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The use of labview environment for the building of the grain Dust control system in grain mill

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Abstract. The work environment in a grain mill is associated with the occurrence of many hazardous and troublesome factors at this work. However, the most important hazardous factor occurring in the work environment in grain mills is grain and flour dust. The aspiration and filtration systems applied in mills frequently do not provide proper protection for workers. The objective of the study was to present the assumptions of a complex system controlling the level of dustiness in a grain mill. LabView environment has been used for the building of such system. The acquisition of parameters was carried out basing upon the information and signals received from the sensors supporting the measuring cards. The actual as well as archived parameters occurring in individual rooms can be displayed on the computer screen via the built-in interface.

Key words: control and supervision systems, LabView environment, grain dust, grain-mill, Maximum Allowable Concentration (MAC),

INTRODUCTION

Work in grain mills is associated with the performance of activities at many sites of the work environment, where there occurs exposure to grain and flour dust. Frequently, mean weighted concentrations at workplaces exceed hygienic standards (MAC values). The work of the staff of a mill is most often connected with a frequent or continuous presence at the sites of the work environment, where high levels of dustiness occur. It is therefore necessary to provide safe dust conditions. This should be obtained by the reduction of dust emission or limiting the workers' access to the rooms where high dust concentrations occur, which may result in exceeding the MAC values at individual workplaces.

Long-term exposure to dust at workplaces in cereal processing may be the cause of morbidity due to dust-related diseases, such as: miller's lung, thresher's lung, asthma, bronchitis, grain fever, and may play an important role in the deterioration of the state of health of workers of grain processing plants [Buczaj A. 2008a, Dutkiewicz et al. 2000, Dutkiewicz 2009].

In order to provide safe working conditions in grain processing plants it is necessary to perform measurements of the hazardous factors occurring at workplaces. To-date, according to the legal requirements in effect concerning work safety and hygiene, measurements of two dust fractions are performed: total (inhaled) and respired (dust penetrating into the alveoli). The results of measurement are referred to the existing hygienic standards for dust of plant and animal origin according to the contents of free crystal silica [Official Journal 2002, No. 217, Clause 1833].

Grain and flour dust is produced both during the processing of grain (cleaning and milling), and while packaging of ready products. A significant risk for workers is also created by dust produced during transport, drying, and storage of grain. Grain dust contains bacteria, fungi, insects, sometimes pesticides residues, as well as dry parts of plants. In addition, grain dust contains free silica, which may create risk for health of the employees [Burdorf et al. 1994, Mołocznik 1981, Nieuwenhuijsen et al. 1994].

The computer system of controlling the level of dustiness by constant monitoring of the appliances connected with technological and extractor processes and by means of elements responsible for the measurement of the level of dustiness, described in the presented report, specifies conditions in which the MAC level is exceeded at a particular time and site of the work environment. In the case of exceeding the border levels, the role of the system consists in the start of the alarm mode. The procedure of the alarm mode consists in the switching on of the additional workplace aspiration systems, and an information signal after the MAC level is exceeded at a workplace and on the screen of computer controlling the operation of the system. In normal conditions information is only

provided concerning the current level of dustiness at all sites of the work environment in the grain mill.

DUSTY WORK ENVIRONMENT IN A GRAIN MILL

The studies of dustiness at workplaces in cereal processing plants conducted to-date at the Institute of Agricultural Medicine show a high level of the concentration of grain and flour dust [Buczaj A., 2008b]. The mean concentration of inhaled dust at a workplace of a head miller remained within the range from 1.28÷10.56 mg·m^{-3}, and for a packer – 4.06÷73.64 mg·m^{-3} (Table 1).

The concentrations of inhaled dust at individual measurement sites in the work environment were within the range 0.26÷81.55 mg·m^{-3} (Fig. 1). The highest mean concentration of inhaled dust was observed in the tunnels under the elevators – 68.32 mg·m^{-3} (57.37÷81.55), while dumping grain into the grain hopper– admission of grain - 20.16 mg·m^{-3} (11.20÷37.5), manual cleaning of flour dust - 17.19 mg·m^{-3} (7.12÷28.60) and dumping of grain from the elevator's chamber to the mill - 15.1 mg·m^{-3} (6.51÷26.98). In the case of respired dust (alveolic fraction), the highest mean values were also noted in the tunnels under the elevators - 3.96 mg·m^{-3} (3.16÷4.96), during the dumping of grain into the grain hopper – admission of grain 1.46 mg·m^{-3} - (0.91÷4.22), manual cleaning of flour dust - 1.17 mg·m^{-3} and dumping of grain from the elevator's chamber to the mill 1.06 mg·m^{-3} - (0.14-3.30) [Buczaj A. 2008b].

