Convert Peanuts into Gold with the Right Pump or Gunite Machine

By Jim Farrell

A concrete pump and a gunite machine are work tools that can help a contractor turn a nickel's worth of concrete material into a dime, a quarter, or even a dollar using the wet- or dry-mix shotcrete process.

The odds of being successful are greatly enhanced with the selection of the correct tool and the correct material, combined with the knowledge and experience to properly use both. There are several types of pumps and gunite machines that can be used for the shotcrete process. Shotcrete is defined by ACI CT-13, "Concrete Terminology," as "concrete placed by a high-velocity pneumatic projection from a nozzle." Concrete material can also be air-placed using a lower velocity of compressed air combined with a smaller orifice nozzle. This technique is not recognized as shotcrete by the American Concrete Institute (ACI) or the American Shotcrete Association (ASA). In Europe, this low-velocity process has been referred to as "spray-up"; however, in the United States, spray-up is used in many concrete applications.

The four types of pumps for the wet-mix shotcrete process include:

- Hydraulic swing tube;
- Hydraulic peristaltic or squeeze;
- Rotor stator; and
- Hydraulic ball valve or ball seat pumps.

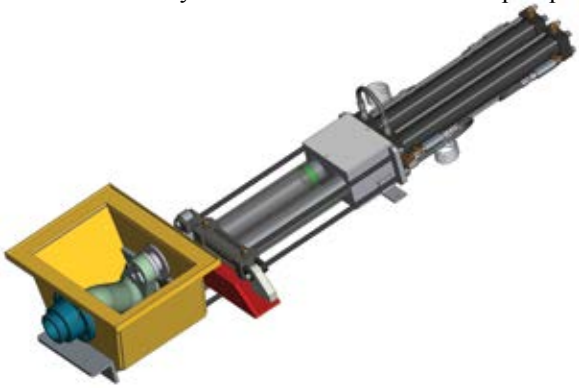

Fig. 1: The swing tube pump is a combination of two hydraulic cylinders that act as differential cylinders that are connected to and shift two material-pumping cylinders that come in direct contact with the material

The most popular type of gunite machine for the dry-mix process is a rotary gun.

Hydraulic Swing Tube Pump

The swing tube pump (refer to Fig. 1) is a combination of two hydraulic cylinders that act as differential cylinders that are connected to and shift two material-pumping cylinders that come in direct contact with the material. A single "S" tube shifts from one material cylinder to the other, activated by a hydraulic cylinder, so that each cylinder that is full of material can be discharged through the "S" tube and into a delivery line that is connected to the outlet of the pump. Each differential cylinder includes a proximity switch that sends an electrical signal to the hydraulic cylinder, which shifts the "S" tube. This pumping process is controlled by a sealed electrical control box and is synchronized.

Swing tube pumps recommended for shotcrete come in sizes with 3 and 4 in. (75 and 100 mm) outlets. The 3 in. (75 mm) pump would be recommended for jobs from 2 to 8 yd^3/h (1.5 to 6 m^3/h), and the 4 in. (100 mm) pump for jobs that require 9 to 20 yd^3/h (7 to 15 m^3/h). Swing tube pumps with outlets larger than 4 in. (100 mm) will result in significant surging at the nozzle because the speed of the pump must be reduced so that the nozzleman will not be overwhelmed with material, which is unacceptable.

The output or material pressure at pump discharge from a swing tube pump can vary from 750 to 2100 psi (5.2 to 14 MPa). The size of the delivery line is typically reduced down to 2 in. (50 mm) or even 1.5 in. (38 mm) at the nozzle. Trying to handle a delivery line in excess of 2 in. (50 mm) is almost impossible for a nozzleman because of the weight of the hose and nozzle. The higher pumping pressure capabilities of the pump typically results in the ability of the pump to convey harsh, lower-slump materials and to pump longer distances vertically and horizontally. The swing-out receiving hopper is very helpful in cleaning and servicing the pump.

Advantages of a swing tube pump:

- Highest pumping pressure for harsh materials and long distance pumping;
- Pump will run in reverse for safety in case of hose plug; and
- Infinitely variable pumping speed for high and low output.

Disadvantages of a swing tube pump:

- Higher cost to purchase; and
- Requires a trained and experienced operator.

