Biosolids Cake Pumping Life Cycle Analysis - A True Operators Story

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ABSTRACT

After decades of continuous operation at municipalities across North America, hydraulic piston pumping has proven itself a reliable method for transporting dewatered biosolids cake. Due to the heavy-duty nature and higher capital costs associated with conveying biosolids cake, piston pumps have been applied to transporting higher cake solids over longer pumping runs. Piston pump systems afford operational resilience when compared to other conveyance options. Generally, piston pumps were evaluated with projects that required cake solids dryer than 20% and piping runs over 100 feet. Lighter duty applications, i.e. with wetter cake solids utilizing shorter runs were assigned progressive cavity pumps due to the lower capital cost associated with that technology. Recently, several municipalities in the US, with what many would consider "light duty" cake pumping applications, have made the business case for converting to Piston Pumps.

Focusing on capital cost, a piston pump is two to three times the price of a comparable progressive cavity pump. A typical rule of thumb used for a life-cycle analysis is to apply a percentage of capital cost to determine the expected annual maintenance costs. This assumption could be a major oversimplification, as piston pumping annual parts cost 4%, while the comparable progressive cavity pump can cost 50% of the capital cost per year to run or more. This is the case even on "light duty" applications, and it greatly influences the cost of ownership. The higher capital cost of a piston pump can pay for itself after about 5 years when factoring in the accurate wear parts consumption cost.

Operations and Maintenance staff have proven that maintenance tasks to change progressive cavity pump rotors and stators can exceed the cost of the parts themselves. Specifically, there are consequential costs due to process downtime and changes to operational strategies. For example, progressive cavity pump stators are typically broken in for a week with thin cake, before they can be used for day-to-day operation. An unscheduled maintenance event costs reactionary personnel time normally allocated to preventative measures elsewhere this strains plant operation. To reduce operational wear on a progressive cavity pump, the dewatering equipment is operated to provide a more flowable cake. Polymer injection lube rings are also used in the pipeline (increasing polymer usage costs), or the cake is wetted down after being dewatered all to improve pumpability. These conditions require increased operator attention, chemical usage, and result in higher hauling and disposal costs. Often, these solids must be further stored and dried elsewhere. These indirect costs further reduce the life-cycle value to less than 5 years. For the last six years Pima County Tres Rios Water Reclamation Facility (WRF) operated both progressive cavity pumps and piston pumps side by side. The plant history provides an ideal example for the life cycle comparison case study.

EXAMPLE: Pima County Tres Rios WRF, Arizona

Since the early 2000's to 2012, the Tres Rios WRF had used a piston pump for biosolids cake conveyance to truck-loading. In 2012, the facility completed a Regional Optimization Master Plan expansion, which included an upgrade to the centrifuge building, storage and load-out building. The upgrade design replaced the existing piston pump with progressive cavity pumps dedicated to each of the three new centrifuges. After 6 years of struggling with excessive downtime associated with the progressive cavity pumps, the 15-year-old piston pump was pulled from storage, sent to the manufacture for rehabilitation and reorientation to fit the existing building and installed to replace one of the progressive cavity pumps. Since its reinstallation, the plant has used the piston pump as its primary pump reducing the downtime and maintenance costs associated with the progressive cavity pumps. The facility has also been able to dry the cake to a higher percentage when using the piston pump, reducing hauling costs. The subsequent uptime and increase in dry cake solids production justified the capital cost of buying an additional Piston Pump. One progressive cavity pump will remain in service as an emergency backup for pumping thickened sludge, which is usually thickened from 6% to 8% solids.

Operating Conditions at Tres Rios WRF: Centrifuge dewatered biosolids cake 13-20% solids, pumped through 105 feet of piping with a vertical rise in elevation of 45 feet to silos located above a truck loading. The pipeline is stainless 10" dia at pump discharge connecting to a 12" dia common header with a polymer lube ring, originally specified by the progressive gravity pump manufacturer.

Table A shows the present value operational cost of ownership considering only capital costs and wear part consumption costs of each pump system. After 5 years the total present value of both pumps is nearly identical, extending out to 10 years the piston pump is clearly the lower cost alternative. Piston pumps have an expected useful life of 20 years, making the savings to the utility quite pronounced.

TABLE A: Piston vs Progressive Cavity Pump Present Value Cost of Ownership [Parts Only @ 3% Interest]		
	5 YEARS	10 YEARS
Piston Pump_Includes Capital Purchase*	($241,370)	($273,606)
Progressive Cavity Pump_Includes Capital Purchase	($223,710)	($358,027)

*Capital Cost of Piston Pump at Three Times Progressive Cavity Pump Cost

Wear parts only, as previously described, do not fully illustrate the complete life cycle costs. The cost and frequency of rotor/stator kit replacement on a Progressive Cavity pump is only one factor to consider. Other factors include maintenance hours consumed working on the Progressive Cavity pump (calculated at $50/service person hour). Secondly, when a pumping system is down the cake production output to truck loading is reduced (95% uptime for Piston Pump, vs 75% uptime for Progressive Cavity). Tres Rios WRF produced thickened sludge (8%) to break in the stators and a continuously thinner cake (13% to 15%) to reduce the failure rate of rotors and stators. The Piston Pump required no break in, and immediately pumped 18% to 22% thick cake. On average, when using the progressive cavity pump the thinned cake resulted in more than 5% more moisture needing to be hauled. Therefore, the piston pump saved the County roughly 5,900 tons/year at a cost of $18.70/disposed ton. These additional hauling costs alone helped pay for the higher capital cost associated with the Piston Pump. Both these critical factors (maintenance hours and hauling costs) were added to the 5 and 10-year present value operating costs for each the competing technologies in Table B.

TABLE B: Piston vs Progressive Cavity Pump Present Value Cost of Ownership [Parts/Maintenance/Hauling @ 3% Interest]		
	5 YEARS	10 YEARS
Piston Pump_Includes Capital Purchase*	($245,034)	($280,431)
PC Pump_Includes Capital Purchase of PC Pump	($774,473)	($1,383,882)

*Capital Cost of Piston Pump at 3 Times PC Pump Cost

Table B clearly shows when these consequential costs (maintence downtime and changes to operational strategies) are considered, the value proposition for Piston Pumping is less than 5 years. After 10 years the cost of owning a Progressive Cavity pump is almost five times the cost of the Piston Pump for the county. This is the case even under relatively "light duty" pumping conditions.

CONCLUSION

Often when evaluating competing biosolids cake pumping technologies, the initial capital expenditure garners the most attention. Then to calculate life cycle costs the tendency is to simply assign a "rule of thumb" percentage of capital cost for each year. These rule of thumb values will significantly underestimate the expenses associated with using progressive cavity pumps to convey biosolids cake, and skew cost of ownership calculations. Further, operational impacts within the wastewater plant, such as producing wetter biosolids, will result in increased hauling costs for the utility. As noted, both operations and maintenance teams will quickly point out the rippling effects downtime can have on their plant. The data shows downtime will quickly add costs, far surpassing the higher initial capital cost of a piston pump over the lifecycle of the equipment.