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SPRAY CLASSIFICATION FOR SELECTED FLAT FAN NOZZLES

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Abstract: The flat fan nozzles made by Mikołajczak Agro Technology Company (MMAT) (standard RS, and pre-orifice AZ), in the ISO sizes of: 02, 03, and 04 were evaluated. The spray quality parameters: D_{V10}, D_{V50}, D_{V90}, and RS, in the working pressure range of: 150, 300 and 450 kPa, were determined. The coefficient of volume fraction droplets smaller than 100 μm was also calculated. The spray classification of MMAT nozzles was defined according to ASAE standards. This information should be useful for the sprayer operator when making a selection of a field sprayer's working parameters according to the pesticide use guide.

Key words: nozzle, flat fan nozzle, droplets diameter, spray classification

INTRODUCTION

In order to enlargen the scope of information about the flat fan nozzles offered for agricultural usage, important technical information about selected nozzles available on the Polish market has been researched. Products which have been offered for several years by the Marian Mikołajczak Agro Technology Company (MMAT) were tested for this study. Some of their working macroparameters have already been determined (Czaczyk 2011), recognizing that the quality of nozzles produced by the MMAT meet basic international requirements [The list of certified nozzles at Julius Kühn Institute in Braunschweig (February 2011)]. For many years, there has been a tendency in research and development of spraying techniques to orientate their studies on reduction of the spray drift potential (Hewitt 1997; Hewitt 2001; Holterman 2003; Southcombe 2007; Czaczyk 2009; Dorr 2010; van de Zande 2011). It is essential as well, to determine the quality of spraying needed for sprayers available on the market, and a legal requirement should be made. Nozzles are one of the smallest parts of agricultural machinery yet they are responsible for an extremely important function: distributing toxic substances (pesticides) to the environment. The biological effectiveness of the used pesticides, but also the risk of contamination to the surrounding areas caused by drifting and losses on the ground (soil), depends on the nozzles. To reduce loss of the pesticide and to limit the damage caused to the environment, it is necessary to provide information about the quality of nozzles approved for practical application (Hewitt 1997). These practices are the duty both of the producer and the appropriate governmental authorities. Voluntary procedures used for many years, for example, in Germany, are not sufficient. This is especially true in Poland, where there is no recognized certification and consultative centre like the: Deutsche Landwirtschaftliche Gemeinschaft (DLG e.V. – German Agricultural Society). A similar role in Poland served fragmentary (safety) Industrial Institute of Agricultural Engineering (Przemysłowy Instytut Maszyn Rolniczych PIMR) in Poznań, and the redactions of agricultural journals. Former also the Institute for Building Mechanization of Electrification of Agriculture (Instytut Budownictwa, Mechanizacji i Elektryfikacji Rolnictwa IMBER) – played similar role. There has been very little research done for certification of agricultural machines in Poland, and marketing is lacking. It should be emphasized that in Germany, plant protection equipment (sprayers, misters, seed treaters, atomizers and others) are the only ones, excluded from the group of machines tested by the DLG. In Germany, the Julius Kühn Institute in Braunschweig [The list of certified nozzles at Julius Kühn Institute in Braunschweig (February 2011)] (former Die Biologische Bundesanstalt fűr Land-und Forstwirtschaft – BBA) deals with the evaluation and certification research of this unique group of machines which are used for applying toxic substances.

The aim of this study was to determine the spraying characteristics of flat fan nozzles: series standard (RS) and low-drift (AZ), according to international methods. These are nozzles which have been available and useful for several years in Poland.

MATERIALS AND METHODS

The full range of nozzles offered by the MMAT company was taken into account, for the research. These

