.5      |

In Fig. 5 is presented diagram of pump characteristics and comparison between motor power, geodetic height and pump flow.

III. DETERMINING OF THE EFFICIENCY OF THE PUMPS

Hydraulic power in shaft of pumps can be estimated by expression given as follow [3-6]:

\[ P_{\text{hydraulic}} = \frac{\rho g H_{\text{tot}} Q}{1000} \]  

(1)

Pump efficiency is determined by the following expression:

\[ \eta_{\text{pump}} = \frac{\text{Hydraulic power}}{\text{Pump shaft power}} \times 100 \]  

(2)

Power in shaft of the pump is determined by the following expression:

\[ \text{Pump shaft power} = \text{Hydraulic power} \times \eta_{\text{mot}} \% \]  

(3)

Where are:
- \( \rho \) - density of water (1000 kg/m³)
- \( g \) - gravity acceleration (9.81 m/s²)
- \( H_{\text{tot}} \) - total head (difference between discharge and suction head),
- \( Q \) - water flow rate,
- \( \eta_{\text{pump}} \% \) - pump efficiency
- \( \eta_{\text{mot}} \% \) - motor efficiency

Measurement of the water flow can be done by:
- Ultrasonic flow measurement
- Tank filling method and

- Installation of an online flow meter.

A. Evaluation of the pump efficiency in Pumping Station Milloshevë

Actually, is implemented only first phase of project for Pumping Station Milloshevë. There are installed 3 split case pumps from Wilo producer, Fig. 6. Technical data of pump installed pump are presented in Table III.

![Fig. 6. Pump design](image)

In SCADA system are collected measured data (Fig. 7) which are presented in Table IV.
B. Estimation of the pump efficiency in Pumping Station Milloshevë

Estimation of the hydraulic power is:

\[ P_{\text{hyd}} = \frac{1000 \cdot 9.81 \cdot 57.2 \cdot 0.311}{1000} = 174.51 \text{ [kW]} \]  

(4)

Estimation of power drawn by the electric motor is:

\[ P_{\text{mot}} = \sqrt{3} \cdot |U| \cdot |I| \cdot \cos \phi = \sqrt{3} \cdot 409 \cdot 472.15 \cdot 0.855 = 285.98 \text{ [kW]} \]  

(5)

Motor input power is: \( P_{\text{mot}} = 285.98 \text{ [kW]} \)

Pump shaft power is:

\[ \text{Motor shaft power} = P_{0} - s \cdot P_{G} = 285.98 - 0.013 \cdot 285.98 = 282.26 \text{ [kW]} \]  

(6)

Motors slip is estimated by the following expression:

\[ s = \frac{N_{g} - N_{R}}{N_{g}} = \frac{1500 - 1480}{1500} = 0.013 \]  

(7)

Finally estimated pump efficiency is:

\[ \eta_{\text{pump}} = \frac{\text{Hydraulic power}}{\text{Pump shaft power}} = \frac{174.51}{282.26} = 0.618 \]  

(8)

Pump efficiency is: \( \eta_{\text{pump}} = 61.8 \% \)

This mean installed pump consume 39.16 \% more energy for transport of the same amount of water compared with efficiency of designed pump. The annual of saving energy from only one pump for one year is: 83.06 kWh x 24 x 365 = 727617.82 kWh. If assuming price for 1 [kWh] is 0.08 €, then for one-year company will save at list 58 209 €.

IV. CONCLUSION

Based on comparison of the actual values with the design performance test values is found a deviation in pump efficiency from 86\% into 61.8 \%. This difference has direct impact in consuming 39.16 \% of energy for transport of the same amount of water compared with designed pump. Based on the actual operation parameters, are highly recommendations to be taken this action for improving pump efficiency:

- Replacement of inefficient pumps,
- Correcting inaccuracies of the pump sizing,
- Impeller trimming

Also using high performance of lubrications can increase energy efficient by reducing friction losses.

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