Willard Says……

Just How Much Dirt
Are We Dishing?

MEASURING SOLIDS PRODUCTION

Most *Willardsays* papers explore ways to modify, equip and operate hydraulic dredge systems with the goal of improving efficiency and finding ways to increase the rate at which solids can be moved from one place to another.

Over the past couple of centuries men have devoted untold amounts of time, energy and ingenuity to the matter of how best to connect pipes to the inlet and outlet ports of centrifugal pumps and move solids from point A to point B. If they float these contraptions are called dredges. The demand to suck up solids and water and spew the ingested mixture elsewhere is worldwide.

Always, the question is or should be, is the dredge operating at its maximum rate of solids production and what is that rate? How can it be measured and how accurately? This paper explores these questions.

Aggregate Mining

When solids are dredge-mined for their intrinsic value—sand and gravel for instance—the producer usually owns the dredge. It is to the producer's advantage to achieve and maintain high dredge efficiency and productivity to keep the cost of production as low as possible. Aggregate producers can observe and measure the output of dry solids produced by their process plants and immediately assess the effectiveness of adjustments made to maximize dredge production.

Lump Sum Contract Dredging

Here the term “contract” dredging refers to projects wherein an owner has determined that he has a certain quantity of solids at or below water that would best be moved to another location and is willing to pay a dredger to relocate it. The money involved—cost to the owner, profit (or loss) to the dredger—is always the crux of negotiations that precede the signing of a contract between the two parties.

The quantity of solids to be moved has been determined by marine survey and the owner is soliciting lump sum bids to carry out the task. The project is considered complete and final payment made after a final survey determines that the agreed upon amount of solids have been removed.

The owner benefits by accomplishing a task for an agreed-upon sum. The dredger has an opportunity to make a killing by moving the solids at the maximum possible rate to minimize his costs and maximize his profit. A win-win situation!

Production Contract Dredging

In many situations it is difficult or impossible to determine the quantity of solids to be moved by surveying. If that is the situation, the owner usually solicits bids from dredgers to accomplish the task on a per yard basis. The bid documents include instructions as to what is to be accomplished, estimated volume and general nature of the solids to be moved and designates a disposal site along with terms for payment. The successful (usually low) bidder agrees to abide by the contract terms, gather up the specified solids for the agreed upon price per yard and deliver them to the disposal site.

Measuring the rate at which solids are flowing through a dredge system is where problems begin. The dredge takes in solids along with a lot of water and moves the resulting slurry to the desired point of disposal. As slurry spews from a pipe many interested parties want to know the rate at which solids—tons or cubic yards—are being delivered to disposal. The fact that slurry contains relatively few solids—seldom more than 20 percent by volume—complicates the task.

This paper will examine various aspects of the question of how to determine contract dredge solids production.

1. What is the rate of solids production?
2. What quantity of solids have been moved?
3. How accurate are the answers to these questions?

Contracts

Per-yard contracts often include a large fly in the ointment; they fail to spell out a valid procedure for determining the quantity of solids that have been moved. Sometimes the methods specified are ludicrous, lacking any relationship to reality. Often, lacking other means, attempts are made to determine solids production by measuring and recording dredge operating parameters such as:

1. Pump manufacturer's production projections.
2. Engine run time.
3. Vacuum.
4. Engine/pump speed, rpm.
5. Discharge pressure.
6. Slurry velocity.
7. Slurry density.

#1 is included only because it leads into what is alleged to be a true story.

#2 through #5 are of little or no value in determining the rate of solids production.

#6 and #7 are the only parameters pertinent to the quest to determine the rate of solids production.

A Truly Inaccurate Way to Measure Solids Production

I am told that, under the auspices of the Florida EPA, it is customary to assess property owners for the cost of annual dredge operations required to maintain recreational waterways that access their properties. At least one group of said property owners is of the opinion that the work is not being accomplished in a satisfactory manner yet the dredger is being paid as if it were.

To me the astounding aspect of this story has to do with what the dredger must do to substantiate his claim for payment.

He must do three things: 1. Certify that the dredge engine ran a stated number of hours doing the job. 2. Submit a copy of the manufacturer's projection of the pump's capacity. 3. Multiply the engine hours by the pump's projected capacity.