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were the standard flat fan nozzles: RS 11002, RS 11003 and RS 11004, and nozzles with reduced drift potential (with pre-orifice), AZ 11002, AZ 11003 and AZ 11004. One copy was chosen to investigate spraying quality from among ten copies of each variant. The nozzles were checked visually to make sure they worked correctly and that the measurement of flow rate qr (l/min) was made. Characteristics of tested nozzles for the three pressures: 150, 300 and 450 kPa were determined by spraying water which was about 18°C. Measurements of droplet size accepted for the study of MMAT flat fan nozzles, were performed on the SympaTec® device (Sympatec GmbH). This device operates on the principle of laser beam diffraction with the HELOS instrumentation. The SympaTec® device was used to measure the droplet size in the range 0.1–3,500 μm allowing for proper measurement of the particles in their movement speed range up to 100 m/s. Measured droplets were catalogued into 30 class sizes. The study was conducted in a wind tunnel (Centre of Pesticide Application and Safety – CPAS, at The University of Queensland in Australia, Gatton Campus), to obtain a stable one-way movement of the particles generated as a result of the spraying. The Helos laser system has an emitter and receiver which were positioned across from each other and outside of the wind channel. The laser was horizontally positioned in a way that the beam was in the centre of the wind channel. The droplet size was measured in the stable air flow. This action was taken to prevent measurement errors (repeated measurements of the same small particles as a result of lower speed, and turbulences) occurring during the gravitational descent of measured drops (Southcombe 2007). During the measurement, the nozzles were moved vertically down at a speed of about 0.2 m/s, so the entire stream of atomized liquid was aimed in the zone of the Helos laser measurement (Fig. 1). The speed of the rush of air moving the measured droplets, was 5 knots (2.57 m/s). Due to the stated influence of liquid and air temperature relations (Spillman 1984), the temperature of the surroundings was similar to the temperature of the fluid (water), and it was approximately 18°C for both factors. The relative air humidity varied between 73 and 75%. A replication was made where the entire spray plume was passed through the SympaTec® Helos laser beam nozzle at a distance of 20 cm from the laser beam of the droplet measurement system. The standard ceramic Albuz AXI 11003 flat fan nozzle of the renowned Coorstek (former Saint-Gobain Solcera) was included to the test, to compare the characteristics of MMAT nozzles. The results from three repetitions were averaged. Each measurement detected a minimum of 10,000 droplets, according to standard methods (Holterman 2003).

