24th International Conference
ENGINEERING MECHANICS 2018
Svratka, Czech Republic, May 14 –17, 2018
Paper **#237,** pp. 233–236, doi: 10.21495/91-8-233

METHOD OF CONTROLLING THE OUTFLOW OF LIQUID FROM THE SPRAYER DURING THE DRESSING PROCESS

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Abstract: *In currently used dressing machines, it is generally not possible to control the outflow of liquid from the sprayer. The paper presents the method of controlling the outflow of liquid from the sprayer based on an innovative prototype device made at the Poznan University of Technology. The main goal was to construct a valve that allows precise control of the working liquid outflow from the sprayer by spraying. In order to characterize the parameters influencing the dressing process, further research was planned. It is expected from the constructed prototype that it will precisely control the process of intermittent spraying*

Keywords: dressing machine, electronically-controlled pressure and pneumatic valve, sprayer valve

1. Introduction

In commonly used devices for applying dressings on potato tubers, the outflow of the chemical agent from the spray nozzle takes place continuously. The chemical agent is applied by spraying the falling tuber. Large intervals between successive seed potatoes contribute to significant losses of the chemical agent. In mobile dressing machines mounted directly on planters, the problem is known and may result from the arrangement of spray nozzles and the type of spray nozzles, however, the control of the liquid outflow from the sprayer, and more precisely the intermittent outflow, can significantly reduce the loss of spray liquid. The most commonly used mobile dressing machines do not allow to control the amount of falling seed potatoes as well as their absence resulting from the malfunctioning of the planting unit. The patent literature contains examples of such solutions based on optical sensors operating in the infrared light band and with electromagnetic valves. The solutions can enable dynamic control of the amount of planted seed potatoes and precisely control the valves spraying seed potatoes. These systems are installed on potato planters and adapted for precision farming purposes (Erlichowski, 2003, 2015, Malkomes, 1993, Nasir et al., 2013). The construction of the prototype in accordance with the patented design should allow maintaining the quality of covering the seed potatoes with a chemical agent, while saving its amount.

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During the review of the professional and scientific literature, similar patterns were not found for intelligent intermittent distribution of chemical agent on potato tubers and other crops, as well as other systems where precise control of the spraying process is required. The proposed solution in the form of an electronically controlled pressure and pneumatic sprayer of a solution or suspension liquid is intended for the precise application of pesticides and other working liquids, used especially in plant protection. Electronic control allows precise, local dosing of the chemical preparation. This sprayer is especially designed for use in mobile dressing machines built on potato planters, but it can also be used in precision agricultural sprayers, for precise, localized spraying, as well as in the industry for applying liquid coatings and preparations on the surface of manufactured parts. The intermittent outflow of the spray liquid allows the chemical preparation to be accurately dispensed at a constant optimal supply pressure. In the currently used agricultural sprayers, the outflow rate of the spray liquid (dose per 1 m^2) is related to the supply pressure, that is, the reduction of the liquid flow rate causes a pressure drop in the sprayers. The sprayers for plant protection mainly used pressure sprays and pressure sprays with an auxiliary air stream of continuous operation. Intermittent nozzles, such as those found in automotive technology in fuel injection systems, both of fuel and petrol engines, are not used. However, sprayers with non-return valves are used more and more often. They prevent unwanted outflow of the spray liquid from the sprayer (dripping) after a pressure drop due to the closure of the spray liquid flow into the sprayer. In some patented solutions special nozzle valves, pneumatically or electrically controlled, are used for this purpose (Goebel & Mueller, 2006). However, they are not fast and precise enough to ensure precise dosing of liquids exactly on falling potatoes. In the precise protection of plants, especially in potatoes spraying equipment (liquid dressings) during planting, there is a need to use sprayers with intermittent effect, electronically controlled in such a way that the dose of the preparation goes exactly to a specific point, that is, in the case of dressing of a potato falling next to the sprayer, and in other cases, for example, in selective control of weeds or other precision treatments, of a specific plant. For this purpose, a special quick-acting sprayer is needed which does not produce coarse droplets when opening and closing, and is resistant to contamination with solid particles contained in preparations made in the form of a suspension that are often used in plant protection, in particular, seed dressing. Due to this last requirement, known solutions of pressure sprayers used in automotive technology are not useful here.

