Pump ED 101

CENTRIFUGAL VERSUS POSITIVE DISPLACEMENT GRINDER PUMP SYSTEMS

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Recently, I saw an article that used an expressway analogy to compare positive displacement pressure sewer systems to those utilizing centrifugal grinder pumps. In this article, the writer compared the centrifugal grinder to an automobile "stuck in traffic" while elevating the positive displacement grinder to "super car" status. Unfortunately this analogy is a misleading one. It tends to diminish the positive displacement pump's weaknesses while overstating its relative strengths. Using this same analogy, lets take an realistic look at these two very different pressure sewer pump designs.

This comparison can be helpful in explaining the operation of a pressure sewer system, because we are all familiar with the expressway and its function as a main conduit for the flow of traffic from numerous feeder streets. In this way, it can be considered analogous to the primary force main of a pressure sewer system. The force main is also a conduit and serves numerous feeder lines, each powered by one or more grinder pump systems.

In many ways the design of a pressure sewer system is similar to that of an expressway. The force main is intended to accommodate some maximum flow rate based upon the expected inflow from a certain percentage of their many feeder lines during some peak flow period. It may also be designed to accommodate future expansion of the project or subdivision it serves. But, due to the increased piping expense, it is not usually designed to accommodate the maximum flow from all of the feeders at one time. Nor should it be, because such an occurrence is the exception rather than the norm.

On an expressway, the velocity at which one travels is dependent upon its design capacity and the number of vehicles traveling on it at any point in time. If traffic density is within design capacity, the legal speed limit is usually attainable. As the traffic increases it will slow and may even come to a complete halt if the number of vehicles far exceeds its capacity.

Unlike an expressway, however, velocity in a pressure sewer main does not decrease as as volume increases. In fact, just the opposite occurs. As more sewage enters the main, velocity increases until it reaches some maximum as defined by a combination of system volume and pressure. If system pressure is self limiting, this maximum volume and velocity can be maintained without adverse effects. If system pressure is not self limiting, pressure will continue to increase due to the pipe friction that results from the volume increase.

An intrinsic feature of the centrifugal grinder pump is that it is self limiting with respect to both flow and pressure. When system flow is low or moderate, as measured by backpressure, the centrifugal grinder will seek a higher flow point on its performance curve. As system volume increases, it will automatically reduce its flow while increasing pressure. In the case of system overload (too many pumps on line at one time) or system failure (a closed valve or plugged line) the centrifugal grinder will run at what is known as shut off head, and suffer no adverse effects.

During shut off head, pressure reaches some pre-engineered maximum and flow is reduced to nearly zero. The power required to operate the pump at shut off head is about one quarter of that consumed when pumping at normal flow. When system conditions improve, the centrifugal grinder will automatically increase its flow and seek the optimum point on its performance curve even as conditions continue to change.
The centrifugal grinder pump is a lot like an well behaved driver on an expressway. As traffic (sewage volume) increases and backups begin, the driver (centrifugal grinder) slows down and goes with the flow, so to speak. If the traffic comes to a standstill he will stop and idle patiently until he can move forward again. Regardless of the circumstances, he will maintain a pace that is prudent under the prevailing conditions.

The positive displacement grinder, on the other hand, is not self limiting with respect to either flow or pressure. In fact, it is designed specifically to maintain flow at all costs. As long as it is running, it will continue to pump at a steady, unvarying rate. If system volume increases, thereby increasing friction, it will increase its output pressure to whatever value is required to support its steady pumping rate.

In certain applications this could be considered a good feature. But, in the case of a pressure sewer system damaging over pressure can occur. If too many pumps start at the same time, the friction generated by the sewage flowing in the force main will create extremely high system pressure. Since each positive displacement grinder pump in the system will continue to try to overcome this backpressure, something in the system must give. Usually the pump motor will overload and trip its thermal switch or circuit breaker. In extreme cases, pipes can rupture or the pump itself can be damaged. Even if the thermal overload keeps this from happening, it is not an acceptable protection scheme since overloading and overheating damages the motor windings and leads to premature failure.

A positive displacement grinder pump can be compared to an expressway driver with a bad case of road rage. As traffic (sewage volume) increases and backups begin, the driver (positive displacement grinder) pours on the gas (pressure) and continues to try to maintain his speed. At some point, though, his luck runs out and he slams into the slow moving traffic injuring himself or those around him. If only he could idle patiently like the former driver, he could wait out the slow down. But, unfortunately, idling is not an inherent trait of either the road raged driver or the positive displacement grinder.

There is, however, one condition where speed (not pressure) is desirable. Pressure sewer force mains and laterals utilize relatively small diameter pipe and, therefore, depend upon the velocity of the pumpage to keep them clean and free flowing. When only a few stations are actively pumping, flow and velocity can be greatly reduced. The positive displacement grinder contributes to this condition due to its low flow, fixed rate design. The centrifugal grinder, on the other hand, will automatically seek the highest flow it is capable of producing under the conditions, thus increasing fluid velocity and the scouring action it provides.

In fact, one small centrifugal grinder pump will produce the same fluid velocity as five small positive displacement pumps. If we assume a minimum cleansing velocity of 2 feet per second, a single centrifugal grinder will maintain a 2.5″ force main. In a positive displacement system, four pumps are required. For a 4″ main, the requirement increases to two centrifugals or ten positive displacement units. And, for a 6″ force main only five centrifugals compared to twenty-two positive displacement pumps will be required.

What makes the centrifugal grinder pump so flexible is that it is a true centrifugal pump. What makes it so different than other centrifugal sewage pumps is its unique grinder mechanism and impeller design.

The high speed cutter assembly of the centrifugal grinder pump performs over 3200 cutting operations per second. Its product is an extremely fine slurry (not sludge) that is over 96% water. Since this slurry is almost all water, it pumps like water and is therefore able to take advantage of the unique
operating characteristics of the centrifugal pump.

Two of these characteristics are extremely important in the design and operation of pressure sewer systems. These are the ability to vary flow and pressure automatically and the reduction of electrical consumption in proportion to reductions in flow.

The centrifugal grinder pump's unique vortex impeller design allows it to take full advantage of centrifugal action in a high head, low flow environment. Unlike the typical closed vane type impeller, seen on most centrifugal pumps, the vortex impeller resides completely out of the pump volute. A major advantage of this design is that heat producing friction is reduced, substantially, when running at shut off head. This allows the centrifugal grinder to operated under zero flow conditions for extended periods of time. It is also immune to the damaging radial forces that other impeller designs experience when running at or near shut off head.

Another characteristic of the centrifugal grinder pump is its low maintenance requirements. Since the vortex impeller resides completely outside of the volute, it experiences almost no wear. Its typical life expectancy is therefore that of the pump itself. The close tolerances and running clearances of the positive displacement grinder, on the other hand, demand increased maintenance and promote a shorter life of the pumping components. Also the high speed cutting action of the centrifugal grinder produces far less torque than the slower positive displacement grinder. This lower torque results in increased life of the cutter components.

Although the features and quality of centrifugal grinder pumps varies significantly from manufacturer to manufacturer, one thing remains clear. Their inherent design is far more suitable for pressure sewer systems than other members of the sewage pump family tree.

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