The INOGATE Programme

BUILDING PARTNERSHIPS FOR ENERGY SECURITY

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The analysis of the cost of the pumping at HOB plant Sud

AHED.120.MD

Outline

- Evaluation of the pumps and pumping
- Data collected at the site visit
- Simplified scheme of pumps
- Calculation of energy and cost of pumping
- Conclusion - recommendations
Energy audit of pumps

Main pump components

- Pumps
- Prime movers: electric motor
- Piping to carry fluid
- Valves to control flow in system
- Static pressure maintenance system
Energy audit of pumps

Pumps layout
Energy audit of pumps

Pump curves (4) - from catalog

Pump efficiency

- Head - $H$
- Power - $N$
- Efficiency - $\eta$
- NPSH
Energy audit of pumps

Pumps curves - identified

System head curve

Duty point

Water flow in the DH network, m$^3$/h

Head, m

\[ y = 3 \times 10^{-8}x^3 - 0.0001x^2 + 0.1772x \]

\[ y = -1 \times 10^{-9}x^3 - 2 \times 10^{-5}x^2 - 0.0042x + 184.66 \]
## Pumps data collection

Specifications and design details – 1.

<table>
<thead>
<tr>
<th>ID code</th>
<th>Application</th>
<th>Make</th>
<th>Type of the pump</th>
<th>Model</th>
<th>Fluid to be pumped</th>
<th>Density of the fluid</th>
<th>No of stages</th>
<th>Rated suction pressure</th>
<th>Rated discharge pressure</th>
<th>Rated total pressure</th>
<th>Rated flow</th>
<th>Rated efficiency</th>
</tr>
</thead>
</table>


## Pumps data collection

### Specifications and design details – 2.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input kW of the pump</td>
<td></td>
</tr>
<tr>
<td>Speed of the pump</td>
<td></td>
</tr>
<tr>
<td>Year of commissioning</td>
<td></td>
</tr>
<tr>
<td>Motor kW</td>
<td></td>
</tr>
<tr>
<td>Motor make</td>
<td></td>
</tr>
<tr>
<td>Motor voltage</td>
<td></td>
</tr>
<tr>
<td>Rated current of motor</td>
<td></td>
</tr>
<tr>
<td>Motor frame</td>
<td></td>
</tr>
<tr>
<td>Motor rpm</td>
<td></td>
</tr>
<tr>
<td>Rated motor efficiency</td>
<td></td>
</tr>
<tr>
<td>Minimum recirculation required</td>
<td></td>
</tr>
<tr>
<td>Type of flow control system installed</td>
<td></td>
</tr>
<tr>
<td>System installed</td>
<td></td>
</tr>
</tbody>
</table>
Energy audit of pumps

Data sheets
Energy audit of pumps

Instruments required

- **Power Analyzer** - used for measuring electrical parameters such as kW, kVA, pf, V, A and Hz
- **Stroboscope** - to measure the speed of the driven equipment and motor
- **Ultrasonic flow meter or online flow meter**
- The above instruments can be used in addition to the calibrated online/plant instruments
Energy audit of pumps

Parameters to be measured

- Energy consumption pattern of pumps (daily/monthly/yearly consumption)
- Motor electrical parameters (kW, kVA, pf, V, A and Hz) for individual pumps
- Pump operating parameters to be monitored for each pump
  - Discharge flow;
  - Head (suction & discharge;
  - Load variation;
  - Pumps operating hours and operating schedule;
  - Pump/motor speed.
## Efficiency and performance evaluation

### Performance parameters for water pumps – 1.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Unit</th>
<th>Design/PG test value</th>
<th>Actual</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump ID code</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump application</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid to be pumped</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density of the fluid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of stages</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suction head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total head developed by pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed of the pump/motor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input kW to the pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input kW of the motor</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### Efficiency and performance evaluation

**Performance parameters for water pumps – 2.**

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Unit</th>
<th>Design/PG test value</th>
<th>Actual</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor efficiency (refer to motor performance curve)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of flow control system installed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge throttle valve position % open</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow control frequency and duration if any</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% loading of pump on flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% loading of pump on head</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% loading of motor</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Efficiency and performance evaluation

Pumping power requirement can be calculated by the formula:

\[ P = V \cdot \text{Total head} \cdot (h_d - h_s) \cdot \rho \cdot g / \eta / 3600 \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Water flow rate</td>
<td>m³/h</td>
</tr>
<tr>
<td>Total head</td>
<td>Difference between discharge head, ( h_d ), and suction head, ( h_s )</td>
<td>m</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Density of water or fluid being pumped</td>
<td>kg/m³</td>
</tr>
<tr>
<td>( g )</td>
<td>Acceleration due to gravity</td>
<td>m²/s</td>
</tr>
</tbody>
</table>
Energy conservation possibilities – summary

- Improvement of systems and drives
- Correcting inaccuracies of the Pump sizing
- Replacement of inefficient pumps and motors by energy efficient pumps and motors
- Trimming of impellers
- Providing booster pumps into the forward and/or upraise pumps into the return pipeline of district heating systems
- Integration of variable speed drives into pumps system
- High Performance Lubricants: The low temperature fluidity and high temperature stability of high performance lubricants can increase energy efficiency by reducing frictional losses.
Checklist of the Pumping Systems – 1.