The aim was to construct an electronically controlled pressure and pneumatic valve that allows precise control of the liquid outflow from the sprayer. The planned functional tests will aim to prove the correct operation of the valve design.

2. Solution design

Developed and built in the Faculty of Machines of the Poznan University of Technology, the model of electronically controlled pressure and pneumatic valve is shown in Figure 1. (3 views of the sprayer body

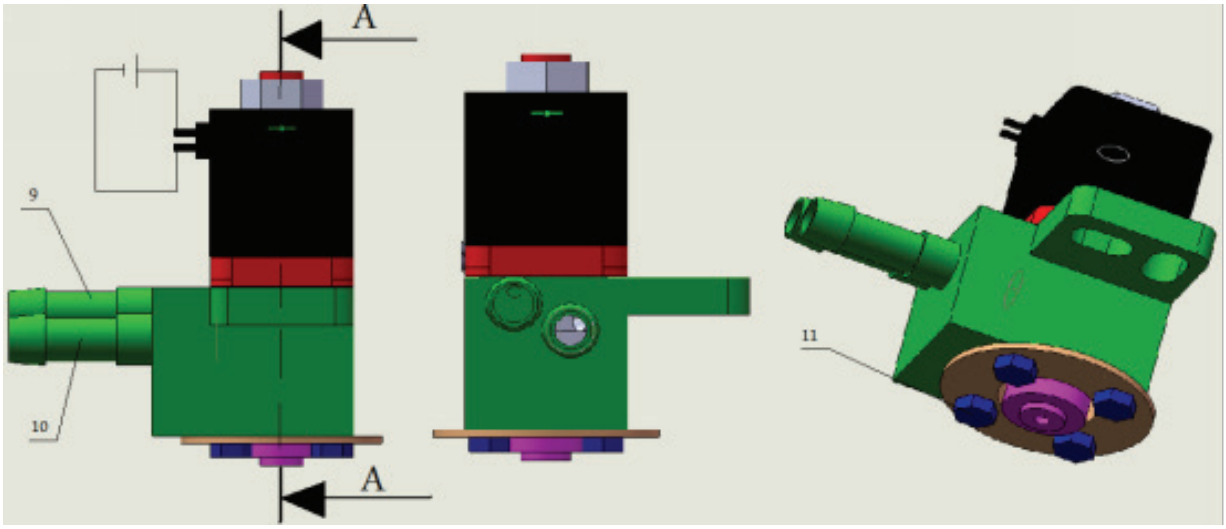

Fig. 1: Model of electronically controlled pressure and pneumatic valve, 9 - spigot powered with compressed air, 10 - spigot supplied with working liquid, 11- screws fixing nozzle clamp (Gierz & Gierz, 2016)

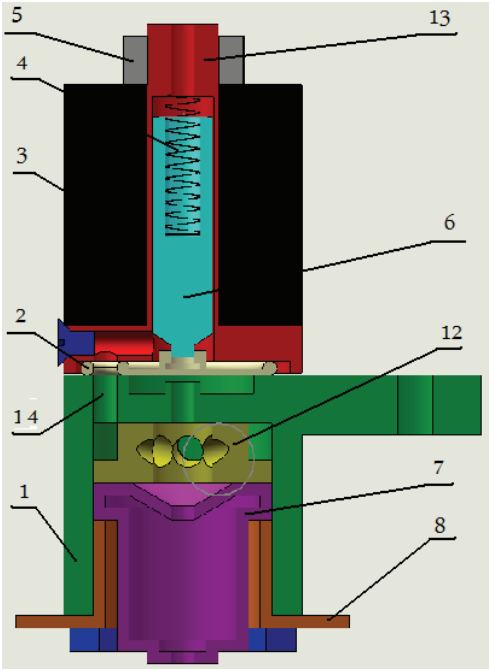

Fig. 2: Cross-section of electronically controlled pressure and pneumatic valve, 1 - body, 2 - membrane, 3 - coil, 4 - spring, 5 - nut, 6 - pin, 7 - nozzle, 8 - clamp, 12 - mixing pad, 13 - pin body (Gierz & Gierz, 2016)