Squeeze Tube or Peristaltic Pumps

A squeeze pump (Fig. 2) operates on the same principal as filling a straw with a milkshake and using your thumb and index finger to squeeze the milkshake out of the straw. Two squeeze rollers are mounted on a roller assembly inside a drum. Pairs of "following rollers" are mounted between the two squeeze rollers to keep the pumping tube in alignment. A rubber pumping tube is mounted on the inside circumference of the drum housing. A heavy-duty shaft is connected to the assembly that holds the squeeze rollers and follower rollers in place, and this shaft is held in place by the pump housing. A heavy-duty gear box powered by a hydraulic motor turns the rotor shaft, which turns the squeeze roller assembly. As the rollers turn and make contact with the tube, the rollers squeeze the tube closed, which causes the material to fill the tube on the suction side and discharge from the tube on the discharge side. The speed the rollers turn is directly related to the pump output, which is infinitely variable from 0 to 30 rpm. The pump can be reversed to pump in either direction. The pump also can be run dry without damage to the pump.

Squeeze pumps come in three sizes: 2 x 22 in. (50 x 560 mm) diameter with an output of 0 to 5 yd^3/h (0 to 3.8 m^3/h); 3 x 28 in. (75 x 710 mm) diameter with an output of 0 to 12 yd^3/h (0 to 9 m^3/h); and 3 x 36 in. (75 x 910 mm) diameter with an output of 0 to 25 yd^3/h (0 to 19 m^3/h). A roller-driven pump, where the squeeze rollers are under power rather than the rotor being under power, is also available in a 3 x 36 in. (75 x 910 mm) pump with 0 to 25 yd^3/h (0 to 19 m^3/h) output.

Squeeze pumps provide the lowest output pressure when compared to swing tube, rotor stator, or ball seat pumps. The maximum output pressure at pump discharge is 500 psi (3.4 MPa). As a result, squeeze pumps would not be recommended for pumping larger than 0.5 in. (13 mm) aggregate, exceeding 50 ft (15 m) vertically and 250 ft (76 m) horizontally. The slump of the material should not be less than 3 in. (75 mm). Squeeze pumps are preferred for cellular concrete because the lower pressure does not damage the bubbles in this material. Squeeze pumps have also been used successfully to pump shotcrete with steel and synthetic fibers.

Fig. 2: A squeeze pump operates on the same principal as filling a straw with a milkshake and using your thumb and index finger to squeeze the milkshake out of the straw

The lower pumping pressure makes a squeeze pump the safest to operate and, in many cases, customers with no concrete pumping experience can safely operate a squeeze pump.

The squeeze pump's wear part is the rubber pumping tube, and the tube can be replaced in about 30 minutes. The pumping tube should be lubricated on the underside where the squeeze rollers make contact with the tube to reduce friction and improve the life of the tube. The squeeze pump is the only concrete pump that is available as a skidsteer work tool. The squeeze pump work tool is the least expensive concrete pump on the market.

Advantages of the squeeze pump:

- Lowest cost to purchase and maintain;
- Low pumping pressure friendly to cellular concrete and low-velocity spray-up as well as standard shotcrete;
- No nozzle blowback, which is much less stressful to a nozzleman;
- Most simple and safe to operate and available as skidsteer work tool; and
- Pumps in both directions without priming.

Disadvantages of the squeeze pump:

- Limited to 50 ft (15 m) vertical, 250 ft (76 m) horizontal, and over 3 in. (75 mm) slump material.

Hydraulic Ball Valve Pump

The hydraulic ball valve (also known as ball seat) (refer to Fig. 3) is similar to the swing tube or "S" tube pump in that both use two hydraulic cylinders as differential cylinders to load and unload the material inside two 24 in. (610 mm) long by 4 in. (100 mm) diameter pumping cylinders. The hydraulic cylinders are attached to

the pumping cylinders on end and the pumping cylinders are attached with a heavy-duty clamp to a pump manifold. The manifold is bolted to the material hopper. The pump manifold includes four balls and four seats. Each hydraulic cylinder has a proximity switch that leads to an electrical control box to automatically shift the cylinder to load and unload the pumping tube. When the pump is loading with material from the material hopper, the suction causes the ball to move to a stop to allow material to be sucked inside the pumping tube. When the hydraulic cylinder reverses to unload the pumping tube, the pressure of the material moves the ball into the seat and the material in the pumping cylinder is pushed up and out of the manifold, which serves as a housing for the balls and seats. The discharge outlet is reduced from 5 in. (125 mm) to 4 in. (100 mm) to 3 in. (75 mm) at the pump outlet, where the 3 in. (75 mm) delivery line is attached.

