Machinery & Energetics
Vol. 15, No. 1. 2024

Journal homepage:
https://technicalscience.com.ua/en

UDC 631.34: 632.98
DOI: 10.31548/machinery/1.2024.95

Borys Onyshchenko*

PhD in Technical Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0009-0009-0350-4275

Volodymyr Onyshchenko

PhD in Technical Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0009-0008-0348-3948

Volodymyr Nazarenko

PhD in Environmental Economics, Lecturer
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-7433-2484

Vasyl Achkevych

PhD in Technical Sciences, Associate Professor
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine
https://orcid.org/0000-0002-1537-6997

Experimental study of the time of pressure rise and fall in the sprayer pipe

Abstract. A wide variety of meteorological factors, soil and climatic conditions, the saturation of fields with many types of weeds, a significant set of cultivated plants and many other factors necessitate the implementation of innovative technological schemes for the use of pesticides, which will reduce the pesticide load as much as possible and determine the safe environmental effect of preparations. Experimental studies were carried out to determine the time of pressure rise and fall in the sprayer pipe and to establish the corresponding functional dependencies. The automatic adjustment system of the application rate was set to change the pressure when the green simulation surface hit 0.5 MPa, and the yellow surface hit 0.2 MPa. Sensor impact on a surface of different colours was simulated. At the same time, the pressure in the system changed. The pressure in the sprayer pipe of trailer sprayer OP-2000-2 was measured using a WIKAI EN837-1 pressure gauge and the readings were recorded with a Panasonic NV-GS75 digital video camera mounted on a Continent TRIPOD A2 stand. As a result of calculating the experimental data, it was found that the arithmetic mean of pressure reduction from 0.5 to 0.2 MPa is 1.94 s. And the arithmetic mean for four experiments, a pressure reduction of 0.05 MPa is 0.32 s. When calculating the experimental data of the pressure rise, it was found that the arithmetic mean of the pressure rise from 0.2 to 0.5 MPa is 2.37 s. And the average value for four experiments, the pressure rise by 0.05 MPa is 0.395 s. After approximation of experimental data obtained during single-factor experiments, when the pressure *P* and the corresponding

Article's History: Received: 13.10.2023; Revised: 26.01.2024; Accepted: 28.02.2024.

Suggested Citation:
Onyshchenko, B., Onyshchenko, V., Nazarenko, V., & Achkevych, V. (2024). Experimental study of the time of pressure rise and fall in the sprayer pipe. *Machinery & Energetics,* 15(1), 95-103. doi: 10.31548/machinery/1.2024.95.

*Corresponding author

time values t change, the corresponding polynomial functions describing the characteristic $t = f(P)$ when operating a sprayer with automatic application rate control were obtained. The results obtained would allow calculating the time of delay or advance opening of the spray torch when working with variable standards for target plans, in order to avoid non-compliance with the application rate with the specified values

Keywords: polynomial functions; boom; field sprayer; plant protection; application rate; spray swath

INTRODUCTION

Agricultural production is a complex process that requires thoughtful and rational use of natural and climatic conditions, soil resources, and the biological potential of plants. To achieve optimal yields and ensure the sustainability of crop production, it is important to effectively control factors that may threaten the crop. In this context, the control of weeds, pests, and diseases that can attack crops plays a key role. These threats can spread to a variety of plant species, creating significant difficulties for agricultural producers.

Due to the wide variety of meteorological conditions and soil characteristics, and the presence of various types of weeds in the fields, production faces various challenges. This is where the introduction of advanced technological methods for the use of pesticides becomes important. This includes the use of advanced integrated plant protection techniques that help reduce the pesticide burden on the environment. This approach allows for effective control of pests and diseases, while maintaining safety for nature and agroecosystems. Consequently, the introduction of advanced technological solutions in the field of plant protection becomes a strategically important stage for ensuring the sustainability and efficiency of agricultural production.

Many researchers have studied technological processes and working bodies for chemical plant protection. M. Hulin *et al.* (2021), M. Djouhri *et al.* (2023) investigated models of the drift of sprayed pesticides, the processes of scattering, evaporation of droplets, their deposition to the ground and interception by air flow, and atmospheric stability and turbulence modes. The researchers considered drift patterns of sprayed pesticides by analysing the processes of scattering, evaporation of droplets, precipitation to the ground, and interception by air flow. In addition, they analysed atmospheric stability and turbulence regimes, which contributed to a deeper understanding of the dynamics and effects of sprayed pesticides in the environment.