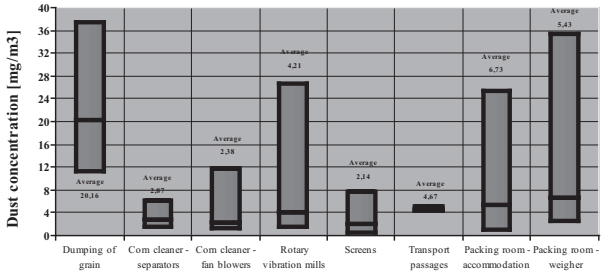

Fig. 1. Dust concentration at work environment sites in grain mills (mean values and range) [mg·m^{-3}]

In industrial mills the studies of dust occurring in the workers' respiratory zone while performing work activities at the workplaces of an elevator operator, miller and packer showed a high level of extra-thoracic fraction in

Table 1. Dust concentration at workplaces in grain mills (mean values and range) [mg·m^{-3}]

Workplace	Measurement of GRIMM 1.108 device		
	inhaled fraction	thoracic fraction	alveolic fraction
elevator operator	22,98 (9,13-47,4)	8,2 (1,86-17,3)	0,8 (1,9-3,5)
miller	3,71 (1,28-10,56)	1,34 (0,30-4,33)	0,18 (0,05-0,52)
packer	10,09 (4,06-73,64)	1,57 (0,64-14,6)	0,10 (0,04-1,43)
admission of grain	20,16 (11,20-37,5)	8,46 (5,72-19,26)	1,46 (0,91-4,22)
central switching station	0,40 (0,26-0,57)	0,20 (0,14-0,25)	0,07 (0,06-0,08)
dumping of grain from the elevator's chamber	15,1 (6,51-26,98)	6,26 (1,78-12,15)	1,06 (0,14-3,30)
separators	2,87 (1,61-6,05)	0,91 (0,29-1,97)	0,16 (0,03-0,41)
fan blowers	2,38 (1,21-11,71)	0,59 (0,29-1,35)	0,09 (0,05-0,36)
rotary vibrations mills	4,21 (1,49-26,73)	1,96 (1,07-4,33)	0,32 (0,11-0,99)
manual cleaning of flour dust	17,19 (7,12-28,60)	7,67 (3,80-11,09)	1,17 (0,8701,45)
transportation passages	4,67 (4,28-5,06)	2,69 (2,44-2,99)	0,79 (0,66-1,18)
cyclone filters	1,85 (1,59-2,18)	1,02 (0,94-1,16)	0,27 (0,24-0,30)
packing room - accommodations	5,43 (1,11-25,46)	1,45 (0,31-6,32)	0,16 (0,05-0,5)

inhaled dust. In the cleaning and packing departments the percentage contribution of the fraction withheld in the head region was the highest. This dust is deposited in the nasopharynx, from where it is removed due to the self-cleaning mechanisms, showing also a lower pathogenic affinity.

Measurements performed at the sites of the work environment in the mill while manual cleaning of dust, near cyclone filters and transportation passages showed that dust occurring at these sites contained a higher content of respired fraction, dust deposited in the thoracic-bronchial section, and also thoracic fraction dust penetrating beyond the pharynx, and therefore a higher exposure to fine particles of dust. In the central switching station the highest percentage of respirable dust was observed, accompanied by a relatively low percentage of extrathoracic fraction, which evidences the penetration there of the finest dust fraction.

