Willard Says……

Slightly useful stuff to know about dredging

Dredge History Done Lite

Recently I was asked to provide background material for an article in Rock Products Magazine. The article, which appeared in the October 2009 issue of that magazine, used only a small portion of the information I provided. The complete paper is presented below.

Background for the Rock Products article.

Willard Salemink is a walking encyclopedia of dredging technology. The 76-year-old founder of Twinkle earned his degree in general science from the University of Iowa in 1961 and began his career in steel fabrication. He founded, Assemblers Inc (No period after Inc), to concentrate on the design and construction of aggregate processing equipment including crushers, screens and conveyors.

In 1978 he got the chance to build a sand and gravel dredge. His research in preparation for building his first dredge revealed a general lack of practical information about dredges and how they work. He observed that many dredges were producing poorly for reasons that he identified despite his inexperience.

He saw opportunity and set a goal of building better hydraulic dredges and finding ways to increase their productivity. Dredges became Assemblers, Inc sole business. Salemink recently took some time with Rock Products to share his knowledge and experience.

His first dredge had a diesel engine, an 8-inch pump and a cutterhead that could dig down to 35 feet. He kept it simple and applied the concepts he observed by visiting other dredges in the area. That was 30 years ago, and the dredge is still operating at River Products in eastern Iowa.

“We made a little money on it, which was our first goal,” Salemink says. “And it seemed to work pretty well.”

Assemblers Inc. began pitching the idea to sand and gravel producers with whom he already had solid relations. It garnered three or four buyers, and over the next five years he designed all of Assemblers dredges. In 1983, he left Assemblers and founded Twinkle Co.

"It just tripped my trigger," Salemink said. "Dredge operation had a kind of mystery about it back then, and there wasn't a lot of available literature. If you did not have ten years of dredge operating experience you were ignored." So he spent a lot of time experimenting and demonstrating his ideas to the industry. He was a one-man gang, he says. He sold instruments and controls to producers all over the eastern two thirds of the United States. Eventually he found new opportunities to start building dredges.

He says the suction inlet of hydraulic sand and gravel dredges usually identifies them as one of four viable versions; plain suction, cutterhead, linear-cutter or bucket wheel. Mechanical dredges are still widely used and include draglines, excavators, clamshells, drag (Sauerman Crescent) scrapers, and bucket ladder dredges.

Plain-suction dredges are getting scarcer as owners come to realize that these machines lack the means to attack the deposit. They see that production suffers when solids are not loosened fast enough and when oversize cobbles are allowed to enter and lodge in the pump. The proper mechanical digger solves those problems.

The cutterhead dredge is an old concept. Salemink says the oldest he ever set foot on dated back to the 1920s. Although, he says dredges started digging much earlier. Back then hydraulics were relatively primitive so dredge machinery was actuated by mechanical means, which made them very cumbersome to operate. Rotary cutters used line shafts extending down the ladder from a gearbox or a set of open gears above the water.

The cutterhead is usually the tool of choice for use in a deposit consisting of free-flowing material containing few cobbles. Salemink says it is a rule of thumb that a dredge pump will pass cobbles that are no larger than half the diameter of the discharge port. Cobbles that are too big will lodge in the pump and cause downtime.

Rotary cutters are common but they have an inherent limitation that often becomes apparent when mining sand, gravel and cobbles. They cannot dig any deeper once a "blanket" of oversize cobbles covers the floor of the deposit. These cobbles keep the cutter from cutting. The usual complaint when this occurs is that the cutter has hit a layer of "hardpan".

The linear cutter becomes the tool of choice when a deposit contains a significant quantity of oversize cobbles and/or clay layers.

A linear-cutter, or chain ladder, essentially consists of a large endless chain moving in a track around a steel frame and operated as a trencher. The chain resembles a giant bicycle chain with each link weighing 35 pounds or more which travels down the bottom track, up over a 180-degree arc "nose" at the end of the frame and back up the top track. The suction pipe inlet is positioned behind the chain at the nose. Only sand and cobbles small enough to pass through the chain links can flow into the pump. The moving chain (ten to twenty feet per minute) loosens solids and moves oversize out of the way so that it cannot interfere with continuing downward digging action. Linear cutters usually solve "hardpan" problems.

