Dry-Mix Guns

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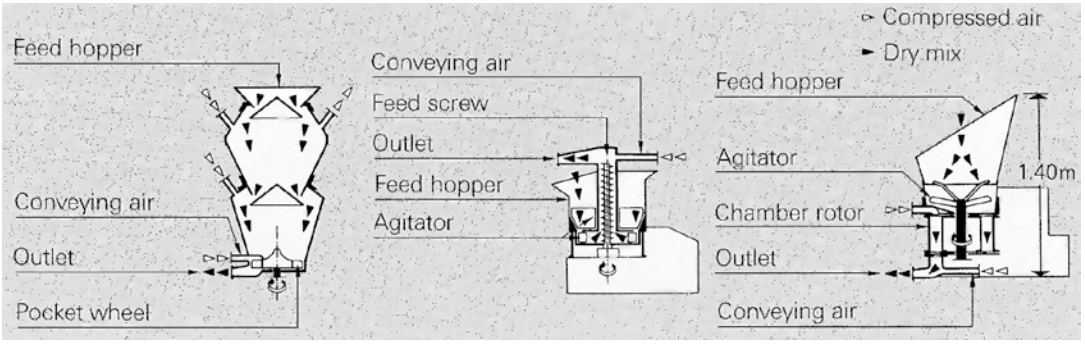

Fig. 1: Operating principle of the double-chamber gun, the screw-type gun, and the rotating-barrel gun

Basically, three different types of shotcrete guns exist for the dry-mix process, all of which work on the suspension-conveying principle. In order of their invention, they are (Fig. 1):

- double-chamber system;
- screw system; and
- rotating-barrel system.

The double-chamber system, which is still used occasionally today, was invented by Carl E. Akeley in 1907.[1] It employs two connected chambers arranged one above the other, with the discharge outlet at the bottom of the lower one. The feed opening of the upper chamber and the connection between the two chambers can be closed off hermetically with bell-shaped valves independently of one another. The bottom chamber is subjected to the same air pressure as the discharge line. The procedure starts with dry mix being filled into the upper chamber with the bell valve between the two chambers closed. Next, the feed opening is closed hermetically and the upper chamber is pressurized just like the lower one. Now the valve between the two chambers can be opened, allowing the mixture to slide from the upper into the lower chamber. After this has happened, the valve between the two chambers can be reclosed and the pressure released in the upper chamber to permit reopening of the inlet valve. In the meantime, the dry mix is discharged from the lower chamber by a pneumatically driven feed wheel and is picked up by the air stream in the discharge line. The upper chamber is refilled at the same time, and the cycle is repeated.

Up until the end of the 1940s, double-chamber machines, and above all the various models of the American Cement-Gun (Fig. 2), were the only machines available for guniting. They are still being built and used. Because of the need to manipulate valves and levers alternately, the gunman needs considerable skill and muscle. If he fails to fill either of the two chambers with dry mix promptly, the flow of material in the hose or pipe may be interrupted. The aggregates have to be dry and relatively small in gradation. These constraints made the application of shotcrete with double-chamber guns uneconomical on certain types of jobs and under certain conditions.

The screw-type gun was invented by Georg Senn and built by Spribag AG at Widen, Switzerland, in the early postwar years (Fig. 3). The machine raised the dry mixture from the open filling container with a screw in the form of an Archimedean screw (Fig. 1). Driven by an electric or pneumatic motor and rotating in a vertical pipe, the screw lifted the mixture up to the blow chamber from which compressed air carried it to the nozzle. The BS-12 screw-type gun handled naturally damp aggregates up to gradations of 25 mm at rates of about 3 m^3 of

Fig. 2: Double-chamber gun (Cement-Gun, 1914)

dry mix per h. This made it possible to produce genuine concrete with the normal gunning process for the first time. In effect then, one could really not speak of shotcrete before the invention of the screw-type gun because the double-chamber machines were suitable only for producing mortar or gunite. The new shotcrete, the ruggedness of Senn's screw-type gun, and the techniques for underground work that came to be developed with it all constituted the foundation for the ultimate worldwide success of the shotcrete process.

When the rotating-barrel system appeared, however, the screw-type gun disappeared from the market without trace. Developed in the postwar years in the United States on the basis of a Dutch patent, the rotating-barrel (rotor) system works on an entirely new type of principle (Fig. 1). The dry mixture passes from an open feed hopper into a rotor with a vertical axis of rotation and from the rotor into the discharge line. The rotor (or barrel) is equipped with vertical chambers of cylindrical or circular-sector chambers. As the rotor revolves, each chamber in turn comes underneath a feed opening, and the dry mixture—which is kept moving in the hopper by an agitator—drops in. The filled rotor chambers proceed to the outlet opening on the opposite side where downward-flowing compressed air blasts them into the discharge line.