The estimated level of the mean weighted concentration of both total and respirable dust for an 8-hour workday at a workplace of a miller in 3 mercantile industrial mills in the study did not exceed hygienic standards, while in one case the standard was only slightly exceeded which suggested the need to carry out additional examinations [Buczaj A. 2008b]. For the workplaces of a packer and elevator operator in all the industrial mills examined the MAC values for total dust were exceeded, while the MAC values for respired dust were not. Considering the exposure to total dust at workplaces of a packer and elevator operator a 2.5-fold and even 6.5-fold exceeding of the MAC values was noted.

FUNCTIONAL ASSUMPTIONS OF THE SYSTEM

The main task of the described and designed system of monitoring and surveillance of working conditions is the control of ventilation and dust cleaning systems in order to reduce the occurring elevated level of dustiness at key sites of the working environment down to the level below the MAC value. In addition, when an elevated level of dustiness occurs in individual rooms of the grain mill (exceeding the MAC value) the system, due to the alarm and access control systems, limits the access for employees not associated with work performed at a particular workplace. This task will be performed through the acquisition of measurement data collected by the supervision system from individual detection elements located in the rooms (climatic parameters) or directly in individual machines (technical parameters). The use of the model of an integrated system shared by the basic control system and by the supervising system for the same infrastructure elements will be the best solution to perform this task [Buczaj M., Sumorek A. 2011]. Such solution will make it possible to limit the costs associated with the use of an additional system (checking supervision system). This system will be additionally characterized by identical signals transmitted to the control and supervision system enabling the correct evaluation of the situation existing in individual objects or rooms. Fig. 2 presents the organizational scheme of the system.

The perfromance of the main task of the system (maintenance of the proper levels of dustiness at workplaces in the mill) is based on the control of executive elements of the system (exhaust fans with regulation flow system), based on the signals from the detection elements (dustiness detectors distributed in the rooms of the mnill and at workplaces). To make the correct operation of the system possible it is necessary to develop individual algorithms for control and construct the control application which would consider the specificity of the particular enterprise.

An additional function of the virtual supervision system increasing the functionality of such system consists in the potential acquisition of measurement data and their archiving as well as the possibility to apply the mathematical models and calculation algorithms in order to determine an optimal work schedule for individual devices. It is possible to provide the program with an additional panel enabling the transmission of information about the necessity to perform planned inspections of the devices with the specification of the parts required for this purpose. The advantage of such system over a standard solution consists in the fact that all necessary data will be displayed and available for the user at the same location on the computer screen in order to enable more complete control over production processes occurring in the grain mill.

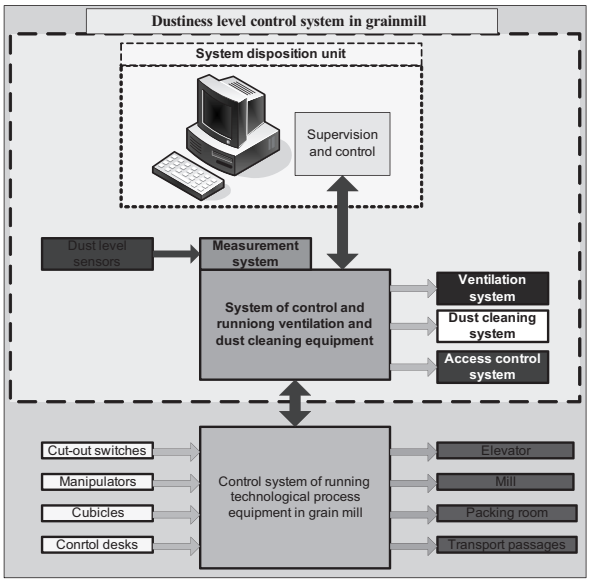

Fig. 2. Block organizational scheme of the system

In the proposed system of control of the level of dustiness in a grain mill the following main elements of the system should be mentioned (fig. 3):

– control unit – a computer by means of which the system is operated;
– disposition system – a selected device servicing and running the programme set by the operator (controllers, power supply and control systems, etc.);

– detection elements (detectors) – detectors of the level of dustiness installed at neuralgic sites in the enterprise which determine the current level of dustiness in a particular zone, shut door detectors in passages controlled by the system, etc.
– executive elements (actuators) – extractor ventilators and dust cleaning filters, and elements blocking access to the rooms controlled;
– elements mediating information exchange among the control systems present in the mill.

