Energy Optimization & Retrofitting of Pumps

Introduction

On November 7th 2017, a Technical Workshop was delivered on Energy Optimization and Retrofitting of Pumps, facilitated by Tolga Candan and Ronak Monga of Grundfos, a corporate member of EmiratesGBC. Topics covered included pump fundamentals and characteristics, energy efficiency measures, and potential retrofitting measures.

Why do we need a Pump?

Pumps account for a massive 10% of the world's electricity consumption and by simply switching to energy efficient pumps, a 40% reduction of that portion can be realized. The savings can reach 60% if smart controls are applied. Pumps are essential for buildings' operations and end-uses such as HVAC systems, hot water systems, plumbing systems, swimming pools, drinking water and indirect influence on a guest's comfort. Across all applications, the main duty of a pump is to transfer fluid from one point to another. This is achieved by generating the right amount of pressure differential by consuming electrical energy depending on the system configuration. Understanding the working principles of a pump's operation is essential to implementing the right retrofit measures.

Pump Characteristics

The pump output depends on the total head loss of the piping network, considering constant flowrate and fluid density. Hence, pump output varies with demand.

Hydraulic Output (P_{hyd}) = Q X H X ρ X g (Watts)

The head loss in the pipe depends on liquid velocity and density pipe roughness, pipe length, pipe area (cross section) and pipe fittings.

Pump Efficiency

The power consumption depends on the following parameters, which directly affect the pump efficiency;

1. P_1 = Power input from the mains (electrical) = $\sqrt{n}\,VI$ cos Θ; *n=1 for One Phase and n=3 for Three Phase.*
2. P_2 = Motor shaft output
3. P_3 = Pump input (power transferred from motor shaft to pump impeller)
4. P_4 = Pump hydraulic output (mechanical) = Q x H x ρ x g

Different pumps can have the same output but a varying input, depending on the pump type. This ultimately defines the efficiency of the pump system.

Pump Performance

Ideally, pumps should always run at the most optimal efficiency. Pump's efficiency would increase or decrease as the flow or head deviates from the Best Efficiency Point (BEP). Factors influencing this deviation might be overheating, impeller cavitation, low bearing and seal life, suction recirculation, discharge recirculation, vibration, and others.

The left part of Figure 1 below represents the system and pump curves intersecting at the operating point (also called duty point), which also happens to be the BEP. The right part illustrates the green efficiency curve and the orange pump curve, indicating the pump's ideal head and flow thresholds.

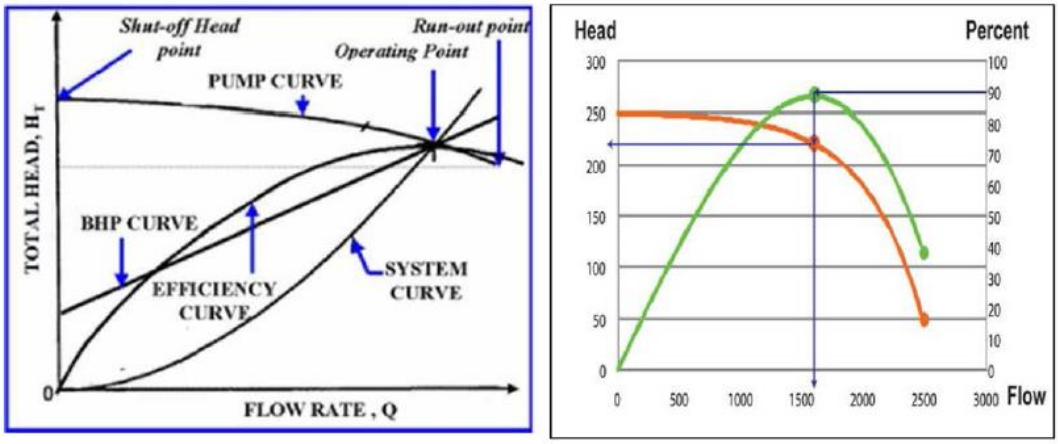


Figure 1 Typical Pump Performance Curve (LEFT) and BEP on Pump Curve (RIGHT)

Figure 2 highlights that a pump system might have different duty points but only one BEP that yields the maximum efficiency. This is important to understand when a pumping system has multiple load demands. In such cases, VFD (Variable Frequency Drives) control system can be utilized to a certain degree to maintain the maximum efficiency as the demand varies.