B. Xiahou *et al.* (2020) conducted modelling and experimental studies of the characteristics of droplet flow and their deposition in the air flow field. They focused on carefully analysing the impact of these factors on the distribution of pesticides and developing strategies to optimise the use of plant protection products to ensure efficiency and environmental safety.

C. Dereumeaux *et al.* (2020), I.W.P. Paulson *et al.* (2022) studied in detail the experimental characteristics of the aerodynamic footprint of a high-clearance sprayer when changing the operating parameters. This helped to establish optimal conditions for ensuring the efficiency of cutting and minimising the negative impact on the environment. The study also revealed important relationships between spray parameters and the distribution of pesticides in the atmosphere, contributing to the development of recommendations for improving the efficiency and sustainability of sprayers in agriculture.

According to the findings by R.N. Martins *et al.* (2021), the effect of sprayer types and sprayer pipe pressure on the characteristics of sprayed droplets was determined. These results provide important information for understanding the impact of these factors on droplet size, distribution, and behaviour, which are key aspects of effective pesticide use in agriculture. In addition, this study contributed to the development of recommendations for optimising the operating parameters of sprayers, which can lead to an improvement in the quality of spraying and minimise the loss of pesticides as a result of uncontrolled dispersion of particles into the atmosphere. Consideration of these factors is an important step in the practical implementation of environmentally effective spraying strategies.

H.V. Mercaldi *et al.* (2017), J. Wawrzosek & S. Parafiniuk (2022) considered the use of a permutation algorithm to suboptimise the location of spent nozzles on the sprayer boom. The use of this algorithm allows optimising the location of the nozzles, considering various parameters, such as the width of the droplet flight, their concentration, and uniformity of distribution. This approach may prove important for improving the efficiency of sprayers by promoting more accurate and cost-effective distribution of pesticides. The results will help to identify optimal nozzle configurations, contributing to the improvement of spray technologies and reducing the impact on the environment.

The analysis of the papers by prominent researchers showed that no studies of the time of pressure rise and fall in the sprayer pipe have been carried out. Therefore, the purpose of the experimental study was to determine the time of pressure rise and fall in the sprayer pipe and establish the corresponding functional dependencies.

MATERIALS AND METHODS

The research was carried out at the National University of Life and Environmental Sciences of Ukraine at the Department of Agricultural Machinery and System Engineering named after Academician P.M. Vasylenko in 2021-2023. Since it is impossible to record the time of pressure rise and fall in the sprayer pipe using a stopwatch and eyesight, it was decided to record the pressure gauge readings using a Panasonic NV-GS75 digital video camera (Japan), which allows 25 frames per second. Experimental OP-2000-2 trailer sprayer (Ukraine) (Fig. 1) transported to the test site. A driveshaft was attached to the sprayer pump and connected to the power take-off shaft (PTO) of the MTW-82 tractor (Belarus). The tractor's PTO speed was set at 540 rpm.

Collector pressure was monitored using a WIKAI EN837-1 pressure gauge (WIKA Group, USA) in accordance with DSTU 7224:2011 (2011). Since the sprayers operated at a pressure of 0.2 to 0.5 MPa, the test was performed at a pressure of 0.2 to 0.5 MPa. The Panasonic NV-GS75 digital video camera was mounted on a Continent TRIPOD A2 (Continent, China) stand. The height of the video camera installation was 1.5 metres above the ground, and 1 metre from the WIKAI EN837-1 pressure gauge. The video camera was set to a shutter speed of 1/500 of a second, an aperture of D=8 to ensure the greatest clarity of shooting, and a 5x optical zoom (Fig. 2). The automatic application rate control system was set to change the pressure when the green simulation surface hits by 0.5 MPa and the yellow by 0.2 MPa. They simulated the sensor hitting a surface of different colours. At the same time, the pressure in the system changed. The survey was carried out in four-fold repetition, to raise and lower the pressure.

