Unit 4

Weeding and plant protection equipment

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DROBLET SIZE DETERMINATION

A spray nozzle produces a range of droplet sizes that can often be summarized by a single number. Which single number is appropriate to use to compare the droplet spectrum of several sprays depends on the application. There are two elements to consider when measuring droplet size Firstly there will be a spread of droplet sizes within a spray so some kind of average will need to be taken but which type of average is appropriate. Secondly there are different methods for actually analysing sprays and they will produce different results depending on the type of spray. It is important to understand which is being used and particularly to ensure that same method is used when comparing the sprays produced by two different nozzles. The mean droplet size is actually a measure of the overall surface area of the fluid being sprayed. The smaller the droplet size the greater the surface area of the spray for any given volume of fluid. If one halves the mean droplet size of any given spray then the surface area of the spray doubles. The surface area of a spray is a reasonable approximation to its overall reactivity. By reactivity this can mean its ability to produce a chemical reaction or the spray's ability to absorb or dissipate heat. So in heat transfer and chemical reaction sprays the droplet size is one of the most important elements in determining how well the spray will perform. Droplet size can also be important when considering the overall entrainment of a fluid within a gas flow. Smaller droplets will get swept along in a moving flow more quickly and if the spray is too fine this could overload mist eliminators. If operating in windy conditions then finer sprays might be blown off target so an understanding of droplet size is important.

Color Codes for Droplet Size

Category	Symbol	Color Code	Approx. VMD Range (microns)
Extremely Fine	XF	Purple	<60
Very Fine	VF	Red	60-145
Fine	F	Orange	145-225
Medium	M	Yellow	226-325
Coarse	C	Blue	326-400
Very Coarse	VC	Green	401-500
Extremely Coarse	EC	White	501-650
Ultra Coarse	UC	Black	>650

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Factors affecting droplet size:

Degree of atomization depends upon:

- Characteristics and operating conditions of the atomizing devices.
- Characteristics of liquid being atomized.

Principal fluid properties affecting droplet sizes are surface tension and viscosity. Increased surface tension and viscosity increases droplet sizes. Emulsifiers or water in oil emulsions are used for increasing viscosity to increase droplet size. For a given flow rate, pressure and spray angle hollow cone nozzles have smaller droplet sizes than fan spray nozzles. Flooding type produces coarser spray.

Droplet sizes and number can be determined by collecting samples of spray on glass slides coated with silicone, magnesium oxide or other similar material or a glossy-surfaced printing material. Correction factor is used to determine original sphere diameter from observed stains.

Droplet sizes can be measured by immersion method. The spray droplets are caught in a shallow dish containing liquid or material in which droplet can sink. There, they remain spherical. Cellulose – thickened water solution containing detergent or soap can be used for oil droplet.

Sizing and counting of collected droplets or stains can be done directly with a microscope, or sample photograph scanned with electronic analyzer. Direct automatic scanning of droplets in flight can also be done.

Field measurement of uniformity of distribution made by collecting sprayed material on mylar sheet or metal plates. Known concentration of trace material is added. The material from each plate is washed into specified volume of water. And concentration of tracer is measured.

Nozzle distribution pattern is determined in lab. By spraying onto a surface that consists of series of adjacent, sloping V-troughs and measuring the liquid collected from each trough. Uniformity of coverage on plant surfaces can be checked by adding fluorescent dyes or insoluble fluorescent materials to spray and viewing surfaces with fluorescent light of the dark.

What affects droplet size?

Pressure A simple rule that holds for all nozzles is that the higher the fluid pressure the smaller the droplet size. For any given hydraulic nozzle the relationship between pressure and mean droplet size can be expressed as: Where D is the mean droplet size at pressure 1(P1) and pressure 2(P2). This gives an approximate relationship for comparing droplet sizes for any given nozzle, but there is no easy mathematical relationship for any generic nozzle as droplet size depends greatly on the design of the nozzle.

$$D1 \div D2 = (P1 \div P2)^{-0.3}$$

Spray pattern type

It is fairly obvious that solid stream sprays do not really have droplets at all. Flat fan patterns may form sheets of liquid without much atomisation or may produce coarsely atomised sprays. Full cone nozzles will produce the next level of atomisation with hollow cone nozzles producing the smallest droplets. Spray angle Very simply, for any given flow rate, the wider the spray angle is the smaller the droplet size will be. It's easy to understand why - larger angles sprays simply have more space to distribute the droplets and so there is less chance of recombination and a greater opportunity to atomise.

Nozzle type

The design of the spray nozzle will obviously affect spray pattern type (flat fan, hollow cone etc) and this will affect droplet size, as discussed above, but even staying within a pattern type there is variation on levels of atomisation. For example, the spiral design nozzle will produce a full cone pattern that, for a given pressure, flow rate and spray angle, will produce smaller droplets than an axial whirl nozzle. How different nozzle designs will affect droplet size can be complex and all the details can't be covered here, but it should be borne in mind that changing nozzle design type can change the consistency of seemingly identical sprays.

Specific gravity of the fluid

The specific gravity of a fluid will affect the overall flow rate achieved at the nozzle and hence will affect droplet size. For a given pressure, the higher the specific gravity the lower the flow rate, hence the lower the mean droplet size. We have software that can calculate these effects so we would advise calling us. But the formula that is generally accepted is

$$D_f = D_w \, SG^{0.3}$$

Df = the droplet size for the fluid in question

Dw = the droplet size for water for that particular nozzle

SG = specific gravity of the fluid

As specific gravity is often very close to 1 and the exponent is 0.3 the effect of this is generally very small.

Viscosity and surface tension

Fluids with higher viscosities than water will have higher mean droplet sizes for any given flow rate and pressure. Similarly fluids with higher surface tensions will form larger droplets. The interplay between the mechanical properties of fluids can get complex but software exists to perform droplet size calculations if the basic properties are fed in. We would advise speaking to one of our experts in order to obtain estimates for the effects of viscosity and surface tension on droplet size. But again the generally accepted formula is

$$D_f = D_W \, V_f^{0.2}$$

Where Df = modified droplet size for the fluid in question

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Dw = Droplet size calculated for water

Vf = the viscosity of the fluid (viscosity in centipoise; water = 1.0 cP)

At first it would seem that the exponent of 0.2 would indicate that viscosity has a lower effect than specific gravity but it needs to be remembered that fluids can have viscosities 1000 times that of water and still be fluids where as even a super heavy fluid like mercury only has an SG of 13.

A similar equation and relationship exists for surface tension

$$D_f = D_w \, (St/73)^{0.5}$$

Where St is the surface tension of the fluid in Dynes /cm with water having a surface tension of 73 Dynes/cm at 20 degree C

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