Bucket wheel dredges are in limited use mostly in ore deposits. They are effective for mining fine grained solids and ineffective when cobbles are present in the materials bank.

Hydraulic sand and gravel dredge mining is best carried out by keeping the suction inlet at the bottom of the material slope so that it undermines the bank to cause cave-ins. The cascading solids create a fairly uniform mixture of the various particle sizes in the deposit. Process plants operate much more efficiently when fed a stream of solids with a constant gradation.

The most common (hullpump) dredge arrangement has the pump located at or above water level. These machines can be very productive for mining down to a depth of about 35 feet. Deeper than that, hullpump productivity decreases and it continues to decrease as the mining depth increases. This limitation applies because any pump located at or above the surface of the water has only atmospheric pressure to cause water and solids to flow into its inlet. This pressure, about 15 psi, will raise a dense mixture a short distance, however, as the vertical lift (depth) increases the density of the mixture must decrease or flow will stop altogether.

The ladderpump dredge overcomes the hullpump's atmospheric pressure limitation by having its pump mounted on the digging ladder where it operates submerged under many feet of water. Immersed, a pump has atmospheric pressure plus the pressure created by the weight of the water above it to cause water and solids to flow into its inlet. A ladderpump's rate of production is not limited by depth, only by its ability to pump the mixture to the discharge point. Salemink has designed dredges that are mining at depths of over 100 feet. Structurally and functionally ladderpump dredges can go much deeper, however, the likelihood of being buried under a cave-in increases with depth.

In the 1970s the number of operating ladderpump dredges began to increase, as sand and gravel producer became aware of their great productive capability.

Salemink says that dredges are usually purchased with the goal of obtaining a certain rate of production. Productive capability relates to pump size. The choice of whether to use a moderately priced hullpump or a relatively expensive ladderpump rests on factors such as the mining depth, the desired efficiency and the desired rate of production. Cost and efficiency concerns dictate that the pump be no larger than necessary to achieve production goals.

Hydraulic dredge mining is usually less expensive than mechanical methods because only one man and one machine are required to pick up solids from underwater and deliver them to a distant process plant.

That contrasts with mechanical mining machines, which raise aggregate from underwater to a point where auxiliary means—conveyors, loaders or trucks—are required to move the material to a process.

The dragline, the modern classic mining machine, is gradually fading from use. Why? Difficulty of finding experienced operators, high operating expense and limited digging depth capability (Approximately one third of the boom length).

The backhoe or excavator is a popular replacement for the dragline. It has a lower operating cost, a large pool of experienced operators, however, it cannot mine very deep and must operate while positioned very close to the bank that it is undermining.

The number of floating clamshell-mining machines is slowly increasing for several reasons; It mines to a depth of 200 feet or more, Can be fully automated, brings up just about everything that is down there—sand, cobbles and boulders. While these machines are costly to buy and operate, there are applications where no other machine will do.

The Sauerman Crescent scraper system should be on the endangered species list of underwater mining machines because it is becoming quite rare. Very popular from the early 1900s through the 1950s, this ruggedly simple mining machine featured state-of-the-art components such as a two-drum winch, a special drag bucket and cables and pulleys. The bucket simply dragged aggregate to the surface from underwater.

As far as Salemink knows, only Ohio can boast of having a bucket ladder dredge at work mining sand and gravel.

Many mechanical dredge users view the idea of hydraulic dredging with a skeptical eye. Evidently that is because the operation of a mechanical dredge is observable. Each yard of solids brought to the surface can be seen and counted as production. In contrast, hydraulic dredge production takes place out of view and requires the use of instruments. Salemink has encountered this bias several times when trying to convince dragline users to try a whole new idea.

Man has always used dredges of some sort to create and maintain navigable waterways. Some theorize that thousands of years ago blocks of stone that make up the Pyramids in Egypt were barged from a distant quarry through a dredged canal.