Figure 1. Conducting experiments on a prototype trailer sprayer OP-2000-2
Source: photo by authors

Figure 2. Recording the readings of the WIKAI EN837-1 pressure gauge when raising and lowering the pressure in the pipe
Source: photo by authors

After the research, the camera was connected using a FireWire connector to a PC based on the Athlon 2800+ processor (China). The video was processed using Motion DV STUDIO 5.3 E (Fig. 3), where the time for the pressure to drop and rise from 0.2 to 0.5 MPa was calculated.

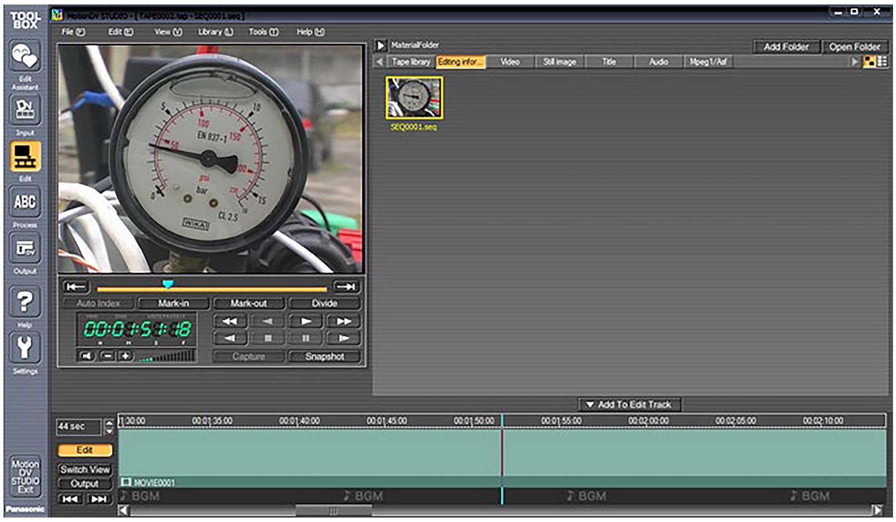

Figure 3. Video data analysis in Motion DV STUDIO 5.3E
Source: photo by authors

The research data were processed using the method of statistical processing of empirical data and evaluated by the arithmetic mean of the time of pressure rise and fall in the sprayer pipe, the standard deviation, and the coefficient of variation. Calculations were performed using the following equations (1)-(4):

- the arithmetic mean of the time of pressure rise and fall in the sprayer pipe (Bugutsky, 1999):

$$\bar{x} = \frac{\sum x_i}{N}, \qquad (1)$$

where x – time, s; N – number of experiments,

- mean square deviation (variance):

$$\sigma^2 = \frac{\sum(x_i - \bar{x})^2}{N-1}, \qquad (2)$$

- mean square deviation (standard):

$$\sigma = \sqrt{\sigma^2}, \qquad (3)$$

- coefficient of variation based on the standard deviation:

$$V = \frac{\sigma}{\bar{x}} \cdot 100\%. \qquad (4)$$

Experiments to determine the time of pressure rise and fall in the sprayer pipe were carried out in four repetitions. Calculations were performed using Microsoft Office Excel 2007 software suite.

RESULTS AND DISCUSSION

The results of calculating the standard deviation (variance), standard deviation (standard) and coefficient of variation are presented in Table 1 (calculations were performed using equations 1-4)

Table 1. Results of experimental studies of pressure reduction

No. of experiment	Average pressure reduction value t, s, by 0.05 MPa	Variance	Mean square deviation	Variation coefficient
1	0.27	0.01	0.11	39.87
2	0.29	0.01	0.12	41.06
3	0.44	0.06	0.25	57.21
4	0.29	0.01	0.12	41.06

Source: compiled by the authors

As a result of calculating the experimental data, it was found that the average value of the pressure drop from 0.5 to 0.2 MPa is 1.94 s. And the average value for four experiments, a pressure drop of 0.05 MPa is 0.32 seconds. Results of pressure drop by 5 to 2 atm (in increments of 1 atm) are shown in Figure 4.