1. The engine run hours can be, and probably are, accurate, however, the fact that the engine ran does not prove that it was moving solids. At least 80 percent of a hydraulic dredge's power consumption is spent moving water through the pipeline.
2. Pump manufacturers usually list a range of slurry flow rates and solids production capabilities for each of their pumps. These projections assume that slurry of a certain density is continuously available at the suction inlet of the pump. They further assume that the discharge pipeline is not overly long and that the pump engine has ample power to maintain the projected rate of production.
3. Multiplying accurate engine hours by a nebulous projected hourly rate of production results in a nebulous tabulation of accomplishment.

The harsh truth is that actual production determined using this method is pure fiction. If the above is true, those folks are being fleeced wholesale and the dredgers are doing quite well thank you.

Another party states that this procedure is customary in Florida and he too is inquiring as to whether there are better ways to measure solids production. He says that dredgers reject any suggestion that electronic production metering might be more accurate and maintain that the current procedure is very accurate.

The *Willardsays.com* website is devoted entirely to spreading information about how to obtain and maintain a continuous capacity flow of solids into dredge pumps and on to discharge. Information that I have garnered over the past 35 years designing dredges as well as components and instruments to make them more productive. Any idea that production can be measured using the “Florida” procedure is pure bunk.

Now let's get back to the more realistic investigation of how dredge production might be measured using electronic instruments.

Vacuum

There are those who think that the vacuum developed in the dredge suction pipe can be used to measure the rate of solids production. WillardSays....*Vacuum* lists four losses that when added together makeup the indicated vacuum reading. Three of these losses are variables that often elude control measures.

Changes in the rate at which solids are raised to the pump inlet generally fluctuate in concert with changes in vacuum, however, the influence of other variables makes it impossible to correlate a certain vacuum with a specific rate of production.

Engine Speed & Run Time

Engine (pump) speed cannot be interpreted to measure the rate of solids production. Most of the power expended to operate a hydraulic dredge is spent moving slurry which at best is comprised of 25 percent solids by volume. The average water content is usually closer to 90 percent. Increased density does not cause a large increase in power demand over that being expended just to move clear water.

Run time indicates just that—the engine ran for that period of time. Whether or not the time was spent working productively must be determined by other means.

Discharge Pressure

An increase in discharge pressure usually indicates the presence of solids in the dredge pipeline. However, just as with vacuum, there is no way to assign a rate of solids production to a specific increase in discharge pressure.

Instruments

Two electronic dredge operating instruments—the velocity meter and the density meter—can provide data that make it possible to derive a continuous, approximate and instantaneous rate of solids production and accumulate a record of the approximate total quantity moved over a certain period of time.

Only when an accurate rate of slurry flow through a pipeline of a certain diameter is known (velocity meter) and the solids content of that slurry (density meter) can accurately be determined can the two values be integrated to derive an accurate instantaneous rate at which solids are moving through a pipeline.

There are two types of velocity meters, Doppler-type and magnetic.

Doppler-Type Velocity Meters

Doppler-type velocity meters are relatively inexpensive with a price of approximately $3,000. This instruments works on all pipeline diameters, however it's accuracy is said to vary ±10% after they are calibrated. I have been told repeatedly by new users that the meter paid for itself in less than 30 days due to the increase in production they were able to enjoy.

These instruments consists of a transducer to be strapped to the side of the dredge pipe and an electronic circuit board mounted in a weather proof enclosure. The transducer sends sound waves into the flowing pipeline and receives the reflected sound wave. A few solids particles must be present in the flow to reflect the sound waves and enable the meter to function. When solid particles are present in the flow, the frequency of the sound reflected off the solids particles will differ from that of the broadcast sound and will vary with changes in the velocity of the flow.

The circuitry interprets those changes and outputs a signal that can be calibrated to indicate the instantaneous velocity. Changes in slurry density usually does not affect the indicated velocity.

Doppler-type meters may not accurately measure the velocity of clear water. This shortcoming should not be of serious consequence since by definition pumping clear water seriously detracts from the goal of pumping solids and should be avoided. Pumping Pure water Pays Poorly—a "P" principle. ("Pee Poor Preparation Precedes Pee Poor Performance" is another.) Knowledgeable operators know when they are pumping clear water and disregard the velocity meter reading while that condition prevails.

Magnetic Velocity Meters

Magnetic velocity meters are reputed to have an accuracy of over 95 percent, however, such accuracy comes at a price of approximately $1,500 per inch of pipeline diameter.

In operation, the electronic circuitry of these meters creates an electrical field within the flowing pipe. This field has certain measurable characteristics that change as the rate of flow through the pipe changes. The electronic signals are interpreted to provide an output signal which can be displayed as velocity on the operator's console.