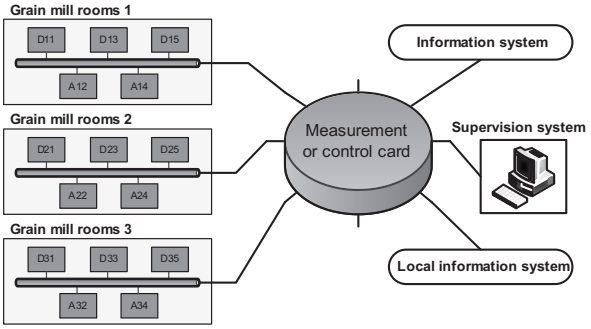

Fig. 3. Topology of the control grain dust supervision system in grain mills, D – detectors, A - actuators

In order to provide the correct operation of the system and perform the tasks associated with the complex servicing of all workplaces in the mill which are exposed to an increased level of dustiness, the system must be an integrated system. Such a system is characterized by a high information exchange between the individual elements of the system [Buczaj M. 2009].

This means that all elements of the system should cooperate with one another and exchange information concerning the current state of operating. Such requirements may be satisfied by the central disposition system. This does not mean that the system may be a dissipation system; however, it is important that the information concerning the state of appliances are constantly exchanged between individual elements of the system. In the solution proposed, the system is controlled from a designated workplace, but it may possess a number of control stations at key sites in the enterprise.

An additional function of the proposed system is its openness. This means that the system can cooperate with other systems in a grain mill, and in this way enable the improvement of work safety, not only due to the decrease in the risk of dustiness, but may also reduce other hazardous factors present at the workplace (e.g. noise).

The Labview programming environment was selected to perform the assumptions of the programme. The Labview environment enables the performance of complex funtions in the proceses of acquisition, archivization, procesing, and the analysis of the measurement data. This not only provides the possibility for free creation of programme structures of measurement and stimulation systems' useful in research projects, but also the creation of applications enabling the construction of modern control systems supervising technological processes. The task of the described system controlling ventilation and dust cleaning systems is to reduce the MAC values for grain and flour dust at selected workplaces in a grain mill.

SYSTEM OF CONTROL OF DUSTINESS LEVEL IN A GRAIN MILLS

The system of control of the dust level in a grain mill was developed based on the LabView programming environment. This environment possesses large capabilities of servicing technological processes, both with respect to measurements and control, and also individualized