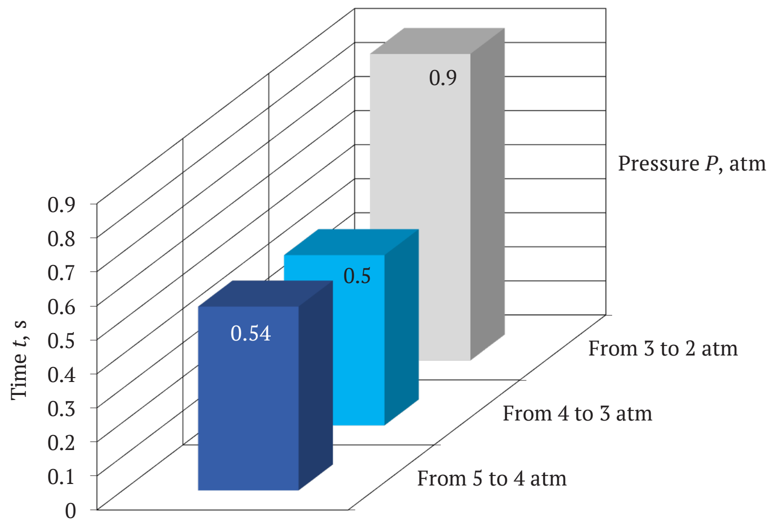

Figure 4. Diagram of the time t required to reduce the pressure in the sprayer pipe by 1 atm

Source: compiled by the authors

As a result of approximation of experimental values obtained during a single-factor experiment with pressure changes P and the corresponding calculated time values t, it is established that the best corresponding functional dependencies are described by a polynomial function. Therefore, the functional dependence describing the characteristic $t = f(P)$ (Fig. 5) when the sprayer with automatic application rate control is as follows:

$$P = 0.4017 \cdot t^2 - 2.4051 \cdot t + 5.1017, \qquad (5)$$

where P – pressure in the sprayer pipe, atm; t – time, s.

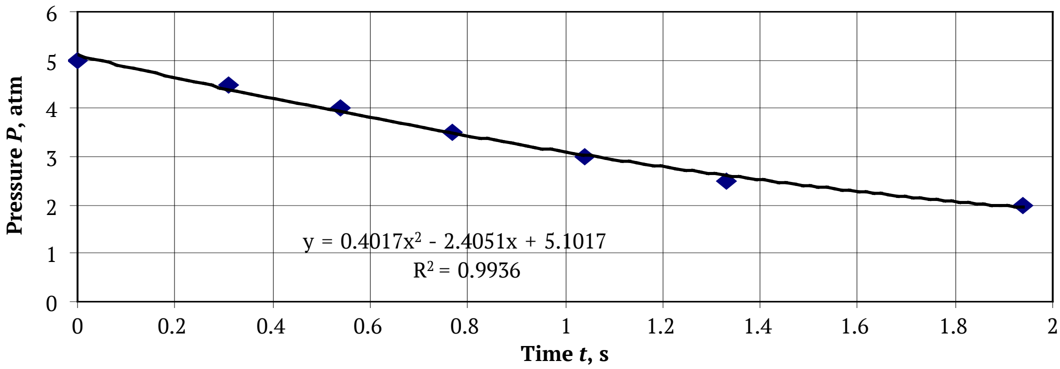

Figure 5. Dependence of pressure in the sprayer pipe P on time t

Source: compiled by the authors

Coefficient of determination of this dependence $R^2 = 0.9936$. Equation (5) is appropriate, given that the probability is 0.99 for the calculated value of the Fisher's criterion $F_{calc.} = 156$ is much larger than the table value of Fisher's criterion $F_{table} = 12.25$. Based on the findings of J.F. Reyes *et al.* (2015), it can be argued that equation (5) is significant and its coefficients cannot be ignored. The materiality of the coefficient of determination was estimated using the Student's t-test. The coefficient of determination of this dependence is significant because the probability of $R = 0.99$, $t_{calc.} = 508$ is much higher than $t_{table} = 3.50$ (Bugutsky, 1999).

The arithmetic mean of the pressure rise from 0.2 to 0.5 MPa, by 0.1 and 0.05 MPa was determined by the equation (1). The results of calculations of the standard deviation (variance), standard deviation (standard) and coefficient of variation are presented in Table 2 (calculations were performed using equations 1-4).