The manifold is attached to the pumping cylinders with heavy-duty clamps. The manifold is bolted to the receiving hopper on the opposite side of the manifold where the material loads into the manifold from the receiving hopper. When the clamps are removed from the pumping cylinders, the manifold becomes a part of the receiving hopper assembly. A hydraulic cylinder attached to the receiving hopper moves this entire assembly up and away from the pumping cylinders for easy access for cleaning and maintenance.

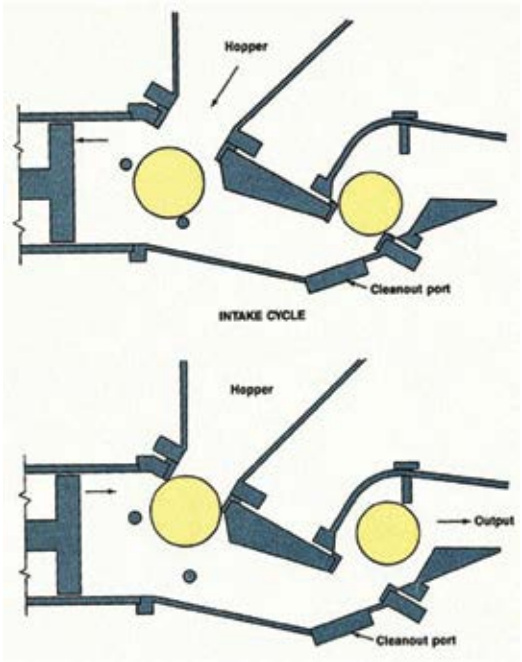

Fig. 3: The hydraulic ball valve, or ball seat, uses two hydraulic cylinders as differential cylinders to load and unload the material inside two 24 in. long by 4 in. diameter pumping cylinders

The ball valve pump delivers up to 1100 psi (7.6 MPa) pumping pressure; however, it is limited to 3/8 in. (10 mm) aggregate and a slump that is not less than 3 in. (75 mm). The ball valve pump will not run in reverse; therefore, extreme caution must be taken to relieve the pressure on the delivery line should the line plug. There is a small ball valve on the discharge pipe of the manifold to manually relieve this pressure. Materials such as gypsum flooring materials, which are very plastic in nature, tend to build up over time in the receiving hopper and manifold. Shotcrete materials do not have these same characteristics and will work well provided the aggregate does not exceed 3/8 in. (10 mm) in diameter.

Advantages of a ball seat pump:

- Lower cost to purchase than swing tube pump; and
- Simple and quick to maintain.

Disadvantages of ball seat pump:

- Cannot run in reverse so caution must be taken with hose plugs; and
- Oversized aggregate will not pass between ball and seat.

Rotor Stator, Screw, Progressive Cavity, or Worm Pump

Rotor stator pumps (refer to Fig. 4) are available in many sizes. The eccentric screw pump or rotor stator is a progressive cavity pump. The design of the progressive cavity pump consists of a single-threaded screw or rotor, turning inside a double-threaded stator. The rotor seals tightly against the rubber stator during rotation, forming a set of fixed-size cavities in between. The cavities move when the rotor is rotated but their shape or volume does not change. As the rotor rotates inside the stator, cavities form at the suction end of the stator, with one cavity closing as the other opens. The cavities progress axially from one end of the stator to the other as the rotor turns, moving mortar through the pump. New spaces/cavities are created when the rotor is turning that move axial from the suction side toward the pressure side. The suction side and the pressure side are always sealed off, and a continuous flow of material is created. The material exits the pump and is conveyed hydraulically, under pressure through a rubber hose or steel pipe, to the point of placement.

The benefit of a rotor stator pump is there is no pulsation when material is continuously fed. Most applications for rotor stator pumps use the low-

velocity or spray-up method. A rotor stator pump can generate up to 600 psi (4.1 MPa) of pumping pressure. These pumps are commonly used for pumping highly flowable materials, but they can tolerate small aggregate. Too sharp of aggregate may result in premature wear of the stator.