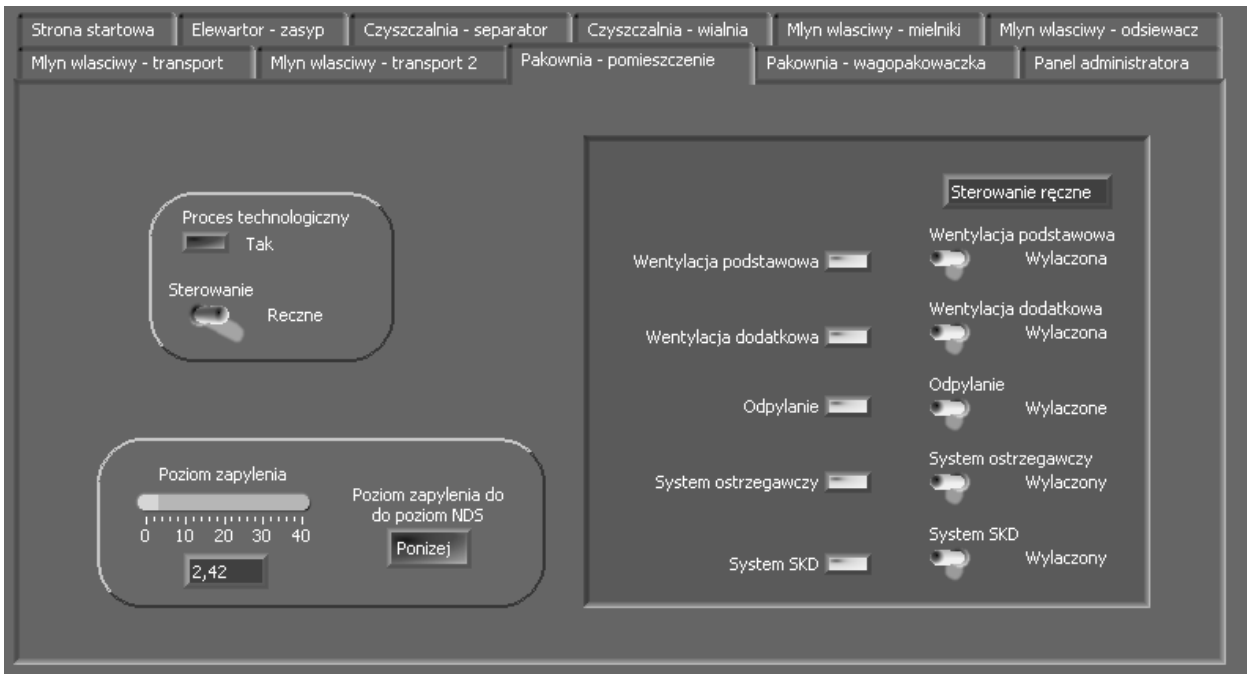

Fig. 4. User's interface of the system

approach to the process of creating systems operated by many users [Tłaczała, 2002]. According to authorizations, individual users may have various access authorization to the system. Due to the above-mentioned, the system is stable and resistant to operating by non-authorized persons. An additional advantage of the applications developed within the LabView program is their individuality. It is possible to use certain schemes, as well as to equip the programmes with individual solutions. This allows the adjustment of applications to sometimes dynamically changing situations in an enterprise (e.g. change of technology, change of the assortment produced, etc.).

The following elements may be distinguished in the programme managing and controlling the operation of the system:

– user's interface (fig. 4) – allows (according to authorization) control, change of configuration, or the control of operation of the system;
– organizational scheme (fig. 5) – internal connection between individual elements of the application enabling the performance of tasks set by the user on the control panel;
– I/0 service (operation of inlet and outlet devices) (fig. 6) – a system component responsible for the acquisition of data from detecting elements of the system and

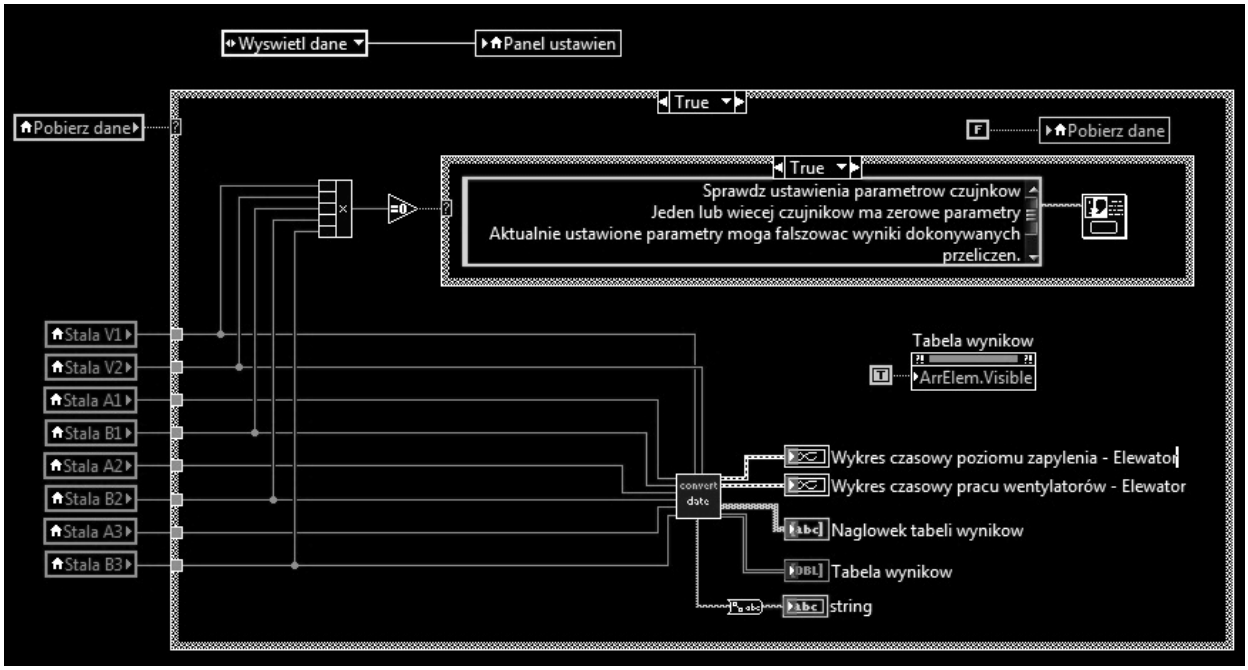

Fig. 5. The procedure of measurement date calibration – a part of the head program

