EXPERIMENTAL RESEARCH ON ELECTRONIC SYSTEM FOR AUTOMATIC ADJUSTMENT OF WORKING FLOW AND MOVING VELOCITY IN AGRICULTURAL SPRAYING MACHINES

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Abstract. Ensuring stability of agrofarmaceutically liquid rate is one of the most important requirements imposed on machines to combat diseases and pests. Laboratory experiments were continued with experiments in real conditions, done on a spraying machine manufactured in Romania, type MET 1200. Preparation of the machine for testing consisted in the implementation of the elements that compose the system of the automatic adjusting system of liquid flow with displacement velocity in the machine constructive scheme and make the electrical circuits for their control and command. Experiencing the machine in working in the field was made using a method that consisted in determining the following work quality indexes: the average quantity of liquid administered on samples test, the uniformity of distribution in the direction of travel of the machine and the stability of liquid rate applied to standard hectare. To determine the distribution chart on the direction of travel of the machine and the work quality indexes four tests were carried out in conditions of variable speeds of movement, with the adjusting system coupled, respectively disengaged. The experimental research shows the functionality of the system designed and developed by the authors. Economic, social and environmental aspects which must be taken into account plead in favour of equipping sprinkling machines with such systems of control.

Keywords: agricultural spraying machine, liquid flow, displacement velocity, automatic control, adjusting system, work quality indexes.

Introduction

Accordingly with the international standards concerning the use of chemicals in crop protections, the equipment for this purpose must be easy to use and very precise during the work process.

Ensuring the stability of the liquid standard unit treated area is one of the major requirements imposed to sprinkling machines. Theoretical research done in order to design and realization of an electronic automatic system correlation for adjusting the liquid flow with work speed led to the definition and achievement of the system components, and also the working methodology.

Materials and methods

In order to make experiments in real working conditions elements have been implemented that compose the system of automatic control of the liquid flow with displacement velocity (proximity sensor, electronic unit, motorized valve) in a constructive scheme of a usually trailed sprayer, type MET 1200 (Fig. 1) [3]. The location of the system components on the tractor and on the sprinkling machine was achieved so [2]:

- electronic block (BE) was mounted on the tractor for a good view of the adjusting process (Figure 2);
- induction disc (1) of the proximity transducer is fixed on the machine wheel (3) and the proximity transducer (2) was mounted with a support, at the distance of 1,5 mm against the plan of the disc (Figure 3);
- electromagnetic flow meter (1) was mounted on the supply circuit (3) of the spray pad, used for sampling; also on this circuit the gauge for indicating the work pressure was mounted.

Experimental investigation of the behavior-based control system was based on collecting particles well distributed over an absorbance paper surface, followed by a quantitative analysis of the samples by weighing, in data acquisition and processing the obtained values through computer system.

The experimentation of the sprinkling machine equipped with the automatic adjusting system was made with a method that consisted in determining the following work quality indexes: the average quantity of solution distributed on the sample tests; the uniformity of distribution on the machine displacement direction; the stability of the liquid rate applied per hectare [1].

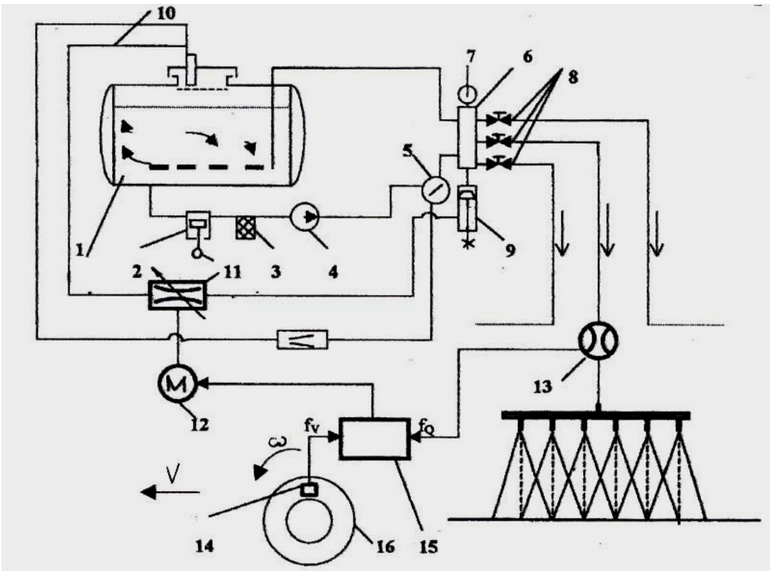

Fig. 1. **Implementation of elements that compose adjusting system in constructive scheme of usually trailed sprayer, type MET 1200:** 1 – tank; 2 – valve; 3 – filter; 4 – pump; 5 – tap; 6 – body distribution; 7 – gauge; 8 – taps; 9 – pressure valve control; 10 – flow surplus circuit; 11 – regulating valve of liquid flow; 12 – electric engine; 13 – electromagnetic flowmeter; 14 – proximity transducer; 15 – electronic block; 16 – transport wheel