Advantages of rotor stator pump:

- No pulsation;
- Low cost to purchase; and
- Good mid-range pumping pressure.

Disadvantages of rotor stator pump:

- Aggregate will affect rotor stator wear; and
- Rotor stator costs.

Rotary Gunite Machine

A rotary gunite machine (refer to Fig. 5) is recommended for the dry-mix shotcrete process. In the rotary barrel-type gun, a rotor, available with rotor openings of various shapes and sizes, is sandwiched between a top plate and a bottom plate that has been machined flat. Rubber wear pads are mounted to the underside of the top plate and the top of the bottom plate. Case-hardened metal wear plates are mounted to the top and bottom of the rotor. A single, self-leveling bolt tightens the top plate to the bottom plate and seals the rotor between the two rubber wear pads to guarantee a seal. A high volume of compressed air is connected to an inlet on the top plate and this compressed air is used to convey the material from the pockets of the rotor that are full of material through a 90-degree fitting attached to the underside of the bottom plate and into the delivery line. Additional compressed air is connected to the delivery line. The speed the rotor turns is directly related to the amount of material that will pass through the rotor section. A nozzle with a water ring is attached to the end of the delivery line to hydrate the material. A water valve adjusted by the nozzleman provides control of the level of water injected into the dry-mix materials flowing through the nozzle. Standard delivery lines vary from 2.5 in. (62 mm) down to 1.25 in. (30 mm) in diameter. Acceptable hydration has occurred when the material has been hydrated to 10 to 12% by weight of the concrete materials.

The power supply is available with an electric motor, air motor, gas or diesel engine, and hydraulics. The rotary gun is also available as a skidsteer work tool. The dry-mix shotcrete process means that the material remains "dry" until it is properly hydrated at the nozzle. Best results occur if the material has 3 to 5% moisture when loaded into the hopper of the gunite machine. To accomplish this, preparation should be made to pre-dampen the material, if needed.

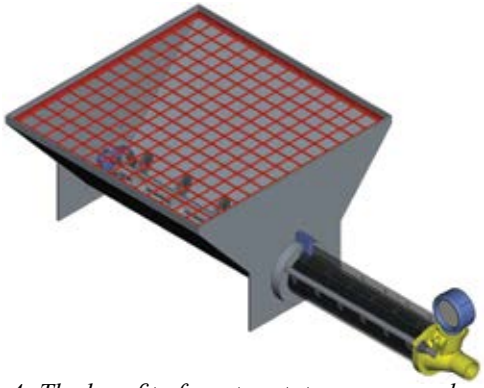

Fig. 4: The benefit of a rotor stator pump, such as this one, is there is no pulsation when material is continuously fed

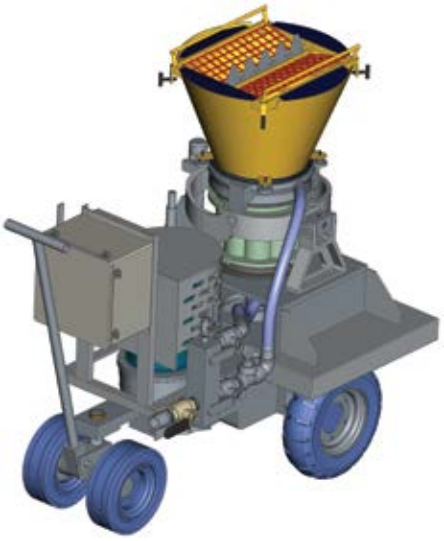

Fig. 5: A concrete pump and a gunite machine, such as the one pictured, are work tools that can help a contractor turn a nickel's worth of concrete material into a dime, a quarter, or even a dollar using the wet- or dry-shotcrete process

Advantages of rotary gun for dry-mix shotcrete process:

- Precise control of material flow for low or high output;
- Easy stop and start with no cleanup; and
- More forgiving to variations in aggregate size.

Disadvantage of rotary gun for dry shotcrete:

- Generates more dust and waste, particularly if not properly hydrated; and
- Requires more compressed air to convey material.

***Jim Farrell**, CEO of Blastcrete Equipment Company, has nearly 40 years of experience in specialty refractory products, including shotcrete and gunite equipment. He heads the family-owned company based in Anniston, AL, and serves customers around the world.*