Table 2. Results of experimental studies of pressure rise

No. of experiment	Average value of pressure rise t, s, by 0.05 MPa	Variance	Mean square deviation	Variation coefficient
1	0.31	0.02	0.14	46.42
2	0.26	0.03	0.17	64.36
3	0.65	0.004	0.07	10.00
4	0.36	0.03	0.18	50.18

Source: compiled by the authors

As a result of calculating the experimental data, it was found that the average time of pressure rise from 0.2 to 0.5 MPa is 2.37 s. And the average value for four experiments, the pressure rise by 0.05 MPa is 0.395 s. As a result of approximation of the experimental values of pressure rise from 0.2 to 0.5 MPa obtained during a one-factor experiment with a change in pressure P and the corresponding calculated values of time t, it was found that the functional dependencies described by the polynomial function are the most appropriate. Therefore, a functional dependency describing a characteristic $t = f(P)$ (Fig. 6) when using sprayer with automatic adjustment of the application rate, has the following form:

$$P = 0.2024 \cdot t^2 + 0.8171 \cdot t + 1.9864, \quad (6)$$

where P – pressure in the sprayer pipe, atm; t – time, s.

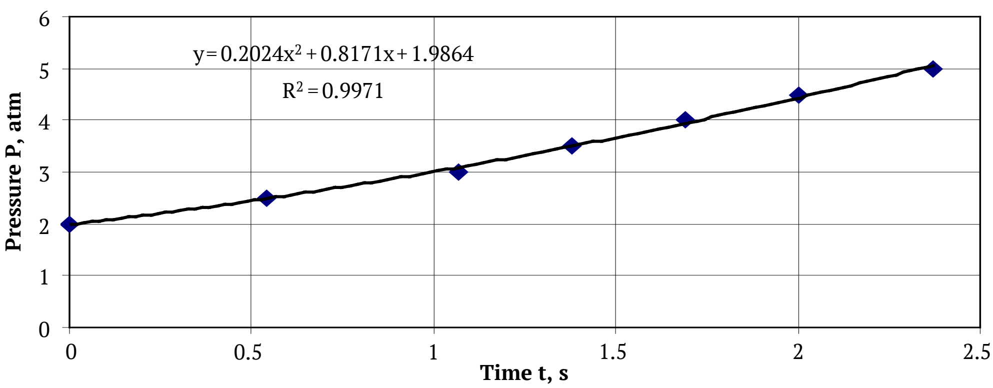

Figure 6. Dependence of the pressure in the sprayer pipe P on time t

Source: compiled by the authors

Coefficient of determination of this dependence is $R^2 = 0.9971$. Equation (6) is appropriate because, with a probability of 0.99, the calculated value of the Fisher's criterion $F_{calc.} = 172$ is much larger than the table value of Fisher's criterion $F_{table} = 12.25$. Based on the findings of J.F. Reyes (2015), it can be argued that equation (6) is significant and its coefficients cannot be ignored. The materiality of the coefficient of determination was evaluated according to the Student's t-test. The coefficient of determination of this dependence is correspondingly significant because if the probability $p = 0.99$, $t_{calc.} = 607$, which is much larger than $t_{table} = 3.50$ (Bugutsky, 1999). J.V. Fabula *et al.* (2020) investigated the effect of pipe pressure uniformity and droplet size when using pulse-width modulation spray technology. D. Nuyttens *et al.* (2017) investigated the drift of working fluid droplets by different application methods using a drift test bench and compared it with other evaluation methods.

Similar studies have been conducted by D.G. Voytyuk (2015), where the researcher reviewed and analysed machine protection devices, describing their characteristics, technological schemes, settings, and methods of use. The study has provided important insights into understanding the diversity and functionality of protective devices, including their adaptation to different conditions and types of cultivated fields, and highlighted not only the technical aspects of plant protection machines, but also considered their technological purpose and optimal settings for effective use. The review included an analysis of various technological schemes used in such machines, and determined their suitability for various types of agricultural land. Special attention is paid to the adaptation of protective devices to different conditions and types of cultivated fields. This is important to ensure optimal efficiency in a diverse agricultural landscape. The results of the study helped not only to improve existing plant protection machines, but also to develop recommendations for the selection and effective use of such technical means, depending on specific business conditions.