The first dredge was probably a barge supporting slaves who were using long-handled dipper shovels to raise solids out of a waterway to the barge deck for disposal elsewhere.

Productivity gains likely came about when animal power was used to increase the digging power of early dredges.

The late 1800's saw the development of electric and steam power units. These high-horsepower prime movers enabled dredgers to build huge dredges with bucket ladders and centrifugal pumps. Interestingly, some of the dredges used to construct the Panama Canal were built by Ellicott and that nameplate is still being put on new dredges today.

Small diesel engines rated up to about 200 horsepower came along in the 1930s and made small 6 to 12-inch hydraulic dredges practical. After WWII, small, mostly home-built sand and gravel dredges proliferated as the nation went on a building boom and cheap war surplus engines came on the market. Starting in the 50's, diesel engines steadily increased in power and decreased in weight, which enabled powerful factory-built portable dredges to enter the market in numbers.

Hydraulic technology made great advancements in the 60s with the result that hydraulic winches and hydraulic rotary cutter drives became a welcome replacement for clunky mechanical drives.

Fixed-site sand and gravel producers often have sufficient, relatively cheap commercial electric power available at their plants to power a mining dredge. In the late 40's scores of motors and controllers salvaged out of obsolescent electric trains came on the market. Many of these were adapted to power small dredge pumps and a few are still in operation. These drives were very inefficient but they were cheap and provided a way to vary pump speed.

DC electric dredge pump drives became popular in the 70s made possible by the large quantity of reconditioned surplus traction motors originally used to power the axles of diesel-electric locomotives. These drives were very dependable, efficient and provided variable pump speed.

AC variable frequency drives are the latest thing in electric dredge pump drives. They are very efficient, use standard electric motors, have variable speed and are available from a number of sources.

Salemink's goal has always been to find ways to improve hydraulic dredge efficiency. He constantly stresses that high dredge efficiency and production is possible only through the use of instruments and controls, especially the velocity meter. He continues work to improve his suction bypass valve system, vacuum and pressure sensors, rotary and linear cutters as well as general dredge design. He freely shares his knowledge and experience and answers specific questions through his website www.willardsays.com.

Salemink takes issue with the quote that says, "There are two kinds of dredge, those that have sunk and those that are going to sink."

Not all dredges have to sink, explains Twinkle founder Willard Salemink.

Most dredges have two types of flotation spaces: sealed (closed to atmosphere) and floodable (open to atmosphere). A dredge cannot sink if it has sufficient sealed flotation space to stay afloat when the floodable spaces are flooded.

Salemink says he agrees with a rule of dredging which says that, "Floodable space will eventually flood."

If a dredge has floodable spaces, calculations are required to determine if the dredge will stay afloat if all floodable space are flooded. If the answer is no, sealed flotation cells need to be added. Of course, many people don't Salemink says. Those who do not pay now will pay later after the dredge goes down.

Salemink is a proponent of round pontoons opposed to square or rectangular. Advantages include fewest pounds of steel per cubic foot of displacement, automated fabrication and no need for internal stiffening.

“I became very sensitive to the need to leave machinery accessible,” says Twinkle Founder Willard Salemink. “Sooner or later this stuff is going to leak, break, wear out, corrode or vibrate to failure.”

Everything eventually will need to be inspected, repaired or replaced. So designing a dredge where parts are inaccessible is counterintuitive. Hydraulic lines should not be covered by the deck or located in the far spaces of the hull. They are better placed on the pontoons. Engines should likewise be exposed and not buried in the pump house. The same is true for drives.

Salemink says that his dredges were built around this theory and often are characterized by competitors as being wimpy. He takes that as a compliment but prefers to call them structurally elegant with touches of rugged simplicity.

The explanation for the name Twinkle Co here excerpted from the intro to Twinkleco.com;

“Like our dredges, our company name is unique. When choosing the name Salemink wanted something to set the new company apart from the crowd. The name had to have a positive connotation, be easy to remember and non-specific as to product or service. "Twinkle" was chosen and the name has been a tremendous success.”