Dry-Mix Equipment Maintenance

By Todd Ferguson

Maintaining your dry-mix shotcrete (gunite) equipment ensures that your crew will get the most efficient production, maximum service life, and safest operation from your machinery and accessories. The typical dry-mix shotcrete equipment setup includes a gunite machine, material nozzle, material hose, water hose, air compressor, and air hose. Equipment manuals from manufacturers should detail all the necessary steps for complete equipment maintenance. Still, it is important to review these procedures with members of the crew, especially those in charge of the equipment on a daily basis.

Dry-Mix Shotcrete (Gunite) Machines: Bowl Type

Gunite machine maintenance begins on the first day you put it into service. When setting up equipment for initial use, you will complete preventative maintenance procedures, such as lubrication. Two main classes of gunite machines are in use today: bowl-type gunite machines and barrel-style gunite machines. Both are considered "rotary" gunite machines (rotary guns), as they both are designed with rotating feed systems. These designs are in contrast to pressurized single- and double-chamber guns, which have fallen out of popular use. This article will focus on bowl-type designs (Fig. 1).

Bowl-type gunite machines contain a feed system including a material feed bowl, steel wear plate, rubber wear pad, and material outlet, also known as the "gooseneck." Owners will have to replace the wear plate, wear pad, and a polyurethane liner within the gooseneck at various intervals of service. Clean the entire bowl and oil its pockets each day to prevent accumulation. Feed bowls are either designed with steel or a combination of steel/polyurethane. To remove buildup on a steel feed bowl, use a hammer and chisel. To remove buildup on a steel/poly bowl, turn it upside down and strike it with a rubber mallet first to loosen any buildup material. Then turn the bowl right-side-up again and carefully remove the loosened material with a screwdriver.

Over time, the wear plate will become misshapen from constant contact with dry shotcrete material. Grooves may appear in the walls of the pockets or the surface of the plate may become uneven (that is, not completely flat). When this occurs, the wear plate will not function correctly, causing air leaks between the bowl and the plate or uneven rotation. The wear plate should then be resurfaced by "Blanchard" grinding or comparable technology described in the equipment manual (Fig. 2).

The wear pad functions as a seal between the wear plate and the gooseneck outlet assembly and is in direct contact with the flow of material. Over time, the wear pad will develop grooves from material passing over it and should be replaced. Grooves in the wear pad can allow excess material to cause additional wear on the plate. Manufacturers highly recommend replacing the wear pad as soon as grooves appear. Replacement at regular intervals will prolong the life of the wear plate, ensure the efficient flow of air in the system, and reduce escaping dust at the gooseneck assembly (Fig. 3). An overabundance of dust-creating materials on the job can lead to unsafe working conditions. Contractors should be sure to limit the exposure of their crew to potentially harmful components that may be present in dry-mix materials. If you find a mound of dry-mix material next to your gunite machine, there is something wrong and the equipment should be checked. The wear pad is the first item to check for wear when material is escaping. Never try to extend the life of a wear pad with excessive tightening of the hold-down clamps. This can cause undue stress on other components on the machine and could potentially lead to unsafe operation (Fig. 4).

A strip of felt provides a seal where the bottom of the hopper meets the wear plate. This felt seal should be lubricated daily until it is flexible enough to provide an adequate seal. Once the felt seal is dry and hardened, you will need to replace it. Some manufacturers have provided a conve-

Fig. 1: Bowl-type rotary gunite machine (dry-mix shotcrete machine)

Fig. 2: Worn plate (left), new plate (right)

Fig. 3: Gunite machine view of wear pad

Fig. 4: New wear pad (left), worn wear pad (right)

nient means of oiling and adjusting the felt seal from outside the hopper without dismantling the machine. This lubrication and adjustment is achieved through strategic access holes designed into the hopper. A felt seal that is in good working condition is critical to avoid letting dust escape between the hopper and the wear plate. As stated previously, excessive dust on the job can create a health risk to workers and must be controlled.

The gooseneck contains a polyurethane liner to prevent wear directly on the steel surface of the gooseneck. Replace the liner when it has worn through to prolong life of the gooseneck. The amount of wear is dependent on the type of materials being used; however, liners should provide approximately 80 yd^3 (61 m^3) of service. It is not advisable to operate the gun without this gooseneck liner for economic reasons. The liner comes with a smaller price tag than the gooseneck, so it only makes sense to keep the usable liner in place to accommodate the wear.