Fig. 2. **Mounting electronik block:** BE – electronik block

Fig.. 3. **Induction disc and proximity transducerlocation**:
1 – induction disc; 2 – proximity transducer; 3 – transport wheel

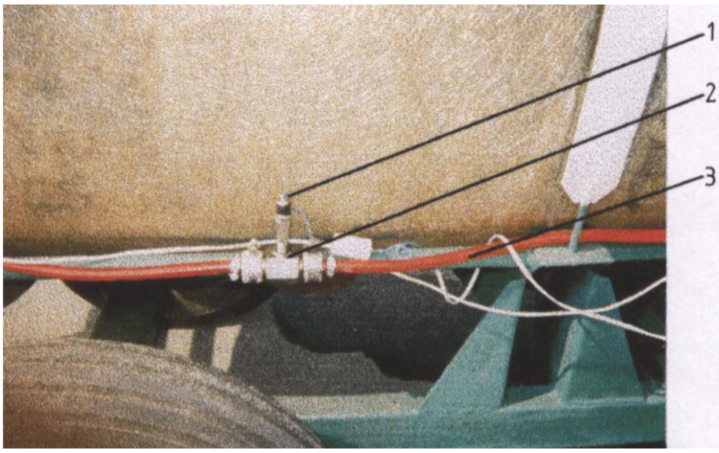

Fig. 4. **Electromagnetic flowmeter location:**
1 – electromagnetic transducer; 2 – turbine flowmeter; 3 – supply circuit

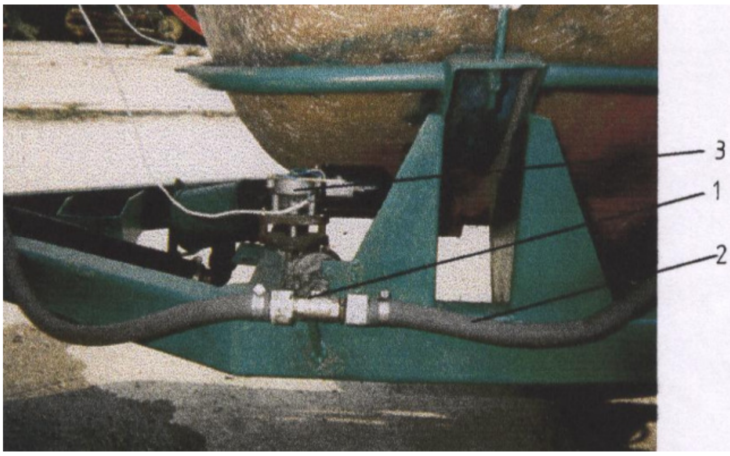

Fig. 5. **Regulating valve and electric motor drive:**
1 – regulating valve; 2 – flow surplus circuit; 3 – electric motor drive

a) The average quantity of solution distributed on the sample tests (each sample test has the surface $S = 0.16$ m^2) is established with relation:

$$g_m = \frac{\sum_{i=1}^{n} g_i + g_{0i}}{n} - g_{0m}; \quad g_{om} = \frac{\sum_{i=1}^{n} g_{0i}}{n} \text{[grams]} \tag{1}$$

where g_i – the quantity of solution distributed on one sample test, in grams;
g_{0i} – weigh of sample tests in initial circumstances, in grams;
g_{0m} – average initial weight of sample tests, in grams;
n – number of sample tests.

b) The uniformity of distribution (U_{dl}) on the machine displacement direction is established with relation [2]:

$$U_{dl} = 100 - C_V = 100 - \frac{\sqrt{\frac{\sum_{i=1}^{n}(g_i - g_m)^2}{n-1}}}{g_m} \cdot 100[\%] \tag{2}$$

where c_v – the coefficient of the uniformity variation distribution on the displacement direction, in %;

c) The stability (S_N) of the liquid rate applied per hectare is established with relation [2]:

$$S_N = 100 - 1_N = 100 - \frac{\sqrt{\frac{\sum_{i=1}^{n}(N_i - N_m)^2}{n-1}}}{N_m} \cdot 100\,[\%] \tag{3}$$

where I_N – the unsteadiness of the liquid rate application, on displacement direction, in %;
N_i – instantaneous liquid rate application, in l(kg)·ha^{-1};
N_m – average liquid rate application, in l(kg)·ha^{-1}.

The location mode of samples (of square shape with side of 40 cm) is shown in Figure 6.

