

NOZZLE TYPES AND CHARACTERISTICS

Dennis W. Bintner
Design Engineer
Delavan Manufacturing Company
West Des Moines, Iowa

The many varieties of herbicides on the market today, make the proper selection of spray nozzles and nozzle materials an increasingly important and difficult task. No one nozzle works best for all types of applications, just as no one chemical can control all types of weeds.

At first glance, spray nozzles may appear to play a rather minor and routine role in the operation of the total spray rig. In reality, however, nozzles are probably the most important part of the spray rig. Other components on the sprayer exist to help the nozzles do their job properly. Even though the nozzles may be a relatively inexpensive part of the total system, they should not be slighted. The nozzles are a critical item in determining the effectiveness of a spray application.

Although requirements may differ from application to application, the basic functions of a nozzle are to:

- (1) Meter the liquid.
- (2) Atomize or break up the liquid into droplets.
- (3) Disperse these droplets as a specific pattern.
- (4) Provide hydraulic momentum or impact to the droplets.

One or more of these functions is involved when a nozzle is used to apply a chemical.

Spray nozzles come in a variety of different kinds, shapes, sizes, materials, and spray patterns. Nozzles used in spraying chemicals may be broken down into several general classes. Let's look at each of these classes briefly.

First, there is the familiar pressure nozzle. This nozzle depends on a pressurized liquid to provide the energy necessary to separate the liquid into small droplets. The pressure nozzle is by far the most widely used type of atomizer for the application of herbicides. We will discuss pressure nozzles more in detail later.

Two-fluid or air-atomizing nozzles are another general class of nozzle. Pressurized air provides the energy necessary to produce liquid breakup into droplets in this type of nozzle. Two-fluid nozzles are capable of much finer atomization than are pressure nozzles. This type of nozzle is used where fine atomization is essential.

A third class is the rotary atomizer. This may consist of a spinning disk, cage, or cup which throws the liquid out by centrifugal action. This type is probably used less for herbicides than for applying insecticides and viscous fertilizer solutions.

A final class of nozzles includes those in which electrical energy plays a part in the liquid atomization. An electrical potential may be applied directly to the liquid to assist liquid atomization. Certain electrostatic atomizers, which rely on liquid pressure for breakup, but impose an electrical charge on the droplets after they issue from the nozzle, would also be considered part of this class.

Let's now take a closer look at the first general class; pressure atomizers. This general class will be broken down still further into subclasses for our discussion. The two most popular types for chemical applications are the flat spray and hollow cone nozzles. We also will look at two special types of pressure atomizers used where drift of fine droplets is critical.

In a flat spray type nozzle, energy from the pressurized liquid produces an unstable flat sheet. Atomization is accomplished through wave formation and the rapid growth of tiny holes which form ligaments and individual droplets. The unstable flat sheet may be formed by an elliptical orifice or by liquid from a straight orifice impinging on a curved deflector.

The elliptical type orifice is formed by the intersection of a V-groove cut with a hemispherical surface. This type of nozzle develops a flat fan shaped spray pattern which is heavier in the center and gradually tapers at each end. For broadcast applications where uniform coverage is desired, the nozzles must be overlapped. The flat spray type nozzle could be termed as "the broadcast nozzle." This nozzle is available in a variety of flow rates and spray angles to make it adaptable to a wide range of application rates.

Twin orifice types are available which are the equivalent of two flat spray tips overlapping to form a wide angle spray. One tip actually contains two flat spray orifices machined to form one wide flat spray pattern. This tip can be used whenever a wide angle (150°) flat spray pattern is desired.

The off-center flat spray tip has the orifice machined in such a manner that the spray exists from the tip in a pattern which is unsymmetrical to the tip axis. The off-center tip is used primarily to provide extended coverage at the ends of the spray boom. Two off-center tips may also be used together to form a small boomless sprayer.

The even spray tip is quite similar in construction to the flat spray tip. However, the V-groove cut is altered slightly in the even spray to produce an elliptical orifice which is not as severely tapered on the ends as the flat spray orifice. This results in more uniform liquid distribution across the spray pattern with sharper cutoff at the pattern ends. This type of tip is used when application of chemicals is desired in an even band type pattern.

All of the elliptical orifice nozzles discussed thus far are of tip type construction and would be used in conjunction with the familiar nozzle cap, body, and strainer to make a complete nozzle. Also, each of the tips produces finest atomization at lower capacities and higher pressures. However, for better drift control, the nozzles should be operated at 40 psi or lower.

Flat spray nozzles in a one-piece threaded design which will attach directly to the spray boom are also available. Generally speaking, this type of flat spray is thought of as a higher capacity nozzle than the tip type flat spray and is consequently used for higher volume applications.

Now, let's take a look at the deflector type flat spray nozzles. In this type of nozzle, a high velocity cylindrical jet impinges on a smooth deflector surface. The momentum of the liquid causes it to spread out on the deflector surface and thus creates the unstable flat sheet necessary to produce a flat spray as discussed earlier. This type of atomizer is commonly known as a flooding nozzle. The flooding nozzles have the advantage of being virtually clog free when compared to the elliptical orifice flat spray nozzles.

Flooding nozzles are available in the tip type design as well as in the one-piece, threaded type nozzle design. Flooding nozzles produce a wide angle flat spray pattern and are usually spaced at 40 to 80 inches depending on nozzle size and pressure. As with the elliptical orifice type flat spray nozzles, flooding nozzles must be overlapped in order to obtain uniform broadcast coverage. A disadvantage of the flooding type nozzle is that distribution across the spray pattern is not quite as uniform as may be obtained with other types of broadcast flat spray nozzles.