Various parts of the gunite machine require regular lubrication. Before every job, lubricate the bowl and plate with oil as specified in the equipment manual. When oiling the feed bowl, make sure to thoroughly coat the pockets of the bowl, which primes the steel for use and helps reduce the amount of dried material that sticks to the surface. The bowl and plate touch each other directly in the machine, so proper, regular lubrication helps reduce wear between these two components (Fig. 5).

Many gunite machines are entirely powered by air, which is used independently to rotate the feed system and to propel dry material out of the gooseneck through the material hose to the nozzle. These machines include an air motor that controls rotation of a series of gears and the main shaft. Air lines (that is, plumbing pipes and fittings) that deliver air to the motor are equipped with a filter and lubricator. The filter ensures that air going into the system is clean and the lubricator gives the passing air a small amount of oil. Both ensure smooth operation of the air motor. Inspect the air filter weekly and clean if needed. New machines may arrive from the factory with an empty air lubricator that is also closed to oil flow. It is critical when receiving delivery of a new machine to fill this lubricator and adjust the flow of oil. Before each job, make sure that the air lubricator is filled with oil according to the directions in the equipment manual. Manuals should include recommendations on the number of drops per second or minute, such as one drop every 10 to 15 seconds. On many gunite machines, the air motor is connected to a gear box, which requires lubrication. You should be able to check the oil level in

the gear box by accessing a dipstick. Check this oil level regularly, for example, after every 40 hours of operation.

Gunite machines include material screens placed over the hopper to help prevent the introduction of aggregates larger than the machine is designed to process. Typical bowl-type gunite machines can process aggregates up to 3/4 in. (20 mm). It is common for material to build up on the material screen over time, which can reduce the size of the spaces in the screen. This may not be cause to worry because you want to prevent oversized rocks from entering the hopper. Keep material screens in good repair so they function as designed, and keep them in place over the hopper to help avoid accidents with the rotating agitator inside the hopper.

Within the feed system, a piece of metal called a rock shear is present to catch any large rocks that may have accidentally gotten into the machine. If a large rock comes into contact with the rock shear, the feed system will not rotate and you will need to shut down the machine to remove the rock. The rock shear is in direct contact with material flow so it is a wear item. Check the rock shear on a weekly basis. It can be rotated four times to place a clean edge in contact with material. You will also need to adjust the rock shear to the correct distance from the wear plate during setup.

Fig. 5: Gunite machine components

Fig. 6: New water ring (left), worn water ring (right)

General maintenance on a daily basis will prolong the life of your gunite machine. Be sure to disconnect the air line from the air compressor and bleed off any remaining air in the system when performing any maintenance on the machine. Do not reach down into the hopper when the air line is connected because the agitator could begin rotating, causing a dangerous situation. If air is flowing to the gunite machine and a valve is opened, that incoming air could cause rotation of the feed system, including the agitator—this is no place for your hands or arms.

Certain areas of the gunite machine will require daily cleaning. Some models may include an exhaust chamber to catch dust and prevent it from rising out of the hopper. This item is not necessarily considered a wear item, but it is important to keep it emptied out each day. Clean any built-up material from the inside of the hopper base, which could catch on the feed bowl and prevent rotation. Clean the main shaft and baseplate daily to ensure a smooth rotation of the feed system. An exhaust hose may be connected to the machine to further reduce dust in the working environment, which helps to provide workers with the cleanest, most breathable air.

Dry-Mix Shotcrete (Gunite) Nozzles

Dry-mix nozzles are designed to receive dry or pre-dampened material from the gunite machine and water from a source with adequate pressure. The two components mix together at the last moment before they are propelled onto the construction surface. Nozzle maintenance is important for achieving proper mixing of water and material within the nozzle. The water ring is the most important part of the nozzle to keep clean. The water ring, which may be brass or aluminum, includes holes to allow water to pass through at high pressure into the nozzle body during operation (Fig. 6). Be sure to inspect the water ring before a job to make sure these holes are free and clear from any buildup. Manu-

Fig. 7: Dry-mix nozzle components (showing "double bubble" style tip)

facturers also recommend coating the water ring with oil to prolong its usefulness. Replace the water ring when it cannot be cleaned or when it has become misshapen. Do not drill out the holes in the water ring because they are specifically sized to provide proper distribution of water into the dry-mix material flowing through the water ring.

Dismantle the nozzle assembly after each day of use and thoroughly clean the inside and outside to ensure performance on the next job. (Fig. 7) You may also be able to clean the nozzle without disassembly by one of two methods: 1) you can use the valves on the gunite machine to send air to the nozzle from the gunite machine without sending material. Combine this with water flow to the nozzle and you may be able to thoroughly clean the nozzle parts, including the water ring; or 2) you may achieve success without the use of compressed air by simply pointing the nozzle down and allowing water to flow through the nozzle's water connection.

