Pesticide Nozzles: Wear and its Consequences

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Any pesticide spray nozzle cannot serve forever, can it? Naturally.
Any pesticide spray nozzle must have the highest service durability!

One of the important factors that may significantly reduce the efficiency in spraying is wear in spray nozzles. According to the National Standard of Ukraine DSTU ISO 12761-2, the nozzle is considered to be worn out, if its fluid flow rate has increased by 10% of the flow rate specified by the manufacturer. The worn slit-type nozzle not only increases the fluid flow rate and alters the droplet distribution of the atomized fluid within the spray pattern (Figure 1), but it also changes the dispersion of the fluid being sprayed. Variations in the fluid dispersion characteristics and a 10 percent increase and even a 30 per cent increase in flow rate may not be readily noticeable visually (Figure 2). The deterioration in spray distribution can be identified either during spraying due to occurrence of streaks or blanks in the nozzle spray patterns, or it is revealed on the completion of the spraying operation as the rates of applied pesticide across the individual areas (swathes) may be drastically different.

The useful operating life of a nozzle is measured in hours of service. International standard DSTU ISO 5682-1 provides the methodological guidelines on the nozzle durability test procedures. According to information presented by the SGS UK Ltd. (a member of SGS S.A., Switzerland), the slit-type nozzles with the brass tip have shown an increase of 10 % in the fluid flow rate after 10 hours of operation; the same increase in the fluid flow rate has been observed after 30 hours of operation in the slit-type nozzles with the stainless steel tip and after 40 hours in the nozzles with the polyvinylidenefluoride (PVDF) tip, while the slit-type nozzles with the polyacetal tips have shown an 8 % increase in the fluid flow rate after 60 hours of operation. As reported by the Albuz company (France), the spray nozzles with the ceramic tip increases the fluid flow rate by 5 % after 50 hours of operation, and after that the fluid rate remains stable for about 100 hours.

One of the requirements of Interstate standard GOST 2.601 is that all products should be furnished with the operational documentation containing information on the product useful operating life, its service life and the guarantee obligations of the manufacturer. However, foreign manufacturers of spray nozzles for pesticides not only violate the standard requirements, but beyond that, the producers enjoin the day-to-day maintenance and control of the nozzle performance upon farmers, but such supervision is feasible only upon the availability of skilled personnel and special equipment. In Ukraine, the only institute which performs the service durability testing of spray nozzles is Dnipropetrovsk State Agrarian University in the city of Dnipropetrovsk.

Under conventional operating conditions, spray nozzles for pesticides are typically subjected to various types of wear, such as:

-corrosion;
-cavitation wear;
-erosion;
-mechanical damage.

Today, the problems of corrosion and cavitation wear in spray nozzles are not the areas of a key concern of the agrarians, because these kinds of wear are of little practical implications. It is absolutely wrong to make exclusively the operators responsible for mechanical damage to nozzles when cleaning, because provided the nozzles are fitted with all filters (strainers) as it is recommended by the manufacturer, a complete failure of the nozzles due to clogging should not happen. Why such failures do occur – and quite frequently – this is an issue to be discussed in one of the forthcoming articles.

A meaningful factor for pesticide spray nozzles is erosive wear due to microcutting. This process is explained by the Sheldon-Kanhere's equation:

$$V = Kd^3U^3\sqrt{\left(\frac{\rho}{H}\right)^3}$$

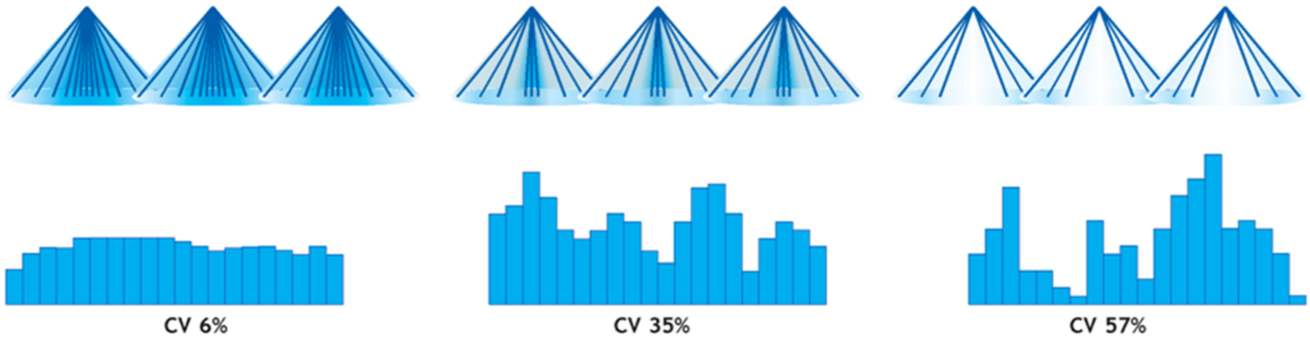
Any plastic material, including that, which the spray nozzle may be made of, is subjected to microcutting with solid particles contained, in this particular case, in the working fluid. **The rate of the erosive wear depends,** first and foremost**, on the spray nozzle design**, because it is basically the nozzle design arrangement which not only creates the conditions for forming a particular angle of impact of the solid particles against the surface of plastic material, but it also determines a value of the coefficient K; secondly, the rate of wear depends **on the level of filtration of the working fluid**, as the smaller the size d of the solid particles, the less wear they exert on the nozzle; and thirdly, the rate of the erosive wear also depends on **the operating pressure**, because the latter predetermines the velocity of the working fluid flow and, consequently, the velocity U of the solid particles suspended within the fluid.

As it is apparent from the above mentioned equation, the erosive wear in the spray nozzle will not take place if and only if no solid particles are present in the fluid, that is when K=0. If either the size d of an individual solid particle is decreased in half or the particle velocity is twice reduced, the wear period is prolonged by a factor of eight! Provided the specific weight ρ of an individual solid particle is reduced by half or, accordingly, by choosing a spray nozzle made of the material, which has the twofold Vickers hardness number H, the wear period becomes at least three times longer.

Any nozzle will serve longer, if the quantity of solid particles in the working fluid and the particle size are minimal. In the slit nozzle designs, the coefficient K is taken as $K \approx 1$ for the tip outlet. For the centrifugal nozzles with the flat tip outlet this coefficient is taken as $K \approx 0$, and only for the cylindrical wall of the swirl chamber the coefficient is taken as $K \approx 1$. In its essence, this wear process is decaying; the wear rate is rather intense at the initial stage of the process, but as the size of the groove on the cylindrical wall surface increases, the wear gradually slackens due to the presence of the solid particles in the groove and their wearing off against each other. For more than 15 years of operation of the ROsa centrifugal atomizers, no cases of a distorted size in the nozzle tip outlet have been recorded, and the swirl cores made of brass have ensured the useful operating life of the atomizer for 7,000 hours, as it is specified by the manufacturer. Figure 3 illustrates the swirl core, which has served out for more than 4,000 hours, but it has not altered either the fluid flow rate or the fluid dispersity characteristics. Therefore, there is no need for the maintenance and control of the centrifugal nozzle performance. The through wear of the cylindrical wall of the swirl chamber is theoretically possible, and it is likely to be accompanied with a drastic increase in the fluid flow rate, a clearly visible droop in the spray angle and its deflection off the axis.

The useful operating life of a nozzle and, accordingly, the technical efficiency of spraying depend primarily on the nozzle design solutions. So, under similar operating conditions, brass in a centrifugal nozzle has a hundred times longer period of wear than in a slit-type nozzle. Even a ceramic tip in slit-type nozzles has the shorter useful operating life than that of a stainless steel tip in centrifugal atomizers.

Worn spray nozzles cause considerable economic losses to the farm production facilities, resulting in the extra expenses for excessive amounts of pesticides and working fluid and also due to shortcoming in revenues from expected crop yields; and moreover, the deterioration in the quality of spray dispersion and the non-uniformity of the distribution of deposited droplets results in contamination of the environment with pesticides.



New nozzles | Worn nozzles | Damaged nozzles

Fig.1. Effects of nozzle wear on the spray fluid distribution
(excerpts from the Catalogue of the ASJ Company, ARAG Group)

New nozzle | Worn nozzle: the fluid flow rate has increased by 30 %.

Fig. 2. General views of the new and worn-out spray nozzles
(photos from the Spraying Systems Co. Catalogue)

Fig. 3. Used swirl core of the
ROsa centrifugal nozzle atomizer