- Ensure availability of basic instruments at pumps like pressure gauges, flow meters

- Determine the head and flowrate required for the safety and quality operation of the investigated system.

- Compare the actual values with the design / performance test values if any deviation is found, list the factors with the details and suggestions to overcome.

- Compare the specific energy consumption with the best achievable value (considering the different alternatives). Investigations to be carried out for problematic areas.
Checklist of the Pumping Systems – 2.

Enlist scope of improvement with extensive physical check / observations

- Based on the actual operating parameters, enlist recommendations for action to be taken for improvement, if applicable such as:
  - Replacement of pumps and/or motors
  - Impeller replacement
  - Impeller trimming
  - Variable speed drive application, etc

Modify pumping system and pumps losses to minimize throttling
Checklist of the Pumping Systems – 3.

Modify pumping system and pumps losses to minimize throttling

- Adapt to wide load variation with variable speed drives or sequenced control of multiple units
- Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area
- Use booster pumps for small loads requiring higher pressures
- Increase fluid temperature differentials to reduce pumping rates in case of heat exchangers
- Optimize number of stages in multi-stage pump in case of head margins

Regular maintenance of the network and pumping system to minimize flows and water losses

- Repair seals and packing to minimize water loss by dripping
- Balance the system to minimize flows and reduce pump power requirements
- Conduct water balance to minimize water consumption
- Avoid pumping head with a free-fall return (gravity)
- Avoid cooling water re-circulation in Diesel Generator Sets, air compressors, refrigeration systems, cooling towers feed water pumps, condenser pumps and process pumps
Pressure diagram alternatives - 1.
- to reduce pumping cost in the DH systems

1 main circulation pump

1 main circulation pump + booster pump
Pressure diagram alternatives - 2.

- to reduce pumping cost in the DH systems

1 main circulation pump + Uprise (lift up) pumps
The static pressure maintenance - 1.

- has to ensure that all parts of the system are filled with water (level pressure) and that the water does not begin to boil (steam pressure).

The static pressure maintenance
- at the bottom point
- at the selected point of the network
The static pressure maintenance - 2.

The static pressure maintenance
- at the middle point
- at the suction head of the circulation pump
Pumping at HOB Sud
Pumping at HOB Sud
## Pressure differences in the heat sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Season</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>P(_{\text{direct}})_1</th>
<th>P(_{\text{return}})_1</th>
<th>P(_{\text{direct}})_2</th>
<th>P(_{\text{return}})_2</th>
<th>P(_{\text{direct}})_3</th>
<th>P(_{\text{return}})_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CET-1 (G1-centru, G2-Ciocana)</td>
<td></td>
<td>1200-2300</td>
<td>0 n/a</td>
<td>11.4-11.6</td>
<td>2.3-2.5</td>
<td>P≠0</td>
<td>P≠0</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>CET-2 Winter (G1-Botanica, G2-Ciocana, G3-linia de conexiune)</td>
<td></td>
<td>2600-3400</td>
<td>2800-3600</td>
<td>3100-3400</td>
<td>11.9-12.1</td>
<td>1.7</td>
<td>11.9-12.1</td>
<td>1.8</td>
<td>11.9-12.1</td>
<td>1.8</td>
</tr>
<tr>
<td>CET-2 Summer (G1-Botanica, G2-Ciocana, G3-linia de conexiune)</td>
<td></td>
<td>1200-1400</td>
<td>1400-1600</td>
<td>11.5</td>
<td>2.1 n/a</td>
<td>n/a</td>
<td>11.6</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT Sud (G1-tr.St.Ialoveni, G2-SP18)</td>
<td></td>
<td>700-850</td>
<td>800-1000</td>
<td>n/a</td>
<td>9.3</td>
<td>2</td>
<td>9.3</td>
<td>2 n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>CT Vest (G1-Oras, G2-Alfa)</td>
<td></td>
<td>1700-1900</td>
<td>850-950</td>
<td>n/a</td>
<td>11.2</td>
<td>3</td>
<td>11.2</td>
<td>3 n/a</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>
HOB Sud  raza_1  str. Ialoveni

Durlesti 720 m³/h

CT Sud
H1=183+92=275
H2=183+22=205

PRtS N11
H1=208+62=270
H2=208+ 3=211 /
H2crts=208+ 30=238

str.Ialoveni_PTC-2113
H1=224+37=261
H2=224+22=246
HOB Sud___raza_2__str.Testemitianu

CT Sud
H1=183+92=275
H2=183+22=205

str. Testemitianu
H1=146+128=274
H2=146+ 61=207

PS - 18 1000 m³/h
Pumps with frequency drivers controlled from the consumer substations at the end of the network.
Pumps with frequency drivers controlled from the consumer substations at the end of the network.
Conclusion

- The electricity consumption of the pumps is high
- The investigation of pumps and pumps connection would result energy and cost saving
- Separation of the suction or discharge collectors in case of two or more network directions and control the speed of the pumps keeping required pressure difference at the end of the system would results significant cost saving.
- Provide booster pumps into the forward and/or upraise pumps into the return pipeline would be beneficial.
Recommendations

Is recommended to

- determinate the head and flowrate required for the safety and quality operation of the investigated system and check the pumps and;
- check the pumps, their connections and pumping based on the recommended check list;
- determinate the benefits and rank the energy efficiency measurements,
- prepare schedule and cost plan.