MONITORING THE MAIN PARAMETERS OF A WATER SUPPLY PUMPING STATION OVER TEN YEARS

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ABSTRACT
The paper presents a methodology for computing the 3D turbulent flow in both distributor and runner of Francis turbines. The 3D computational domains correspond to interblade channels for the GAMM Francis turbine distributor and runner, respectively. In order to couple the steady absolute distributor flow field with the runner steady relative flow, a mixing interface technique is developed and employed on the conical distributor-runner interface. Our mixing algorithm removes the circumferential variation of velocity components, pressure and turbulence quantities using a piecewise polynomial least squares algorithm.

KEYWORDS
Francis turbine, mixing interface method, turbulent flow

1. INTRODUCTION
The water distribution systems are composed of supply pipes, main pumping stations and booster-stations in the areas where pressure boosting is needed. This is the case of the water supply system of Bucharest, where water distribution is done through a pipe system that includes a number of 7 main pumping stations, 38 repumping stations and over 200 booster stations. As a consequence, the major priority in the rehabilitation process of the water distribution system of Bucharest has constituted the rehabilitation of pumping, repumping and booster stations, whose operating performance have suffered in time significant alterations, caused by changes due to the continuous variation of water consumption and suction conditions in the last 10 years. We have selected, for the present study of the operating parameter evolution in the last 10 years, a single repumping station, part of the water distribution system of Bucharest.

2. DESCRIPTION OF THE REPUMPING STATION AND HER TIME OPERATING EVOLUTION
Erected in 1967, the repumping station has been designed to operate like a classical station, having a battery of two reservoirs, with a capacity of 500 mc each on the suction side and discharging into a high pressure pipe system, supplying a residential district with P +10 high rise apartment buildings. The pumping station was been equipped with 6 pumping groups, 4 pumps type DN 200, with QN = 360mc / h; HN = 64 mCW coupled with electrical motors having P = 90 kW and 2 pumps type EKM – WEB, having QN = 360mc/h; HN = 62 mCW coupled with electrical motors having P = 100 kW (figure 1).

The operating regime of the pumping station was a classical one, storing water during the night and low consumption periods in the reservoirs (operating with reduced number of pumps), and following the daily demand variations by starting and stopping pumps. This type of regulation ensured a minimum discharge pressure and had also a maximum pressure limit. The control of the operating regime is a sequential one, through manual starting and stopping of the pumps. The operating personnel of the station, is monitoring and correlating two parameters: the pressure in the discharge pipe and the water level in the suction reservoirs.

In the last 10 years, the operating regime of the pumping station has undertaken significant changes, resulting in lower parameters of the pumps, and consequently very high specific energy consumptions. The first major transformation has taken place in 1990 when the suction tanks have been by-passed and the pumps where connected directly to the main artery network. The reason was a very low pressure in the
main artery network during the day, causing an insufficient flow towards the compensation tanks. The tanks where put back into operation in 1993 but the by-pass was always open.

The second major transformation, was in 1996, when because of pressure increase in the pipe system (as a result to rehabilitation great pumping stations as well as losses decrease because of punctual replacing of damaged pipes), the reservoirs where definitely put out of service, and the suction was realized directly from the main pipe system, where the pressure value was up to 20 m.

The advantages of this solution, where obvious: exclusion of discontinuous supply periods, recovery of the existent pressure from the pipe system and reducing the costs by not maintaining and operating the reservoirs.

The third major transformation relating to the evolution of the operating parameters from the repumping station, was registered in year 1998, and had consisted in retrofit of two impeller pumps, the most used in station. This operation was done by modifying the impeller diameter to satisfy the system requires, consequently the pumps run closer to BEP and the specific energy reduced significantly.

The Table 1 presents a comparison between the operating parameters recorded during the two periods of analysis.

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<tbody>
<tr>
<td>Total daily flow</td>
<td>Daily energy consumption</td>
<td>Average specific energy</td>
<td>Total daily flow</td>
<td>Daily energy consumption</td>
<td>Average specific energy</td>
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<tr>
<td>mc/zi</td>
<td>kWh</td>
<td>KWh/mc</td>
<td>mc/zi</td>
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<td>7032</td>
<td>0.231</td>
<td>25737</td>
<td>4296</td>
<td>0.166</td>
<td>2736</td>
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Table 1
This period of reducing the specific operating costs, was a very short one, because in the last period (after year 1998), due to the introduction of primary water metering, and the detection and repair of major losses, the pumped water flows in the pipe distribution system have continuously decreased. Those causes determined the operation of the repumping- and booster- stations to move again away from the BEP simultaneously with the increase of the suction pressure attracting a closure of the discharge valve in order to control the outlet pressure.