along with the nozzle holder). There are also electric connectors and electrical circuits supplying the electric coil and connectors supplying the mixer with working liquid and air. Figure 2 shows the cross-section of the working fluid mixer, with particular attention to the method of fixing the coil with the membrane, the mixing pad, and the sprayer nozzle.

The sprayer consists of a body 1 that has a mounting bracket. The clamp 8 fixes the mixing pad 12 and the sprayer nozzle 7. The clamp 8 is tightened with screws 11. The next elements are the electromagnetic coil 3 together with the pin 6 and the tension spring 4. The coil is mounted on the body of the pin 13 by means of the nut 5. At the end of the pin, a membrane 2 is mounted. The task of the membrane is to open and close the flow of working liquid by covering the opening in the body 1. The compressed air from the pressure accumulator is supplied through the channel 14 into a slot above the valve membrane. The compressed air in this slot reduces the pressure of the diaphragm against the dosing opening. This force may be lower than the standard one and independent of the pressure fluctuations in the sprayer supply system. A 24V DC power source, necessary to excite the electromagnetic coil 3, is supplied to the electrical connections. The control voltage is managed by an electromagnetic relay. Compressed air is also supplied to the spigot 9 and the working fluid at a given pressure to the spigot 10. The design of the valve allows continuous air flow through the mixing pad 12 and the sprayer nozzle 7. After switching on the voltage, electromagnetic forces are created lifting the pin 6 together with the membrane 2. Raising the needle with the membrane causes the opening in the mixer body to be exposed and thus the working fluid flow to the mixing pad 12. In the mixing pad, the working fluid is mixed with air and continues to flow through the sprayer nozzle 7. After disconnecting the voltage, the spring 4 presses the pin 6 and the membrane 2 against the valve body 1. The supply of working liquid is cut off.

The basic feature that distinguishes this new sprayer is the use of a membrane valve that cuts off the flow of working liquid, the membrane of which is pressed against the nozzle of the working liquid by the spring. This membrane is lifted by the pressure of the working liquid when the valve is opened due to the electromagnet's opposing force against the spring force closing the valve. The working liquid stream dispensed through this valve is sprayed and lifted by the auxiliary air stream entering the mixing chamber. In order to reduce the force required to close the valve, an additional spigot was made which bring the gas over the membrane from the pressure accumulator, which is usually found in sprayers. The pressure of this gas is essentially equal to the pressure of the working liquid. To minimize the duration of the transient state, the air flow is not interrupted during the spraying operation, but it is closed only when the treatment is stopped. This prevents the formation of coarse droplets when opening and closing the valve.

The main movable element of the valve in the form of an electromagnet anchor was modeled to be light with a short pitch to minimize the inertia forces causing the elongation of the transient states during the closing and opening of the sprayer valve.

3. Summary and Conclusions

The performed prototype tests of the electronically controlled pressure and pneumatic valve show that the solution covered by the patent protection and the built-in prototype meet all the assumptions made. The electronically controlled valve developed for the purpose of this work was tested during the falling potatoes dressing process. The intermittent outflow of working liquid from the sprayer valve significantly reduced the chemical agent losses, while improving the ecological aspects and the economic result of the dressing process. In order to fully improve the dressing process of falling seed potatoes by means of an intermittent stream of spray liquid, it would be necessary to carry out a series of tests on the bench, so as to improve the control program. One can also see a chance of development in the optimization of the process of mixing the working fluid with air, respectively changing the structure of the mixing pad.

Acknowledgements

The research was supported by statutory resources appropriated to Institute of Machines and Motor Vehicles, Poznan University of Technology as "The Grant for Young Researchers" No. 05/51/DSMK/3537.

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