These meters usually come factory calibrated to measure the flow of water which means that it is likely that they will need to be re-calibrated to measure slurry velocities. Rocks and large particles in the flow may affect the accuracy of the indicated velocity and may cause damage that renders these meters useless.

Calibration requires that the meter's indicated velocity be adjusted to match a known rate of flow in the pipeline, a condition that is often difficult to attain.

The most accurate method is to divert the full flow into a container for a certain, short period of time at a fixed velocity. The captured volume is then converted to gallons and divided by the pumping time in minutes to obtain the flow in gpm. The actual velocity can then be calculated for the inside diameter of the pipe and the meter adjusted to show the correct rate of flow.

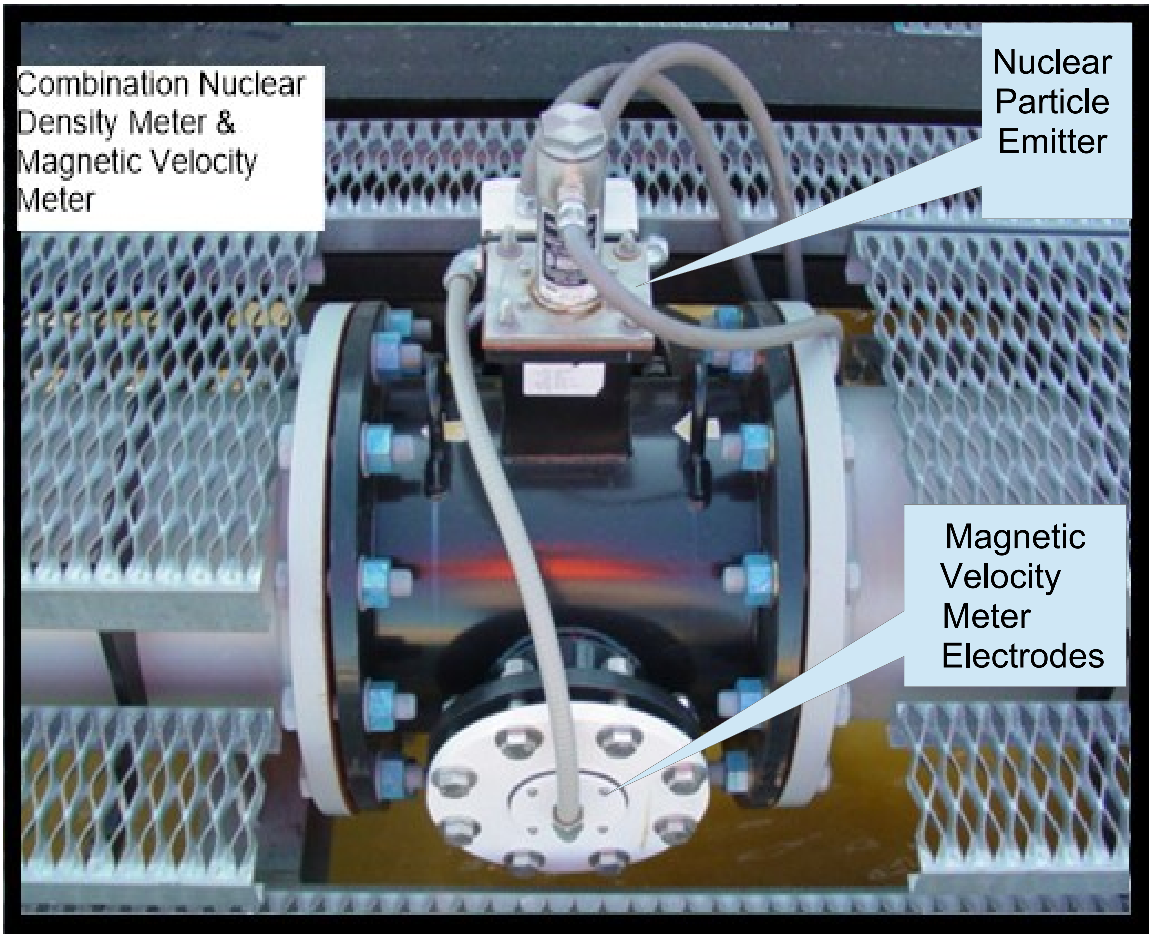

Figure 1

Another fairly accurate method is measure the trajectory of the stream of slurry as it issues from the end of the discharge pipe.