The American gun, called Jetcreter (Fig. 4), was a heavy, awkward device that was hardly suitable for use underground. Meynadier & Cie AG in Zurich, Switzerland, proceeded to improve upon it with the sturdy Meyco GM 57 gun (Meyco for Meynadier, GM as an abbreviation for gunite machine, and 57 for 1957, the year the first machine was built). The Meyco GM 57 is suitable for use in tunnels. This 1957 model has been improved repeatedly in the meantime. Its clear superiority, in many respects, over the double-chamber system and the screw principle made it very successful right from the start.

The name Meyco GM 57 evokes some personal memories. The very first machine, Serial No. 1 (Fig. 5), was tried out for several months starting in October 1957 by Ernst Laich in Locarno, Switzerland, then a sole proprietorship (today Laich SA in Avegno), in Allotment 4 of the Fionnay-Nendaz pressure tunnel of the Grande Dixence hydroelectric power plant in Valais, Switzerland. Laich was satisfied and purchased the gun. The Laich company was working on this job as a subcontractor of the main contractor, for which I was working as an intern at the time to earn money for my education. One of my assignments was to record the performance figures for the new shotcrete gun. As a matter of fact, the Meyco GM 57 No. 1 is

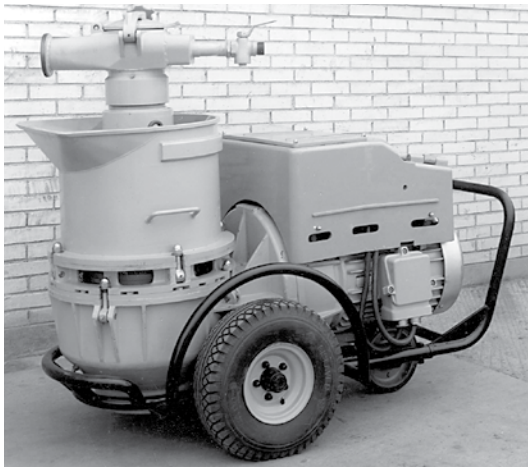

Fig. 3: Screw-type gun (Spribag BS-12, around 1950)

Fig. 4: American rotating-barrel gun (Jetcreter)

Fig. 5: Rotating-barrel gun (Meyco GM 57, No. 1)

still parked in our equipment lot, now out of service but operable and ready to go after all these years.

Soon, other machine manufacturers had also switched to the new system. The screw-type gun has disappeared, while the double-chamber unit still has its advantages for special applications. With the rotating-barrel system, the dry-mix process seems to have reached a progress plateau that will be difficult to improve upon in any revolutionary way. On the other hand, there is still room for improvement in today's rotating-barrel guns. Users would like to see the expense of wear cut down, maintenance simplified, and the incidence of rebound and dust reduced.

Modern rotating-barrel machines, such as the Aliva-246.5 of Sika Schweiz AG at Widen (Fig. 6) or the Meyco GM 090 built by Meyco Equipment at Winterthur (Fig. 7), weigh about 450 to 1400 kg, require floor space of 1.0 x 2.0 m, and are about 1.5 m high. In 2002, a gun of this type with standard equipment was priced at about 15,000 to 30,000 Swiss francs. The guns, which are driven either by electric or pneumatic motors or by internal combustion engines, handle aggregate gradations up to 20 mm. Throughput is on the order of 1 to 15 m^3 of dry mix per h. The compressed air requirement for conveying is 3 to 20 m^3 per min.

Fig. 6: Rotating-barrel gun (Aliva 246.5, 2002)

Fig. 7: Rotating-barrel gun (Meyco GM 090, 2002)

Fig. 8: Double pressure cylinder on truck, with bottom-mounted batching screws (Rombold-Spritzmobil, 2002)

A number of dry-mix guns are available on the international market, all of them essentially variations or combinations of the aforementioned systems, that is, double-chamber system, screw system, or rotating-barrel system. Most of these machines are suitable for handling both dry mix from naturally moist aggregates and factory-produced mixtures with oven-dried aggregates.

More recently, special spraying devices have been developed exclusively for factory-produced mixtures. These are not machines as such but merely so-called metering or batching devices that feed the dry mix from a pressure container into the air stream of the spraying hose (Fig. 7). "The system consists essentially of a pressure tank holding the material (either a vertical silo or pressure cylinder mounted on a vehicle). At the outlet of the tank, dust-free encapsulated batching screws are installed, to which the spraying hose is connected. To convey the material, compressed air is admitted to the pressure tank (silo) and the material is blown continuously via the batching screw into the air stream and conveyed to the nozzle. The conveying rate is infinitely variable between 1.5 and 12 m^3/h."[2] These devices exhibit relatively low wear-and-tear-related costs.

References

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2. Balbach, W., and Ernsperger, H., "Development and Practical Experience of a New Technology for the Preparation and Placing of Ecologically Desirable Shotcrete," paper presented at the 5th Conference on Shotcrete Technology, Innsbruck/Igls, Austria, Jan. 1996.

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