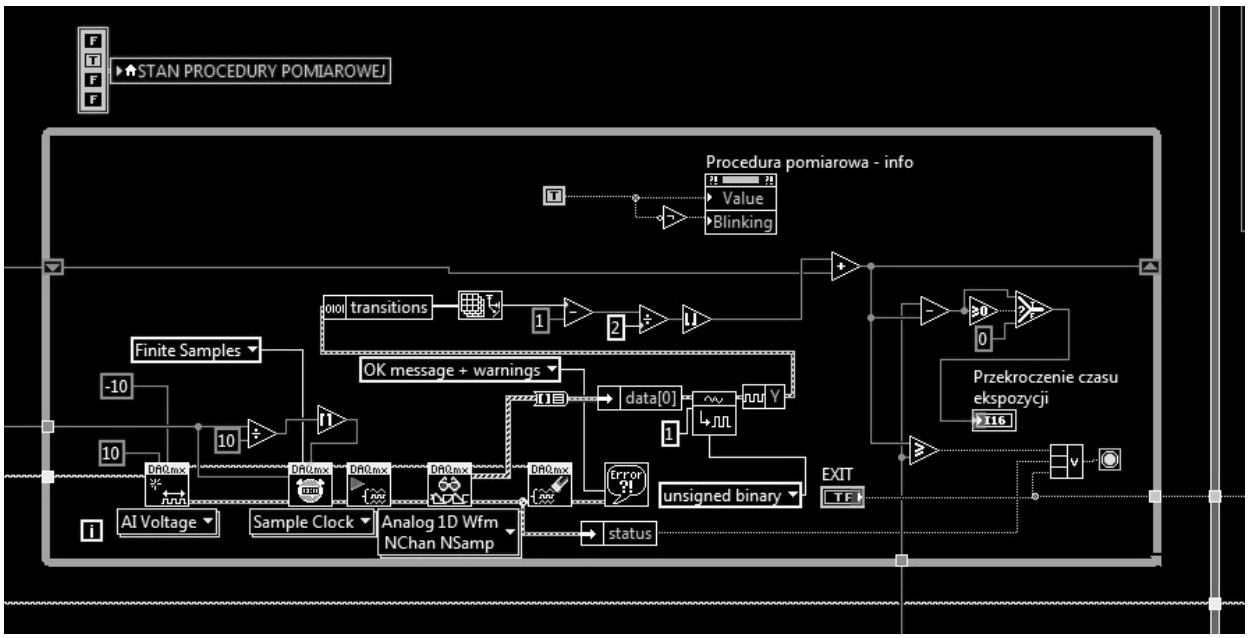

Fig. 6. One of the acquire measurement date procedure – a part of the head program

sending information to the devices controlling the operation of executive elements.

The proposed system of control of the level of dustiness in a grain mill may operate in an automatic mode, or manual mode controlled by the dispatcher from the main distribution centre, and in an emergency mode controlled by the user at a workplace. Such a solution not only makes it possible to optimize the operation of the system in normal conditions, but also allows the adjustment to the current demands in case of state of emergency, or risk for life and health of an employee.

Apart from managing and control of the operation of the system it may be equipped in the registration of events. This means that a history of the system operation is created, through to which it is easier to determine the causes of occurrence of states of emergency, and due to time registration it is possible to specify the periods of the planned conservation breaks.

CONCLUSIONS

Dust concentrations exceeding the MAC values which occur at the sites of the work environment in grain mills may constitute risk for the health of the employees exposed to them, therefore it is necessary to undertake actions in order to reduce workers' exposure to grain and flour dust. This should be obtained by the reduction of the emission of dust or by limitation for the employees of access to the rooms where high concentrations of dust occur which, in consequence, result in the exceeding of MAC values at an individual workplace.