The discharged stream flows horizontally for a distance that depends on its velocity as it exits the pipe. The discharged stream also starts to travel downward due to the influence of gravity the moment it exits the pipe. The arcing path taken by the stream of discharged slurry is the trajectory.

Formulas developed to forecast the trajectory of a stream of solids as it is cast off a conveyor head pulley can be used to accurately calculate the velocity of a spewing stream of slurry once its trajectory is plotted. The velocity meter readout can then be adjusted to show the true velocity.

I am not aware that any dredgers have actually performed these calibration procedures and take that as an indication that most electronic velocity measurements are imprecise.

Density Meters

A great variety of instruments and devices have been developed in the attempt to measure slurry density. Currently, nuclear radiation meters are widely viewed as being the most accurate. My experience says that is true as long as the slurry consists almost entirely of fine particles. Accuracy and reliability decline when the slurry contains large particles.

Nuclear device manufacturers, have over the years, kept refining their circuitry to reduce the amount of radiation emitted by their instruments. Their efforts have succeeded to the point where regulations governing their possession have been reduced to the category of a nuisance.

Early nuclear density meters contained radioactive material potent enough to require that a federally certified technician be present for such mundane tasks as moving the meter from a worn pipe to a new pipe. Paperwork requirements were burdensome. Most of those bothersome details have now gone away, however, the government still demands to know who owns these devices.

Nuclear density meters consist of an emitter that causes a beam of radioactive particles of known intensity to "shine" through the discharge pipe. A receiver on the opposite side of the pipe measures the intensity of the beam as it exits the pipe wall. The strength of the beam will be degraded (weakened) after passing through the pipe wall twice as well as the water contained in the pipe. That clear-water signal strength equates to zero slurry density. The strength of the beam will degrade further as solids are introduced into the flow and vary with slurry density.

The intensity of the degraded beam can be electronically equated to slurry density and a signal generated to indicate the instantaneous density on the operator's console and integrated with the velocity signal to obtain the rate of solids production in tons or yards per hour.

Alternate Methods

Another theoretically accurate method of measuring the density of a flow of slurry is to compare pressure readings taken at both ends of a section of discharge pipe that has been convoluted in a specific manner.

A unique type of, non-nuclear density meter has come on the market that features a section of flexible tube enclosed in an oversized pipe. The cumbersome-appearing unit is inserted into the dredge pipeline onboard the dredge. As I understand it, deflection of the inner tube is measured as it sags in response to changes in slurry density. The deflection evidently can be equated to density. This is a neat idea if it proves to be accurate, durable and easy to maintain over time. Now, some four years after its launch into marketplace it seems to have dropped out of sight.

Instantaneous Readings

I have applied the word “instantaneous” to the word “readings” several times. That is because dredge parameters vary constantly. Such variability makes it necessary to take continuous instantaneous readings or “snapshots” and use the running average of the observed readings as a basis for the parameter readout or display.

Closing Thoughts

Pipeline velocity and density vary due to many factors only some of which can be controlled. For these reasons, measuring any dredge parameter with the expectation that it will remain constant for any length of time is not realistic.

Currently, in my view, the present methods of measuring velocity and density are suspect, not necessarily because the instruments are inherently inaccurate, but because their accuracy depends entirely on difficult-to-accomplish calibration procedures. Despite the questionable accuracy of the values generated by velocity and density measuring instruments these instruments will continue to be used as basis for payment until better methods are found.

Skullduggery

I once visited a contract dredging operation and saw the job superintendent “re-calibrate” the velocity meter that was being used to measure production. He explained that he knew the reading was too slow and must be adjusted.

I don't know if his conclusion was correct, but I do know that this man lacked any qualification or knowledge to make such a judgment.

This was likely a case of “putting a thumb” on the scale to increase the recorded rate of production. The customer was a government entity who evidently placed full confidence not only in the validity of the electronic production measuring system, but also in the integrity of the contractor. Such confidence was terribly misplaced.

Conclusions

Integrating values for flow and density to calculate rate of production is a straight-forward mathematical exercise that can be verified at any time. In this instance, mathematical certainty cannot apply to the derived rate of solids production because the validity of the input data—density and velocity—is suspect.

Inability to accurately determine the rate of solids production affects both owner and dredger. It behooves the owner to assure that access to both velocity and density meter circuitry is denied to all except when the owner (or his representative) accompanies the dredger. The effects of any adjustments (re-calibration) should be fully understood and agreed to by both parties.

Hanky-panky prevention is the goal here.

Contact willard@willardsays.com with questions, comment or criticism.