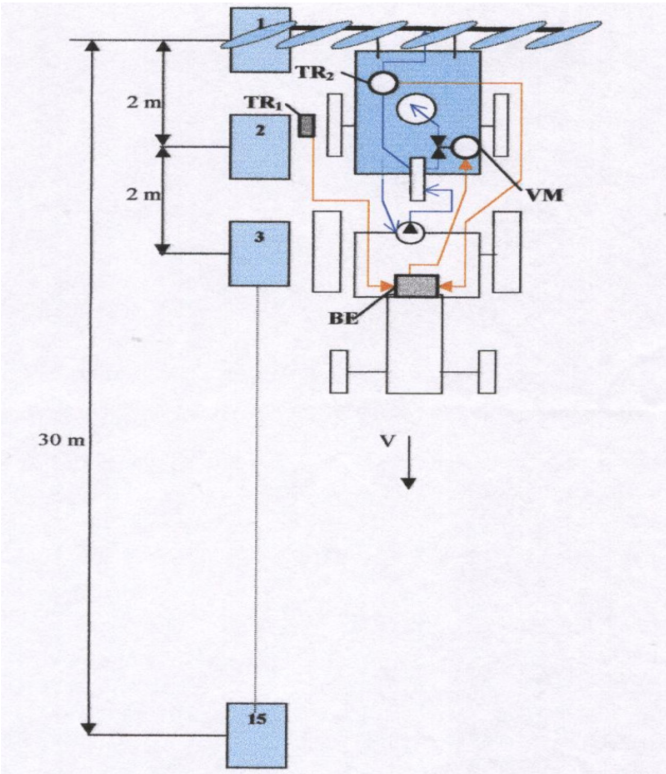

Fig. 6. **Layout mode of samples at experiments; overview of how placement controls system equipment components:** TR_1 – proximity transducer; TR_2 – electromagnetic flowmeter with impulses transducer; BE – electronic bloc; VM – valve control

The equipment for measurement and data acquisition includes the following components: portable computer PC 586/250 MHz, electronic balance Metler PM 6000 type, power supply, system for collection the distributed particles based on absorbent paper. Before setting the sample tests on the experimental work surface, each of these are weighed [2].

The obtained values (g_{0i}) are recorded into computer with aid of a specialized soft which allows recording maximum 120 measured values (through cumulate data base into the order of their measurements with the electronic weighing balance). To determine the distribution diagrams (on the direction of displacement) of the sprinkling machine and the work quality index four tests were performed in terms of variable speeds of displacement, specific for the work process. Also the work pressure was increased at 2.4 bar, to ensure the prescribed liquid rate (300 l(kg)·ha^{-1}), for a constant speed of 1.38 m·s^{-1}.

The first two tests were made with the system-off control. The other two tests were made with the adjusting system in active state pursuing the strict observance of the values of speeds and distances from the tests I and II (control tests). This way the evolution of the sprayer behavior with the adjusting system in those two states can be seen: ON and OFF. The specific conditions to achieve these tests are the following:

TEST I, III

- first interval (distance of 8m) was covered with a constant speed of 1.11 m·s^{-1} in time t_1 = 8/11 = 7.2 s (uniform movement);
- during the second interval the displacement velocity has increased from 1.11 m·s^{-1}) at 1.38 m·s^{-1} in time t_2 = 5 s; the length of this interval is $x = v^2/2a - v^2_0/2a$ = 6.2 m (uniformly accelerated movement, with a = $\Delta v/ \Delta t$ = 0.054 m·s^{-2});
- third interval (which has a length of 15.8 m) was covered with a constant speed of 1.38 m·s^{-1} in time t_3 = 11.2 s (uniform movement);
- TEST II, IV
- first interval (distance of 8 m) was covered with a constant speed of 1.38 m·s^{-1} in time t_1 = 5.7 s (uniform movement);
- during the second interval the displacement velocity has decreased from 1.38 m·s^{-1} at 1.11 ms^{-1}, in time t_2 = 5 s; the length of this interval is x = 6.2 m (uniformly decelerate movement, with $a = \Delta v/ \Delta t$ = - 0.054 m·s^{-2});
- third interval (which has a length of 15.8 m) was covered with a constant speed of 1.11 m·s^{-1} in time t_3 = 14.2 s (uniform movement).

Results and discussion

In Table 1 the data file where there are recorded discrete values corresponding to the four tests, obtained by comparison of ($g_i + g_{0i}$) values with values g_{0i} is presented.

