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incorporating PK Phosphorus & Potassium

Iraq: a phosphate Klondike?

FSU projects: a dash for growth

Wastewater treatment update

Cost-optimised phosphate pumping systems

Casting a spotlight on an area where significant efficiency gains and cost savings can be achieved.

Pumping equipment and energy costs comprise a significant element in both the capital expenditure of a phosphate project and in the subsequent facility operating costs. The criterion of minimising the outlay on pumping and piping systems during the planning and construction phase of the project may be incompatible with achieving the lowest running costs during the operational life of the facility. In his paper presented at the 2010 AIChE Clearwater Conference (*Cost-Optimised Pumping in the Phosphate Industry)*, Eric Coffin of Green Energy Engineering, Inc. observed: "It has been the author's experience that the 'under budget' claim was accomplished with 'value engineering' that focused only on a cheap bid and not true life-cycle cost."

Eric Coffin made the further comment that "When energy auditors like myself walk the plant, calculate operating cost and develop energy-saving options, it is then that we sometimes discover that capital cost was 'king' during construction and that long-term maintenance and operating costs were often ignored." All too frequently, Coffin observed, pipes and pumping systems were undersized, resulting in higher pumping and energy costs. "Cooling towers were purchased based on square footage, with little regard for fan horsepower," he said.

The continuing escalation in energy costs has put the optimisation of pipes and pumping systems in the spotlight as pump motors consume the majority of the electricity used in the phosphate business. Piping and pumping systems are in turn a critical element in the operation of the phosphate plant, since around 80% of the pumping horsepower involves water directly or as a carrier fluid for sand, clay and phosphate slurry.

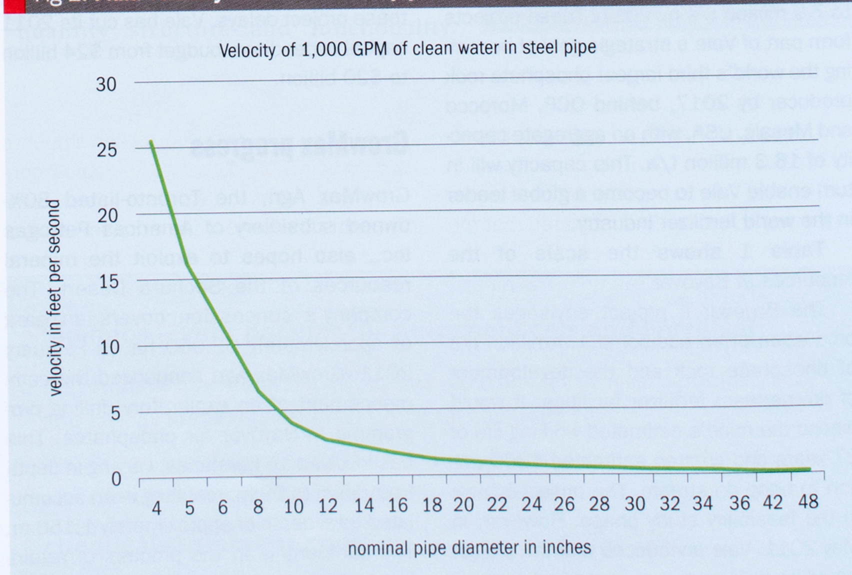
Various parameters influence the choice of piping and pumping systems, including:

- Length and diameter of pipe
- Piping material
- Flow rate (gallons/minute or litres/minute)
- Operating temperature
- Viscosity, density and roughness of materials handled.

One parameter is fluid velocity as a function of pipe diameter. For a fixed volumetric flow rate of water, velocity in feet/second or metres/second drops as pipe diameter increases. (Fig. 1) Another significant parameter is head loss. This is likewise a function of pipe diameter and it is evident that pump size, motor horsepower, pump purchase cost and operating cost decrease considerably as pipe size increases. At this stage, Eric Coffin observes, an engineer may have sufficient information to make a pipe diameter choice and pump/motor size and performance selection. This selection information can then be used by the cost engineer to produce a construction cost for the pipe, pump and motor.

Fig. 2 shows an estimated installed cost of the pipe, based on weight or diameter as a function of pipe diameter. The graph is dynamic and changes according to the length of the pipe. It is clear that many design engineers would consequently opt for the smallest diameter pump in order to

Fig 1: **Fluid velocity as a function of pipe diameter**



minimise capital costs, but this may not be the optimal solution over the full life of the installation.

Among the determinants of the operating costs of a piping and pump system are:

- Pump efficiency
- Motor efficiency
- Equivalent full load operating hours
- Electricity costs.

An assessment based on these criteria tends to favour the provision of larger diameter pipes. Account should also be taken of the expected life of the installation. Amortising the capital cost of the installation over 20 years will place a greater emphasis on the more dominant annual cost of electricity. A better picture of life cycle cost thus emerges.

Further costs of ownership include maintenance costs and various fixed costs, including insurance and taxes. While noting that additional investment in pipe diameter tends to result in lower operating costs, Eric Coffin asks just how much extra investment is justified. "An optimised system, which balances capital costs and annual costs, would be selected based on employing the concept of Incremental Investment and Incremental Return (IIIR)," he noted. In short, the incremental investment is justified if that additional money (extra outlay for a next larger sized pipe) is recouped by an incremental return (extra annual energy and operational savings) that equals or exceeds the amortised cost of capital.