The work environment in a grain mill is associated with the occurrence of many hazardous and troublesome factors at this work. The most important hazardous factor occurring in the work environment in grain mills is grain and flour dust. While penetrating into the airways, dust is settled and deposited in various sections of the respiratory system. The biological effect of dust depends, among other things, on its biological and mineral composition, size of particles, and amount of dust settled in individual regions of the respiratory system. Minimization of dust-related risk, and especially the reduction of the dust concentrations registered to the allowable values, should become a goal for the managerial staff in the mill.

Owing to the application of the virtual supervision system integrated with the autonomous control systems applied for the execution of the production and storage processes at grain mills it is possible to extend the scope of parameters and functions obtained by the user. Additionally the status of individual systems is monitored the supervision system and the user is provided with the complex access to information from one place.

Thanks to the application of LabVIEW software delivered by National Instruments, the access of the user is possible to advanced applications enabling the communication with external devices in several ways. In this system it is possible to use the serial and parallel ports, TCP/IP protocol as well as wireless connection with the devices. The last option increases the data transmission process efficiency. The systems are under uninterrupted control and the user is immediately informed thereof. Therefore the systems users are able to quickly localize the failure and to eliminate the defect source in case of a breakdown or danger status.

The system of dustiness control developed enables the measurement of dust concentration at specified sites of the work environment, and such a control of dust cleaning systems which would minimize risk occurring in the form of grain and flour dust.

The application of the LabView environment for the construction of the system allows the creation of systems adjusting themselves to the needs of an individual units and users. It provides a possibility to implement this system in a simple way to various units, e.g. change in the number of work sites, dust cleaning systems, etc.

REFERENCES

1. **Buczaj A. 2008.** Studies of the level of farmers exposure to dust on private farms based on fraction analyses. Ann Agric Environ Med 15/2008. s. 153÷167.
2. **Buczaj A. 2008.** Badania poziomu zapylenia w młynach przemysłowych w oparciu o poszerzone analizy frakcyjne. Temat statutowy IMW nr 2.16/07. Sprawozdanie z działalności IMW. Lublin.
3. **Buczaj M. 2009.** Integracja systemów alarmowych i systemów zarządzających pracą urządzeń w budynku mieszkalnym. Zabezpieczenia 4(68)/2009. s. 64÷68.
4. **Buczaj M., Sumorek A. 2011.** The use of LabView environment for the building of supervision system controlling the climatic and technical parameters in farm room, Teka Komsji Motoryzacji i Energetyki Rolnictwa, t. 11, s. 18÷28.
5. **Burdorf, Lillienberg L., Brisman J. 1994.** Characterization of exposure to inhalable flour dust in swedish bakeries. Ann. Occup. Hyg. 38 (1): 67÷78.
6. **Dutkiewicz J. 2009.** Biologiczne czynniki zagrożenia zawodowego w rolnictwie i przemyśle rolno-spożywczym. Lekarz Medycyny Pracy, 10, s. 7÷13.
7. **Dutkiewicz J., Skórska C., Mackiewicz B., Cholewa G. 2000.** Zapobieganie chorobom wywoływanym przez pyły organiczne w rolnictwie i przemyśle rolnym. Lublin, IMW.
8. **Mołocznik A. 1981.** Ocena zapylenia na stanowiskach roboczych związanych z wybranymi procesami produkcji zbożowej. Roczniki Nauk Rolniczych t. C-75-2.
9. **Nieuwenhuijsen M.J., Sandiford C.P., Lowson D., Tee R.D., Venables K.M., McDonald J.C., Newman Taylor A.J. 1994.** Dust and flour aeroallergen exposure in flour mills and bakeries. Occup Environ Med; 51, 584÷588.
10. Rozporządzenie Ministra Pracy i Polityki Społecznej z dnia 29 listopada 2002 r. w sprawie najwyższych dopuszczalnych stężeń i natężeń czynników szkodliwych dla zdrowia w środowisku pracy. Dz.U. 2002 nr 217 poz. 1833.
11. **Tłaczała W. 2002.** Środowisko LabVIEW w eksperymentach wspomaganych komputerowo. WNT. Warszawa.