The RHEA airblast sprayer: studies on intermittent flow rate nozzle for the VRA.

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RHEA airblast sprayer: studies on intermittent flow rate nozzle for VRT

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Abstract: Current commercially technologies for the pesticides management are designed in many configurations, allowing a wide range of regulation, which however must be accompanied by technical and operational skills of the user. This condition introduces variable risks in relation to the proper configuration of the spray machine and the correct operating set-up and procedure. These aspects may be solved today by the introduction of sensor systems and operational monitoring tools to assist the operator work. In the project RHEA (robot fleets for highly effective agriculture and forestry management), the Florence O. U. has the aim to develop a sprayer prototype for the tree crops treatments to manage in real time, the quality and quantity of the pesticide mixture distributed and the intensity and direction of the air, depending on the structural variability of the canopy. For the variable rate application of dose in accordance with the canopy thickness it has been developed and tested the concept of pulsating flow rate technique that controls each nozzle in an independent way. To obtain an intermittence flow rate is applied, on the nozzles, an high frequency solenoid valve (HSFV) with the purpose of interrupting the pesticide flow rate. This is adjusted by acting on two parameters of the HSFV: frequency and duty cycle. The obtained data were processed and evaluated to verify the spray cloud features varying frequency and duty cycle adopted. Variation in terms of flow rate and of the droplets diameter were analyzed. In this preliminary study, significant results were obtained by adopting frequency of 8Hz and 10Hz with reductions of the flow rate respectively of 44%, with 30% duty cycle and 25%, with 50% duty cycle, obtaining the same amount of the flow reduction independently of the type nozzle used.

1. Introduction

The new trend in reduction of the pesticides dose, while also ensuring the effectiveness of treatments, needs to gain new technical knowledge and development of new pesticides sprayers, to ensure precise and safe treatments. The reduction of the doses does not mean the decrease of the unit dose on the parts to be protected, but the reduction of losses and dispersions that occur during the treatments operations (a part of the mixture is uselessly superposed on the previous, a part is lost on the ground and another is wasted for drift).

Recently, technologies that adapt the spraying to the canopy geometry and to the target characteristics, have reached an high development, allowing to eliminate loss to the ground and to improve the vegetation cover. This was possible, also, by adopting automatic devices able to use relief sensors, by computer analysis and actuators that can adapt the sprayer configuration to different conditions of use.

The control on the precision treatment is therefore an economic and productive objective, since that are required quality production, healthy and low cost. Accordingly it is conceivable to assume a technology development that will permit the realization of more efficient tools, which will allow further to reduce the environmental impact of agricultural production. In this context, the European project RHEA (Highly Effective Robot Fleets for Agriculture and forestry management) plans to create three autonomous vehicles that interact with each other and with the operator, working in fleets and operating in three specific contexts and cultures: wheat, corn and olives.

The main advances in the future spraying technology, will affect the design of vehicles that allow to adapt the spray only to the target vegetation. This will be done using a sensors system that detect height, shape and density of the canopy and regulate both the jet of air and the size of the droplets and so, the quantity of mixture.

Many research has been conducted in order to obtain a variable flow rate control to adjust the dose to the canopy thickness. A solution that has been planned by the UO of Florence, in the project Rhea, is a device able to control the frequency and the duty cycle of a solenoid valve for the generation of an intermittent spray nozzle.

The pulsating spraying technique or intermittent jet has been developed by Falchieri et. Al. in 2008, with the aim of optimizing the activity of pesticides, exploiting the phenomenon of the active substance diffusion in the leaf cuticle. The system is based on the nozzles flow rate interruption with small time intervals.

The pulsating spraying technique combined with width pulse modulation was also recently adopted and studied by other researchers, such as these of Escolà et al., 2007, Hočevar et al. 2009, Chen, 2010.

The Modulated Spraying Nozzle-Control systems (MSNC), allow to perform variable rate treatments controlling the drift of the spray jet in a wide range of operating conditions. The system MSNC check the timing and duration of the pesticide spray from the nozzles.

2. Materials and methods

The intermittent spray system test was conducted with three different nozzles Albuz ATR 80, color code: PURPLE, BROWN and YELLOW and a pump Annovi Reverberi AR-19 model. Each of the three nozzles worked at two different pressures: 0,5 and 1,0 MPa. Before the nozzles in the pipe were positioned the solenoid valves to obtain the pulsed jet. The high frequency solenoid valve (HSFV) worked in the following conditions:

- Frequency: 3Hz, 5Hz, 8Hz, 10Hz.
- Duty cycle: 20%, 30%, 50%, 75%

The solenoid valve used is the model ZB16 Parker that works at a maximum pressure of 1,0 MPa. To check if the solenoid functional parameters were properly adjusted (frequency and duty cycle) was used a 4-channel digital oscilloscope 100MHz HP. All the measurements were achieved by measuring the spray nozzles flow rate for one minute, the liquid delivered was collected in the graduated cylinder and subsequently weighed with the load cell. All the measurements, including those about the verification of nozzles operation, were performed in three repetitions in order to reduce the variability of sampling (72 measurements for each nozzle).