The optimised cost can be expressed by the formula $X = \sqrt{b/a}$, where X = is the value of the design variable (that is, the pipe diameter that results in minimum cost); b = the capital cost for the pipe, pump and motor converted to an annual value, using an interest rate and project life; a = all of the annual costs, such as electricity, maintenance, insurance and taxes.

Adapting this financial concept of incremental investment and incremental return to the pipeline, pump and motor system is illustrated in Fig. 3. This indicates that the minimum-cost point is an 8-inch diameter pipe. For this specific example, the parameters included:

- Distance pumped = 5,000 ft
- Gallons per minute = 1,000 gallons/minute
- Pump efficiency = 80%
- Motor efficiency = 96%
- Equivalent full load operating hours = 7,280 hours
- Electricity cost of $0.12/kWh
- Project life of ten years
- Loan interest rate of 12%.

Fig 2: Installed pipe cost as a function of diameter

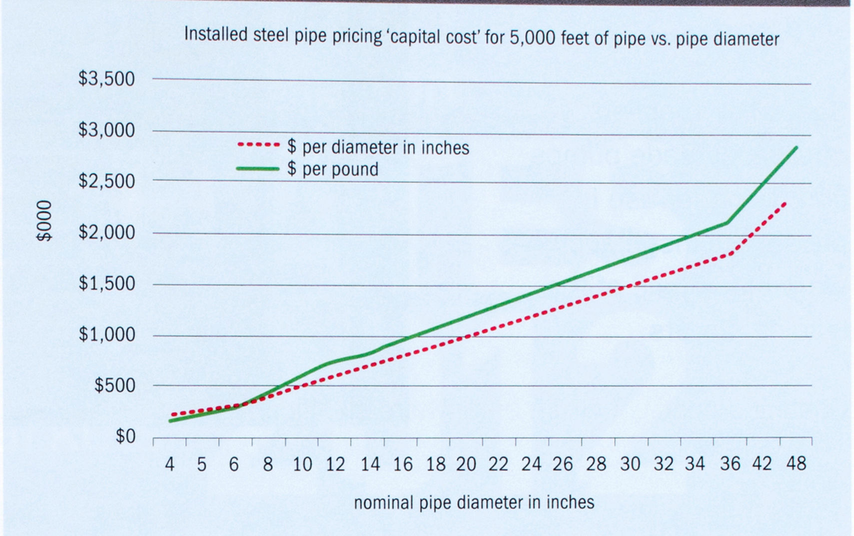
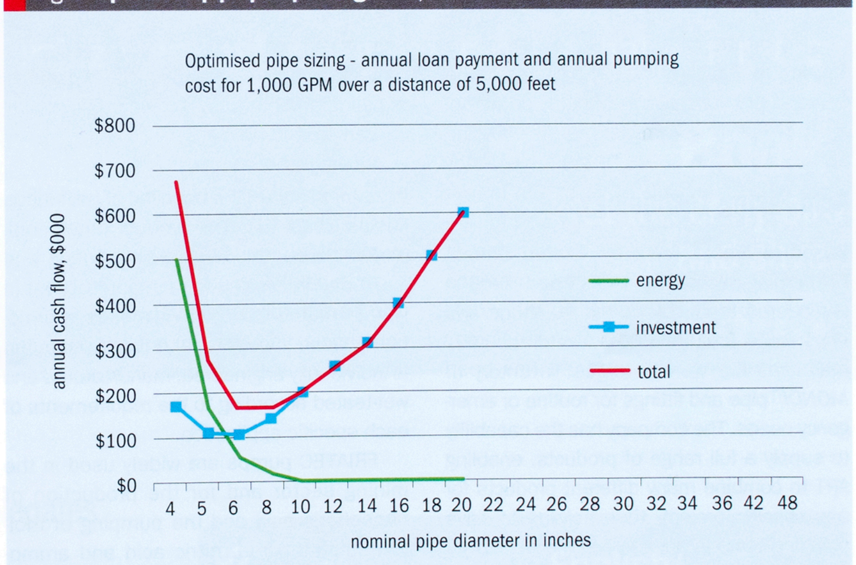


Fig 3: Optimised pipe pump sizing for 1,000 GPM



Changing the low rate to higher amounts and keeping all the other variables constant will result in different pipe sizes. Changing the project life from ten to four years results in a smaller pipeline, as do higher interest rates.

The pumping of the phosphate matrix from the mine to the washer plant accounts for the single largest handling of water in the phosphate industry. This delivery of matrix then results in the pumping of water to carry away tailings, clays and the initial source of water to the mining site. A similar model can be developed to ascertain optimal pipeline size for a pumping facility.

The choice of pipe size, pumps, maintenance and operation for water flow impacts on corporate profits at the facility and thus merits attention at the highest level of management. (This has not always been the case when the facility was originally designed.) Poor performance due to cost- or specification-cutting at the design and installation stage may require the later redesign and remodelling of the facility because it did not perform as required. ■

*The above article was derived from the paper presented by Eric Coffin at the AIChE Clearwater Meeting in June 2010, to whom *Fertilizer International* expresses its thanks for permission to use. The paper may be read in full from the website www.GEEintl.com