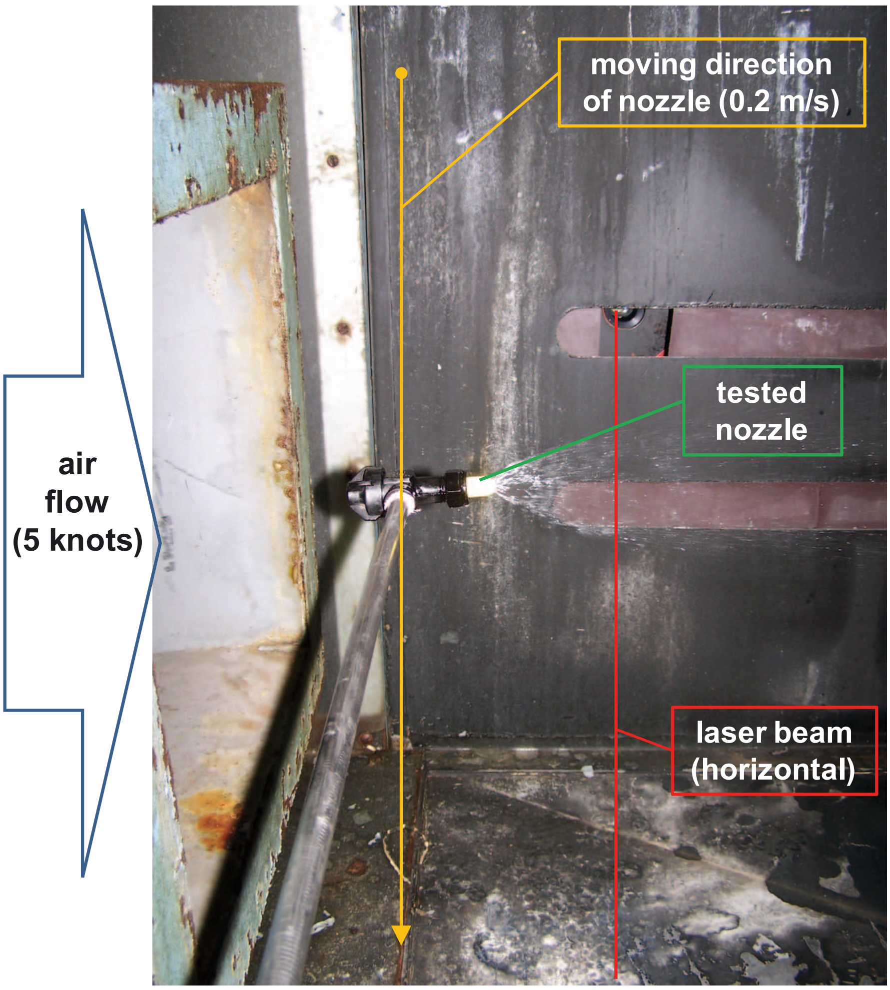


Fig. 1. Scheme of a measuring stand inside of wind channel

RESULTS AND DISCUSSION

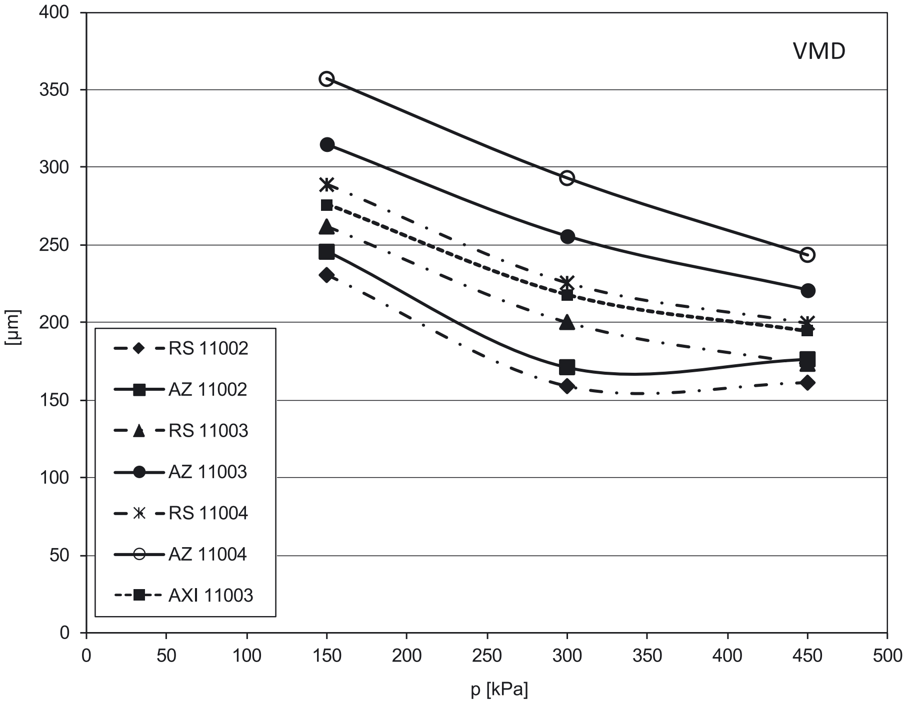
The obtained results are presented in table 1, and figure 2 which contain a typical set of spraying quality parameters according to international standards (ASAE S572.1. 2009).

D_{V10} – vol. diameter is the value, meaning that 10% of the liquid is atomized into droplets with diameters below this value. D_{V90} the diameter below which 90% of the liquid volume is atomized into the smaller droplets (so the 10% of the volume drops with diameters larger than this value). D_{V50} means interchangeably VMD (Volume Medi-

Table 1. Results of investigations on the droplet size. Investigations on droplet size were carried out according to ASAE standard (ASAE S572.1. 2009) (water ~18°C)