A. Sharda *et al.* (2011) investigated the norm of working fluid from a single series of sprayers when using water-sensitive paper maps. This approach helps to determine in detail the distribution of liquid on the surface and evaluate the efficiency of sprayers. The study considered the interaction of the liquid with the surface based on the characteristics of each sprayer. The results obtained have a positive impact on improving the accuracy and efficiency of sprayers in agriculture, and on the rational use of working fluids. O.I. Melezhik (2010) improved the dispersion of pesticide spraying, and developed a new type of centrifugal sprayer. This approach helps to determine in detail the distribution of liquid on the surface and evaluate the efficiency of sprayers. The study considered the interaction of the liquid with the surface based on the characteristics of each sprayer. The results obtained have a positive impact on improving the accuracy and efficiency of sprayers in agriculture, and on the rational use of working fluids.

V.M. Polischuk (2005) substantiated the parameters of the pneumohydraulic system for dosing and supplying working fluid in sprayers. He investigated the optimal characteristics of this system to maximise the accuracy and efficiency of spraying, reduce fluid loss, and optimise the flow rate of working material. Based on the findings, it can be stated that the developed parameters of the pneumohydraulic dosing system are of great importance for improving the control of the spraying process. This approach helps not only to increase the efficiency of sprayers, but also to reduce the negative impact on the environment through more accurate dosing of the working fluid. J.D. Luck *et al.* (2011), A.B. Dorneles *et al.* (2018) investigated the flow characteristics, spray pattern, and droplet spectra of an actively controlled nozzle with a variable opening at constant carrier pressure. Their results helped to identify optimal operating modes of the nozzle, ensuring maximum spray efficiency and saving working material. This study occupies an important place in understanding the technical aspects of the operation of actively controlled injectors and indicates the prospects for their use in modern spray systems. The analytical approach to investigating the characteristics of injectors contributes to the development and improvement of spraying technologies, which affects the quality and efficiency of using working fluids in agriculture.

O. Baranovskyi & V. Polischuk (2001), O. Baranovskyi *et al.* (2010) studied a jet pump for direct delivery of pesticides to the sprayer discharge line and analysed the metering systems of boom sprayers. They analysed the dosing systems of boom sprayers aimed at improving the accuracy and efficiency of the distribution of working fluids during spraying.

Research on this aspect of spraying technology is important for agriculture, as it aims to develop and improve systems that ensure efficient delivery of pesticides to the field. The results obtained can affect the rational use of working fluids, increase productivity, and reduce material losses during spraying. These results should be considered when developing and implementing modern spraying technologies in order to optimise the use of pesticides and ensure sustainable production in agriculture.

CONCLUSIONS

As a result of calculating the experimental data, it was found that the arithmetic mean of pressure reduction from 0.5 to 0.2 MPa is 1.94 s, and the arithmetic mean for four experiments, a pressure drop of 0.05 MPa, is 0.32 s. As a result of approximation of experimental values obtained during a single-factor experiment with pressure reduction P and the corresponding calculated time values t, it is established that the best corresponding functional dependencies are described by a polynomial function. Therefore, a functional dependency describing a characteristic $t = f(P)$ when the pressure drops, has the following form: $P = 0.4017\ t^2 + 2.4051\ t + 5.1017$. When calculating the experimental data of the pressure rise, it was found that the arithmetic mean of the pressure rise from 0.2 to 0.5 MPa is 2.37 s. And the average value for four experiments, the pressure rise of 0.05 MPa is 0.395 s. As a result of the approximation of the experimental values of the pressure rise from 0.2 to 0.5 MPa obtained during a single-factor experiment with a change in pressure P and the corresponding calculated values of time t, it was found that the polynomial function describes the best corresponding functional dependences. Therefore, a functional dependency describing a characteristic $t=f(P)$ when the pressure rises, is $P=0.2024\ t^2 + 0.8171\ t + 1.9864$. These experiments in the future would allow calculating the time of delay or advance of opening the spray swath when working with variable standards on target plans.

Further research can be aimed at experimentally studying the time of pressure rise and fall in the sprayer pipe. A detailed analysis of these parameters is key to optimising the operation of sprayers and improving the efficiency of pesticide use in agriculture. The study of the pressure rise time in the pipe will help determine the optimal parameters for a quick and efficient start-up of the spraying system. Pressure reduction is a critical factor in ensuring the accuracy of the working fluid distribution, so a detailed study of this process can lead to improvements in the design and functionality of sprayers. Optimisation of these parameters can improve spray efficiency, reduce working fluid loss, and affect the consistency and accuracy of the process. Such studies will be an important contribution to the improvement of modern spraying technologies in agricultural production.