Table 1

Average quantity of solution collected on each sample

Sample number	Corresponding discrete value, g			
	Test I	Test II	Test III	Test IV
1	4.7	4.7	4.6	4.6
2	4.6	4.8	4.7	4.7
3	4.8	4.7	4.8	4.6
4	4.8	4.6	4.7	4.7
5	4.4	5.0	4.2	5.1
6	4.0	5.3	3.9	5.5
7	3.5	5.7	4.3	5.2
8	3.4	5.8	4.9	4.9
9	3.4	5.7	4.7	4.7
10	3.5	5.9	4.8	4.8
11	3.4	5.8	4.7	4.8
12	3.5	5.8	4.8	4.6
13	3.6	5.7	4.9	4.7
14	3.4	5.6	4.8	4.8
15	3.5	5.7	4.9	4.9

Graphical representation of the data file with the obtained values allows representing the diagrams of the longitudinal distribution achieved by the sprinkling machine, in terms of these tests (Fig. 7, 8).

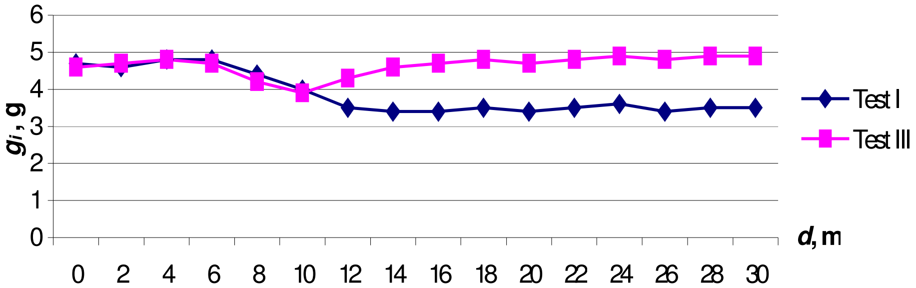

Fig. 7. **Dependence between liquid quantity administered per unit area and distance, for tests I and III**

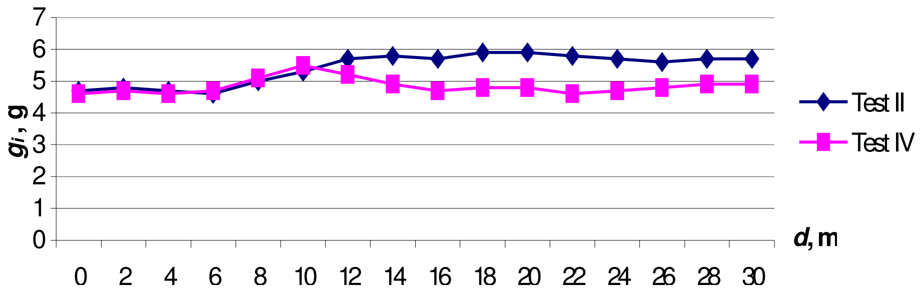

Fig. 8. **Dependence between liquid quantity administered per unit area and distance, for tests II and IV**

The analysis of the obtained results through the diagrams of distributions emphasizes the following:

1. The stability of liquid rate application is ensured in the case of the tests I and II (control tests) only during the interval of distance (0.8 m), when the admissible values (28.5…31.5 $g \cdot m^{-2}$) are respected; after completing the first interval (when the movement became uniformly varied) variation of the quantity of solution in reverse proportion with the variation of the displacement velocity can be observed.
2. In the case of the tests III and IV it can observed that the action of the adjusting system determines adequate changes of the quantity of solution just to the value necessary to ensure the prescribed liquid rate.
3. The values of the obtained work quality index are presented in Table 2.

Table 2

Values of obtained work quality index

Test	g_m, g	U_{dl}, %	S_N, %
I	3.90	85.00	85.00
II	5.30	84.5	84.5
III	4.58	93.9	93.9
IV	4.84	94.3	94.3

Conclusions

1. Adequate adaptation and implementation of the physical model of the automatic adjusting system on a sprayer MET 1200 type allowed to achieve the main set objectives for experimental research in real work conditions.
2. In order to verify the efficiency of the designed adjusting system and also the need to equip the sprinkling machines with such systems compared experiments were achieved both the system-control decoupled and in work state; in both cases the same values for the input sizes were observed: the liquid rate distribution and respectively, the variation mode of the displacement velocity.
3. The efficiency of the designed and developed physical model of the adjusting system is materialized by increasing the longitudinal uniformity distributions and also the stability of the liquid rate per hectare from 84.5 % to 94.3 %; the economic, social, environmental aspects which should be taken into account advocate in favor of achievement, homologation and equipping domestic manufacturing machines with such systems.

References

1. Alexandru T., Glodeanu M., Exploitation of agricultural machines. Sitech Publishing House, Craiova, 2009, pp. 162-180.
2. Glodeanu M., Theoretical and experimental researches concerning the automatic correlation of liquid flow with displacement velocity at sprinkling machines. PhD Thesis, Transilvania, University of Brasov, 2000, pp. 198-210.
3. Technical note MET 1200, Trading Company Agroservice, Alba-Iulia/Romania, 1994.