Type	p [kPa]	< 100 µm [%]	D_{V10}	D_{V50}	D_{V90}	Classification	RS
RS 11002	150	10.7	96.3	230.6	399.6	fine	1.32
AZ 11002	150	9.3	103.2	245.6	444.7	medium	1.39
RS 11003	150	8.2	110.3	261.9	463.4	medium	1.35
AZ 11003	150	4.2	133.0	315.1	422.0	medium	0.92
RS 11004	150	6.7	121.8	288.9	514.2	medium	1.36
AZ 11004	150	3.5	159.3	357.0	584.9	coarse	1.19
AXI 11003	150	6.8	120.1	276.7	469.2	medium	1.26
RS 11002	300	17.9	76.0	159.0	271.5	fine	1.23
AZ 11002	300	12.8	92.0	171.2	284.7	fine	1.13
RS 11003	300	16.2	77.4	200.3	361.2	fine	1.42
AZ 11003	300	9.7	101.3	255.7	444.7	medium	1.34
RS 11004	300	13.3	86.2	225.6	415.6	fine	1.46
AZ 11004	300	6.9	120.0	293.1	508.2	medium	1.32
AXI 11003	300	13.8	84.4	218.4	377.0	fine	1.34
RS 11002	450	25.4	60.0	161.3	307.7	fine	1.54
AZ 11002	450	21.9	64.9	176.4	334.7	fine	1.53
RS 11003	450	22.5	63.7	173.4	332.4	fine	1.55
AZ 11003	450	14.2	82.7	220.9	388.1	fine	1.38
RS 11004	450	17.8	72.4	199.7	390.1	fine	1.59
AZ 11004	450	11.1	94.5	243.6	444.7	fine	1.44
AXI 11003	450	17.1	74.5	194.8	346.2	fine	1.39

D_{V10} – vol. diameter, the value meaning that 10% of the liquid is atomized into droplets with diameters below this values
D_{V90} – the diameter below which 90% of the liquid volume is atomized into smaller droplets
D_{V50} – means interchangeably Volume Median Diameter
RS – relative span



VMD – Volume Median Diameter
Fig. 2. Droplet size characteristics for tested nozzles interpreted with VMD

an Diameter), which is an average volume diameter. This average was the value according to which a half of the sprayed liquid is atomized into the droplets larger than this value, and the other half on droplets smaller than this value. VMD is a recognized factor of the quality of spraying. Additionally, the percent of volume less than 100 µm, which is a coefficient of the driftable fraction of spray, was also computed along with relative span (RS) (ASAE S572.1. 2009), which is a dimensionless value of the spread of the droplet sizes in the generated population of droplets:

$$RS = (D_{V90} - D_{V10})\, D_{V50}^{-1}$$

Values of D_{V10} for the studied nozzles MMAT, were varied for different quantity of flow and pressure. Similarly, like in the research of nozzles made by other companies, the D_{V10} value decreased together with the increasing pressure, and it was from 96 to 160 µm at 150 kPa, from 76 to 120 µm at 300 kPa, and from 60 to 94 µm at 450 kPa. The values of D_{V90} also changed in a similar way – they decreased respectively with the increasing pressure. For the pressure of 150 kPa, the values ranged from 400 to 585 µm, at 300 kPa, from 272 to 508 µm, and at 450 kPa, they were from 308 to 445 microns.

Spraying classification is also determined according to international standards (ASAE S572.1. 2009). As far as highest pressure (450 kPa) was concerned, all tested nozzles were characterized by as having a fine category quality of spraying (Table 1). For the test pressure of 300 kPa, nozzle AZ 11004 and AZ 11003 was characterized as having a medium quality of spraying. The other tested MMAT nozzles and the ceramic nozzle Albuz AXI 11003, which was approved for this research for use as a comparison, showed atomization in the fine category. At the lowest test pressure (150 kPa), only the RS 11002 nozzle was characterized as having a fine spraying quality. The drift reduced nozzle AZ 11004 generated droplets in the coarse spraying category. The other tested nozzles were characterized as having a medium spraying quality.

CONCLUSIONS

The investigated flat fan nozzles in the international classification of spraying (ASAE S572.1. 2009) for plant protection have fine, medium, and coarse categories depending on the working pressure and type.

According to the recommendations for the safe use of plant protection products (PPP) (printed on each guide of use), it is possible to apply all types of pesticides with the group of RS and AZ nozzles (at different pressure and type) produced by MMAT.

The spraying characteristics of the investigated nozzles deliver a spatial increase of droplet size from type RS 11002, followed by AZ 11002, RS 11003, RS 11004, AZ 11003 up to type AZ 11004 (Fig. 2).

Nozzles AZ 11002 and RS 11002 showed a somewhat specific effect. In the working pressure range of 300 and 450 kPa, VMD values did not change significantly.

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