Consequently, at the end of 2002, at the request of Apa Nova (Bucharest’s Municipal Water Company), the Technical University of Civil Engineering, through the Department of Hydraulics and Environmental Protection, has performed measurements “in situ”, of the pumping units existing in station and has performed a technical-economic analysis based on measurements and hourly operating parameters, recorded in the stations register.

The results of the measurements, using Yates Meter equipment, where processed and delivered in the form of characteristic curves, like the one in Figure 2.

Thereof, considering the study conclusions realized by UTCB, it has been decided that the existing pumps in the station shall be replaced with new variable speed driven pumps.

In consequence, because of design-, bidding-, purchase, performance-, procedures and putting into service, at end of year 2003 the respective pumping station was commissioned in a new configuration equipped with Grundfos pumps type HS 250-200380. That was the last major change in the pumping station’s life till now.

The operation parameters of the rehabilitated pumping station have been also monitored and compared to the available set of historical data.

3. CONCLUSIONS AND COMMENTS

The need for rehabilitation of the pumping-, repumping and booster stations for the water supply systems was obvious but has been done efficient only when systematic measurements have been performed and coherent measures have been taken based on measurements rather than on “heuristic” approaches.

Two facts concurred towards the need of selection of appropriate pumping equipment. On one side the old obsolete pumps, working at fixed speed could not adapt to the tremendous variations of the requested parameters and on the other hand, the rehabilitation of the network and the reduction of the demands, changed the system curves dramatically.

The changes of the parameters for one typical day are shown in Figure 3 for Head, in Figure 4 for Total Energy, Figure 5 for Flow rate and Figure 6 for Specific Energy. Figure 3 presents the variations of the pumping station’s Head during 1995-2004.
The continuous decrease of the stations head occurs mainly due to the increase of suction pressure. The station’s Head is the difference between the delivered specific energy at the outlet of the pumping station and the specific energy at the entrance of the pumping station.

Figure 4 is presenting the variations of the energy consumption in station for one typical day in each analyzed period. The energy consumptions have decreased continuously up to 5 times in almost ten years.

Figure 5 is presenting the evolution of the pumped flow in the period 1998-2004 (no data was available for 1995). The flow decrease is spectacular but we have to consider also that the pumping station is not working alone and some external stations have increased their flows in 2004. Compared to 1998 the peak flow in 2004 is 4 times lower.
Figure 5

Figure 6 is presenting the evolution of the specific energy in the same time interval 1998-2004. This is the most synthetic parameter for the pumping station, showing the evolution of the overall efficiency of the station. Defined as Instant Power over flow rate, it represents in fact the specific cost of the supplied water. The intervention in 1998 was successful for the demands at that time. The demand reduction increased in 2002 the specific energy and the rehabilitation in 2004 reduces again the parameter for daily consumption. The night period has high values due to the fact that the pumps are operating at very low heads and flows.

The analysis of the evolution has emphasised a few important issues specific to the rehabilitation process:

Figure 6

The rehabilitation process is a dynamic one, the ten years analysed being probably the most dynamic ones in the whole life cycle of the water distribution system in Bucharest;

Retrofitting the pumps is an efficient step, reduces the specific energy, but is only valid in a narrow range of operation;
Variable speed driven pumps are flexible and satisfy a wide range of requirements but, as in Figure 6, there are certain regimes where the operation is still inefficient.

The changes occurred in the last ten years have been illustrated through a few diagrams in the present paper. The monitoring of the pumping station has been done through the adaptation process of the system to new requirements from water shortage at the end of the second millennium to less demand at the beginning of the third. In the whole period the water company has followed the trends and tried to adapt the pumping station to the new conditions. The successive changes in management have imposed stronger and stronger a reduction of the specific consumption in the system, thus a reduction of the specific energy in the pumping stations. The result for this pumping station is a significant reduction from 0.350 to 0.100 kWh / m³.

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