ACKNOWLEDGEMENTS

Dmytro Hryhorovych Voytyuk, PhD, corresponding member of the National Academy of Sciences of Ukraine, Professor and Department of Agricultural Machinery and System Engineering named after Academician P.M. Vasylenko

CONFLICT OF INTEREST

None.

References

[1] Baranovskyi, O., & Polischuk, V. (2001). Analysis of metering systems for boom sprayers. *Bulletin of the State Academy of Agrarian Sciences of Ukraine,* 2, 141-146.

[2] Baranovskyi, O.S., Pyatachenko, V.I., & Sergeeva, O.V. (2010). Investigation of a jet pump for direct supply of pesticides to the sprayer discharge communication. *Mechanization and Electrification of Agriculture*, 94, 206-215.

[3] Bugutsky, O.A. (Eds.). (1999). *Statistics*. Kyiv: Complex Vita LLC.

[4] Dereumeaux, C., Fillol, C., Quenel, P., Denys, S. (2020). Pesticide exposures for residents living close to agricultural lands: A review. *Environment International*, 134, article number 105210. doi: 10.1016/j.envint.2019.105210.

[5] Djouhri, M., Loubet, B., Bedos, C., Dages, C., Douzals, J.-P., & Voltz, M. (2023). ADDI-Spraydrift: A comprehensive model of pesticide spray drift with an assessment in vineyards. *Biosystems Engineering*, 231, 57-77. doi: 10.1016/j.biosystemseng.2023.05.008.

[6] Dorneles, A.B., Bottega, E.L., Oliveira, Z.B., Knies, A.E., Silva, C.M., & Souza, I.J. (2018). Using different spray tips to control diseases in wheat. *Ciencia e Natura*, 40, 11-17. doi: 10.5902/2179460X35494.

[7] DSTU 7224:2011. (2011). *Metrology. Pressure gauges, manovacuum gauges, vacuum gauges, pressure meters, traction pressure meters, weights with pneumatic output signals. Verification (calibration) methods*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=67905.

[8] Fabula, J.V., Sharda, A., Flippo, D., Ciampitti, I., & Kang, Q. (2020). Boom pressure and droplet size uniformity of a pulse width modulation (PWM) spray technology. *ASABE*. doi: 10.13031/aim.202001041.

[9] Hulin, M., *et al.* (2021). Monitoring of pesticides in ambient air: Prioritization of substances. *Science of the Total Environment*, 753, article number 141722. doi: 10.1016/j.scitotenv.2020.141722.

[10] Luck, J.D., Pitla, S.K., Zandonadi, R.S., Sama, M.P., & Shearer, S.A. (2011). Estimating off-rate pesticide application errors resulting from agricultural sprayer turning movements. *Precision Agriculture*, 12(4), 534-545. doi: 10.1007/s11119-010-9199-9.

[11] Martins, R.N., Moraes, H.M.F., de Freitas, M.A.M., da Costa Lima, A., & Furtado Junior, M.R. (2021). Effect of nozzle type and pressure on spray droplet characteristics. *Idesia*, 39(1), 101-107. doi: 10.4067/S0718-34292021000100101.

[12] Melezhik, O.I. (2010). *Improvement of dispersion for pesticide spraying*. (PhD thesis, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine).

[13] Mercaldi, H.V., Peñaloza, E.A.G., Mariano, R.A., Oliveira, V.A., & Cruvinel, P.E. (2017). Flow and pressure regulation for agricultural sprayers using solenoid valves. *Escola de IFAC PapersOnLine*, 50(1), 6607-6612. doi: 10.1016/j.ifacol.2017.08.693.

[14] Nuyttens, D., Zwertvaegher, I.K.A., & Dekeyser, D. (2017). Spray drift assessment of different application techniques using a drift test bench and comparison with other assessment methods. *Biosystems Engineering*, 154, 14-24. doi: 10.1016/j.biosystemseng.2016.09.013.

[15] Paulson, I.W.P., Gerspacher, J., Gagnon, B.J., Landry, H., Sumner, D., & Bergstrom, D.J. (2022). Experimental characterization of the aerodynamic wake of a high-clearance sprayer with changing operating parameters. *Journal of the ASABE*, 65(3), 665-679. doi: 10.13031/JA.14941.