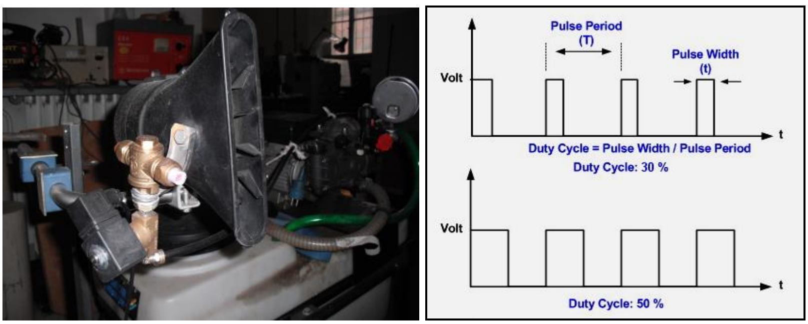

Fig. 1 - The solenoid valves to obtain a pulsed jet (left) and the HFSV operative scheme (right).

3. Results and first conclusions

The preliminary results of the research, highlights the possibility to vary, in real time, the nozzles flow rate, without changing other spraying parameters. In this study case, significant results were obtained by adopting frequency of 8Hz and 10Hz with mean reductions of flow rate (44%, with 30% duty cycle), and (25%, with 50% duty cycle), obtaining the same amount of flow rates reduction for all types of nozzle.

Were discarded, however, the results obtained with the lowest frequencies (3Hz and 5Hz), in fact, under these conditions, we have obtained flow values completely different from those expected. It is assumed, that the phenomenon is due to interference with the pulsation of the pump that resonates with the solenoid valve.

Therefore, on the basis of this preliminary results, it was assumed that the system was working exclusively at frequencies higher than 5 Hz. The values obtained with 20% and 75% duty cycle were discarded, because they did not reduce significantly the flow rate.

Another important aspect, that emerged during the preliminary laboratory tests, it has been the localization point of the solenoid valve. In fact, significant results are obtained only when the valve is placed in correspondence of the nozzles, since placements distant from the nozzle, determines significant loss of flow energy and, consequently, flow rates fluctuations.

These preliminary studies will be completed with further survey about spray cloud features in the different duty cycle and frequency condition to get technical information on the pulsed-jet spray system, which, seems to be an interesting possibility to vary in real time the flow rate to the nozzles, in order to develop new systems for variable rate spraying.

Many are the bibliographic scientific references and many are researchers to find innovative technological solutions to make variable-rate spraying, with the aim to get a proportional distribution of mixtures to the vegetation target characteristics.

Ugello GIALLO							
bar	Freq. (Hz)	D cycle (%)	misura (l/m)			media	%
5	tabella albuz 0,73		0,67	0,68	0,68	0,67	100
5	3	30	0,51	0,51	0,51	0,51	24
5	3	50	0,38	0,38	0,39	0,38	43
10	tabella albuz 1,03		0,94	0,94	0,94	0,94	100
10	3	30	0,69	0,70	0,70	0,70	26
10	3	50	0,52	0,52	0,52	0,52	45
Ugello GIALLO							
bar	Freq. (Hz)	D cycle (%)	misura (l/m)			media	%
5	tabella albuz 0,73		0,67	0,68	0,68	0,67	100
5	5	30	0,55	0,56	0,56	0,56	18
5	5	50	0,42	0,44	0,42	0,43	37
10	tabella albuz 1,03		0,94	0,94	0,94	0,94	100
10	5	30	0,75	0,74	0,74	0,74	20
10	5	50	0,56	0,55	0,56	0,56	41
Ugello GIALLO							
bar	Freq. (Hz)	D cycle (%)	misura (l/m)			media	%
5	tabella albuz 0,73		0,67	0,66	0,66	0,66	100
5	8	30	0,34	0,34	0,33	0,33	49
5	8	50	0,45	0,46	0,46	0,46	31
10	tabella albuz 1,03		0,94	0,94	0,94	0,94	100
10	8	30	0,45	0,46	0,45	0,45	52
10	8	50	0,64	0,64	0,63	0,64	32
Ugello GIALLO							
bar	Freq. (Hz)	D cycle (%)	misura (l/m)			media	%
5	tabella albuz 0,73		0,67	0,66	0,66	0,66	100
5	10	30	0,40	0,39	0,39	0,39	41
5	10	50	0,52	0,51	0,51	0,51	22
10	tabella albuz 1,03		0,94	0,94	0,94	0,94	100
10	10	30	0,48	0,50	0,49	0,49	48
10	10	50	0,64	0,66	0,66	0,65	30

Tab. 1 – Preview of the achieved results.

References

Chen, Y. (2010) Development of an intelligent sprayer to optimize pesticide applications in nurseries and orchards , unpublished Ph.D. Dissertation.

Escolà, A., F., Camp, F., Solanelles, J., Llorens, S., Planas, J.R., Rosell, F., Gràcia, E., Gil & L. Val (2007) Variable dose rate sprayer prototype for dose adjustment in tree crops according to canopy characteristics measured with ultrasonic and laser lidar sensors, Atti del Convegno internazionale “ECPA-6th European Conference on Precision Agriculture”, pp. 563-571.

Falchieri D., Lolli M., Romagnoli L, Vicini M., Brandi M., 2008. Una tecnica di applicazione a getto intermittente per trattamenti a dosi/Ha fortemente ridotte: risultati nel diserbo di grano e sorgo e nella difesa antiperonosporica della vite. Atti Giornate Fitopatologiche, 2, 65-72

Grisso R., Alley M., Thomason W., Holshouser D., Roberson G. T., (2011), Precision farming tools: variable-rate application., Virginia Cooperative Extention.

Hočevar, M. et al. (2009) Design and testing of an automated system for targeted spraying in orchards, Journal of Plant Diseases and Protection, 117 (2), 71 79.