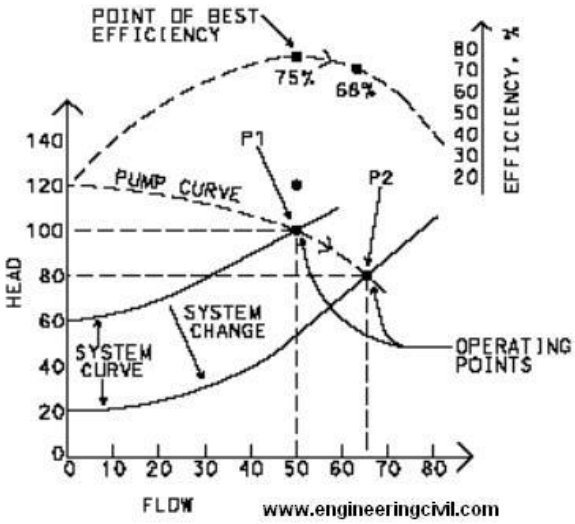


Figure 2 Pump, System and Efficiency Curves

Most pumps only need to run at full speed for 5% of the time, proof that including better control systems has direct impact on the overall energy consumption. In regards to the duty point, that can be served by one pump or two pumps running in tandem (deciding on a parallel or series arrangements will depend on whether the aim is to increase the flow or head, respectively). Either way, the overall efficiency will depend on the system design and better control technologies/methodology.

When to Retrofit Pumps?

Pump Size – Typically in the Middle East, during the course of a project cycle the pump size would vary from design until construction with an increase on the safety factor.

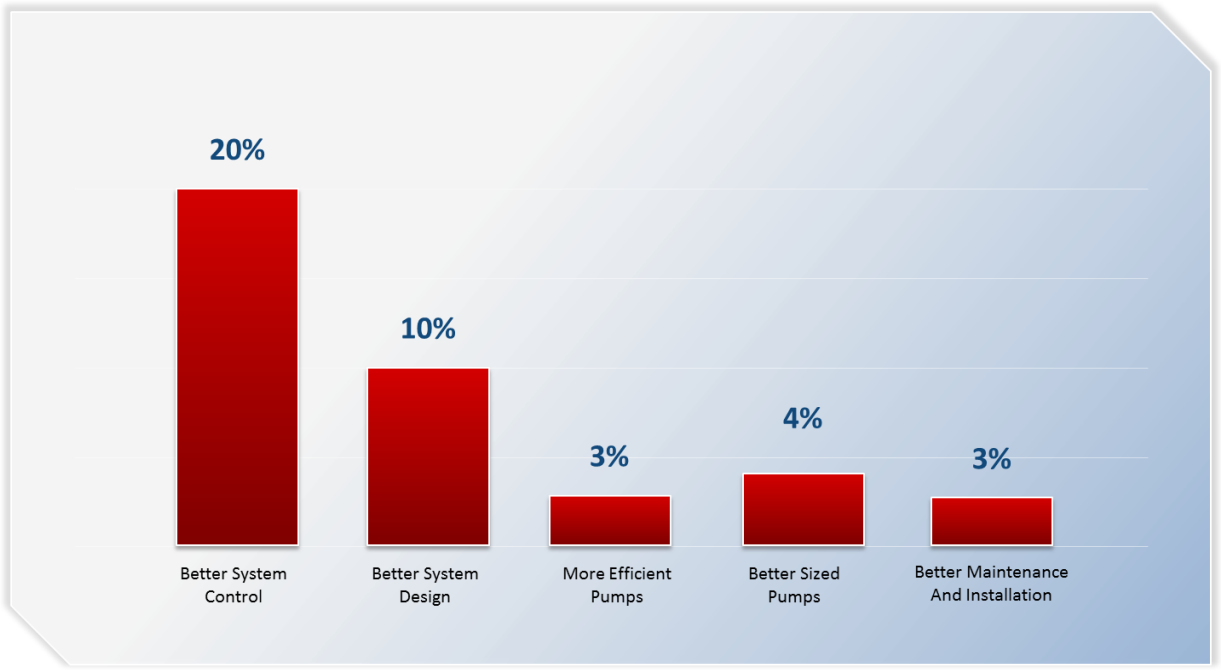
Pumps are commonly oversized due to the safety factors put in the design, contracting and procurement stages. This practice leads to the installation of an overall bigger pump, which will eventually run at a lower efficiency.

For retrofit applications, any pump that is of 15kW in capacity or above is a good candidate for inspection and efficiency measure implementation.

Pump Age & Efficiency – Pumps lose between 0.5-1.5% efficiency per year as they age. Pumps running below their rated efficiency due to aging or other operational factors should be considered for a retrofit and energy efficiency measure implementation.

Hours Run-time – Pumps that operate for prolonged periods and that have a dynamic demand load profile are great candidates for a control retrofit.

Figure 3 below represents some measures that can be implemented in design and retrofitting stages:



Source: European pump industry energy commitment, Europump

Figure 3 Measures for increasing Pumping system efficiency

Conclusion

Achieving energy efficiency does not solely depend on the pump but rather the integration of the entire pumping system. The following are possible measures that need to be taken into consideration that comprise of both visual and physical checks that can achieve the BEP;

1. Visual Checks 1: Replacement
2. Visual Checks 2: Energy Check – Recommendations based on customer's own data and analysis based on calculations.
3. Physical Checks 1: Pump Audit Measurements
4. Physical Checks 2: Energy Auditing – Recommendations based on actual measurement of customer's system and report based on accurate data.