[16] Polischuk, V.M. (2005). *Substantiation of parameters of the pneumohydraulic system of dosing and supply of working fluid in sprayers*. (PhD thesis, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine).

[17] Reyes, J.F., Esquivel, W., Cifuentes, D., & Ortega, R. (2015). Field testing of an automatic control system for variable rate fertilizer application. *Computers and Electronics in Agriculture*, 113, 260-265.

[18] Sharda, A., Fulton, J.P., McDonald, T.P., & Brodbeck, C.J. (2011). Real-time nozzle flow uniformity when using automatic section control on agricultural sprayers. *Computers and Electronics in Agriculture*, 79(2), 169-179. doi: 10.1016/j.compag.2011.09.006.

[19] Voytyuk, D.G. (Ed.). (2015). *Agricultural machinery*. Kyiv: Agroosvita.

[20] Wawrzosek, J., & Parafiniuk, S. (2022). The use of the permutation algorithm for suboptimising the position of used nozzles on the field sprayer boom. *Applied Sciences*, 12(9), article number 4359. doi: 10.3390/app12094359.

[21] Xiahou, B., Sun, D., Song, S., Xue, X., & Dai, Q. (2020). Simulation and experimental research on droplet flow characteristics and deposition in airflow field. *International Journal of Agricultural and Biological Engineering*, 13(6), 16-24. doi: 10.25165/j.ijabe.20201306.5455.

Борис Володимирович Онищенко
Кандидат технічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0009-0009-0350-4275

Володимир Борисович Онищенко
Кандидат технічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0009-0008-0348-3948

Володимир Анатолійович Назаренко
Доктор філософії з «Економіки природокористування», асистент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-7433-2484

Василь Іванович Ачкевич
Кандидат технічних наук, доцент
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна
https://orcid.org/0000-0002-1537-6997

Експериментальне дослідження часу підняття та зниження тиску в колекторі обприскувача

Анотація. Велике різноманіття метеорологічних факторів, ґрунтово-кліматичних умов, насиченість полів багатьма видами бур'янів, значний набір культурних рослин і багато інших факторів обумовлюють необхідність втілення інноваційних технологічних схем використання отрутохімікатів, це дозволить максимально зменшити пестицидне навантаження та зумовить безпечну екологічну дію препаратів. Експериментальні дослідження були проведені з метою визначення часу підняття та зниження тиску в колекторі обприскувача та встановлення відповідних функціональних залежностей. Систему автоматичного регулювання норми внесення було налаштовано на зміну тиску при потраплянні зеленої імітаційної поверхні на 0,5 МПа, а жовтої на 0,2 МПа. Імітовано потрапляння сенсора на поверхню різного кольору. При цьому змінювався тиск в системі. Тиск в колекторі обприскувача ОП-2000-2 вимірювався за допомогою манометра WIKAI EN837-1 та фільмовано показання цифровою відеокамерою Panasonic NV-GS75 встановленою на штатив Continent TRIPOD A2. В результаті обрахунку експериментальних даних встановлено, що середнє арифметичне значення зниження тиску від 0.5 до 0.2 МПа становить 1.94 с. А середнє арифметичне значення по чотирьом дослідам, зниження тиску на 0.05 МПа становить 0.32 с. При обрахунку експериментальних даних підняття тиску встановлено, що середнє арифметичне значення підняття тиску від 0.2 до 0.5 МПа становить 2.37 с. А середнє значення по чотирьом дослідам, підняття тиску на 0.05 МПа становить 0.395 с. Після апроксимації експериментальних даних, отриманих при проведенні одно факторних експериментів, при зміні тиску P і відповідних значень часу t, отримані відповідні поліноміальні функції, що описують характеристику $t = f(P)$ при роботі обприскувача з автоматичним регулюванням норми внесення. Отримані результати в майбутньому дають можливість розрахувати час затримки або випередження розкриття факелу розпилювача при роботі з змінними нормами по картам завдань, для уникнення невідповідності нормі внесення заданим значенням

Ключові слова: поліноміальні функції; штанга; польовий обприскувач; захист рослин; норма внесення; факел розпилу