Flooding nozzles are generally operated at lower pressures than are elliptical orifice flat sprays. When used at 10 to 20 psi, flooding nozzles produce relatively large droplets which tend to minimize drift. However, when nozzle pressure is increased, atomization becomes finer as is typical of most spray nozzles.

Large flooding type nozzles which are designed for use as boomless sprayers are also available. This type of nozzle will maintain a spray pattern up to about 36 feet in width with fairly uniform coverage.

Now, let's consider the hollow cone pressure atomizers. In the hollow cone type nozzle, pressure energy is used to form a high velocity, swirling, unstable film which collapses into ligaments and droplets.

One type of hollow cone nozzle contains a distributor with diagonal slots which produce liquid swirl in a converging chamber and the resulting unstable film mentioned above. This type of nozzle is of the tip type design and must be used with body, cap, and strainer to make a complete nozzle. These are low capacity tips which produce fine atomization for complete coverage of plant surfaces. The tips should be operated at higher pressures with a minimum pressure of about 40 psi being recommended.

The disc cone type hollow cone nozzle consists of a core with tangential slots and an orifice disc. Pressurized liquid passing through the core creates liquid swirl in the chamber between the core and the orifice disc. The swirling sheet then exits from the orifice and liquid breakup occurs.

The two disc cone components fit into a standard nozzle cap and body for attachment to the spray boom. The disc cone is best suited for higher volume applications and is very popular for spraying abrasive wettable powder type chemicals.

Right angle hollow cone nozzles are the last kind of hollow cone we will look at. In this nozzle, pressurized liquid enters the swirl chamber through a single tangential inlet. This inlet passage is at a right angle to the outlet orifice and consequently the spray is directed 90° from the inlet flow.

Large internal passageways and no internal vanes combine to minimize clogging problems in the right angle hollow cone nozzle. The nozzle is designed for low pressure operation and produces relatively large droplets when operated in the 10 to 20 psi range.

Now let's take a look at two special types of pressure atomizers sometimes used where drift is critical. One concept of drift reduction is chemical application in foam. A specially designed nozzle combines the spray solution containing water, chemical, and foam adjuvant with air to create large foam droplets. The spray solution is expanded some four to seven times in volume when the air is combined with it.

Foam nozzles can replace conventional nozzles on a spray rig. To convert to foam spraying, all that need be done is to replace the conventional nozzles with foam nozzles and add a foam agent to the tank.

Air aspirating foam nozzles are available in several styles. Flat spray foam nozzles are commonly used for boom type broadcast applications. Foam nozzles, both straight stream and off-center types, are used on handgun installations. The off-center foam nozzles are also used for boomless broadcast applications. Both straight stream and flat spray nozzles are used to aerially apply foam.

Foaming type nozzles tend to produce fewer, but larger, drops than conventional type pressure nozzles. The decrease in the number of droplets is offset by increased droplet volume of the foam spray and the adjuvant action of the foaming agent. All in all, the foaming concept is a step in the right direction in regards to drift reduction.

The other special type of pressure atomizer is a nozzle which has been recently developed at Delavan. This new nozzle is called the "Raindrop" nozzle. The "Raindrop" achieves drift reduction without using a foaming agent. The number of fine droplets is reduced greatly, but at the same time, large droplets which would affect coverage are not formed in this nozzle.

The "Raindrop" produces a hollow cone spray pattern. In comparing the spray from a "Raindrop" with that from a conventional hollow cone nozzle, the drops are larger and much more uniform in size than in the conventional spray.

In recent studies at Delavan, comparing nozzles at identical conditions of 40 psi and 0.3 gpm flow, a standard disc cone nozzle produced a spray with a mass median diameter (MMD) of 193 microns with 3.0% of the spray droplets by volume being less than 50 microns in diameter. A "Raindrop" under the same conditions produced a spray with MMD of 405 microns with only 0.3% of the droplets by volume measuring less than 50 microns.

Another nozzle used in this test was a larger size disc cone nozzle. This nozzle was operated at 13 psi in order to get 0.3 gpm flow. The idea here of course, was to use a larger nozzle at lower pressure to produce larger droplets. This nozzle produced a spray with MMD of 324 microns, but still had 1.5% of the droplets by volume measuring less than 50 microns. The droplet analysis also showed that the "Raindrop" produced drops which were much more uniform in size than either of the disc cone nozzles.

Although the "Raindrop" is a new development and hasn't received vast amounts of field testing yet, preliminary testing indicates that it may well have considerable merit as a drift reduction nozzle.

Now that we have looked at various nozzle types, let's touch briefly on nozzle materials. Materials commonly used for spray nozzles are brass, nylon, stainless steel, and hardened stainless steel. When selecting a nozzle material, chemical corrosion as well as abrasive wear should be considered.

Brass and aluminum are probably the most widely used materials because of their lower initial costs. This does not necessarily make them the most economical since in many applications they will not provide adequate corrosion and erosion resistance. Generally, nylon and stainless steel will offer better corrosion and erosion resistance. Hardened stainless steel offers even better erosion resistance.

Flow rate increase through the nozzle is probably the most apparent result of nozzle wear. Although not always visible with the naked eye, nozzle wear will also result in an uneven spray pattern. Sprayers should be calibrated frequently and worn nozzles replaced.

In closing, I would again like to stress the importance of the nozzle in the total spray system. The nozzle is the device most likely to be praised or blamed for the effectiveness of the total spray unit.