Nozzles may either have a steel tip with a rubber liner or a polyurethane tip. If using a nozzle with a liner, be sure to inspect it regularly and replace the nozzle liner when worn through. The amount of wear is dependent on the type of materials being used; however, liners should provide approximately 80 yd^3 (61 m^3) of service. The nozzle liner should include "steps" or ridges that are built in to help mix material in the nozzle. (Fig. 8) These steps can be seen close-up or can be felt by touching inside the end of the nozzle liner. When steps have worn away from material flow, it is time to replace the nozzle liner. Nozzle tips should not be cut or shortened, as this can prevent material from mixing adequately in the nozzle. Without proper mixing within the nozzle,

Fig. 8: Dry-mix nozzle liner with interior steps/ribs

the quality of the concrete being placed on the construction surface is compromised. It may lead to uneven distribution of sand and cement, which can result in an unreliable or even unsafe structure. Polyurethane tip designs may last longer than a liner. Their overall longevity may vary depending on the thickness of the material used or overall design and shape.

Fig. 9: Nozzleman using anti-static dry-mix hose

Material Hoses

Be sure to only use a material hose designed for dry-mix to ensure performance and allow for predictability in terms of wear. Before every use, inspect all material hoses, air hoses, and water hoses for cracking, abrasions, or excessive wear, and replace hoses if necessary. Hose fatigue will vary with the type of material being used. Squeeze and bend hoses to determine if they have become too thin or can be bent too easily. If you notice a split in the hose or if it appears "bleached out" and lightened in color, that hose may be due for replacement. Worn-out hoses can burst during operation, so it is important to monitor hose wear and replace as necessary (Fig. 9). Also inspect hose couplings regularly to ensure they are in safe working condition. A compromised coupling may become disconnected under pressure, causing risk to those within range. Look for any cracks, dents, or misshapen couplings and replace them right away. If couplings will be in direct contact with material during your job, be sure to cover the couplings to prevent buildup of material. For example, you may wrap the couplings with plastic. Hose fittings should be secured adequately to the hose and threads should be in good condition for use. To ensure the highest-strength coupled hose assembly, manufacturers and contractors should use elevator bolts instead of screws to install dry-mix couplings on hoses. Clean and grease all couplings daily to prolong their use. When using pre-dampened materials, hoses may be more susceptible to build up within the hose. This buildup could potentially cause a blockage. Be sure to review the following procedure on hose blockages with all members of your crew(s).

When dry-mix hose blockages occur, the nozzleman should:

- Hold the nozzle firmly and brace against a wall or scaffold (do not lay the nozzle down);
- Direct the nozzle in a safe direction;
- Signal to shut off the gun/pump and water/air input; and
- Bleed off pressure at the gun.

When clearing a plug out of a dry-mix hose:

- Shut down and relieve pressure as noted;
- Locate the plug by walking along the hose to find where the hard points are;
- Once the plug is located, disconnect the nearest location between the nozzle and the plug;
- Work on the hard points with a hammer to try to loosen them up. I would suggest using a carpenter's hammer rather than a sledge-hammer, as you are only trying to loosen dry material by vibrating it—you do not want to damage the structure of the hose;
- Loosen up material from the nozzle end toward the gun. If you work the opposite way, you may just be allowing more material to get behind the plug and add to it;
- As you loosen up material, work to shake the loose material out of the end of the hose;
- Once the plug appears to be gone, have the nozzleman hold the hose while bracing himself, as stated previously. If the plug was loosened up properly, the material should just empty out of the hose as it normally would. The nozzleman should brace himself in case the plug was only partially cleared and lets loose; and
- If the plug persists, work to manually shake more material out of the hose on both sides of the plug and try to clear again when it seems to be loosened.

Use "whip checks" on all air hose connections at the air compressor and gunite machine. Consider using whip checks on material hose connections because they are also subjected to high-pressure air flow.

Additional Equipment

Equipment owners should follow all manufacturers' recommendations to prolong the use of their machinery and accessories. Consult all manuals for maintenance of any other equipment used on the job, such as an air compressor, dry-mix batch plant, or pre-dampener, and keep up with regular maintenance. Proper maintenance also ensures that dry-mix equipment will deliver maximum output and efficiency. Consider developing a user-friendly checklist to help organize and manage the daily and weekly maintenance of your dry-mix equipment.

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