STUDIES ON EFFICIENCY OF AUTOMATED DUST RETENTION INSTALLATIONS FROM COMPOUND FEED FACTORIES

Cristian Vasile[1], Mihnea Glodeanu[1], Ion Saracin[1], Adina Glodeanu[2]
[1]University of Craiova, Romania;
[2]University of Medicine and Pharmacy, Romania
cristi_vasile_4you@yahoo.com, mihneaglodeanu@yahoo.com,
ion_saracin@yahoo.com, glodeanuadina@yahoo.com

Abstract. The first stage in the flow of activities carried out in a compound feed factory involves grinding of cereal grains in order to mix the obtained flour with other ingredients in the recipe that will be produced. The paper presents some aspects of interest about the technological process of preparation of compound feeds, with emphasis on the grinding phase, as well as a study of the process of removing dust from the air circulated in the installations and technical equipment used. The dust resulting from the grinding process, or from granules sterilized with hot steam jets and then cooled with air jets, tends to be released in the atmosphere, and if it is not retained immediately, the air in the workroom will be polluted, endangering the health of the operators. That is why there are increasingly strict rules and laws, which limit the emission of dust in the atmosphere in order to achieve adequate protection of the environment. Thus, the retention of dust before its elimination in atmosphere is a necessity that must be taken into account when equipping compound feed factories with high-performance installations, with a high degree of automation, provided with special dust filters. These equipments ensure the separation of the air from the solid particles contained, so that the clean air can be released in the atmosphere, and the solid materials are recovered and then reintroduced in the technological process. The research presented in this paper was performed for two types of mills used in the installations, with which the compound feed factories are equipped: double mills with rollers and hammers, or single mills with a circuit for grinding larger particles that do not pass through the sieve. The experimental measurements were performed with the Strohlein gas detector for different recipes of compound feeds produced and showed that the values of dust concentrations are not exceeding 2 mg/m^3_N, thus complying with the European environmental protection standards.

Keywords: compound feeds, grinding, automation, dust, environmental protection.

Introduction

During the technological flow in a compound feed factory, a series of very complex processes and activities are carried out, which must be monitored very carefully, in order to continuously improve the quality of the final products obtained [1-3]. One of these activities is grinding of grain cereals in special mills in order to mix the flour produced with the other ingredients in the desired fodder recipe to be obtained [4].

It is very important that the cereals (which are the most important component of compound feed) be ground as evenly as possible and at the same time the amount of dust removed in the air should be as small as possible [5; 6]. Grinding is made until the particles reach a sufficiently small size to allow them to pass through the holes of the sieves mounted at the outlets of the grinding installations [7; 8].

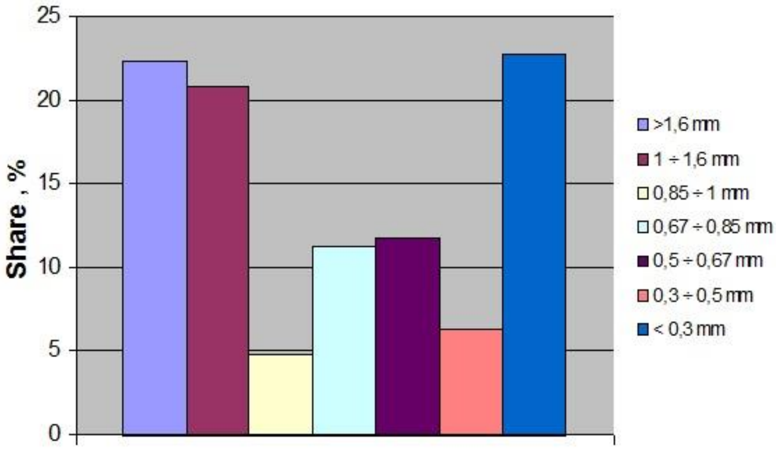

Fig. 1. **Share of fractions in the grinding mass**

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This statistical study shows that the largest share (over 23%) has small particles with a diameter of less than 0.3 mm. In this fraction there are many very small particles, that will inevitably be removed into the air in the form of dust (a phenomenon that must be avoided or minimized as much as possible) [5; 9; 10].

Combustion installations also produce steam jets at very high temperatures, which play an important role in the homogenization and sterilization of finished product granules. Then, in order to be packaged, the combined feed grains will be cooled with air jets at low temperatures. Thus, due to the high pressure at which these jets work, very small particles detach from the surface of the granules and are removed into the air in the form of dust. The dust released into the air affects both the staff working in the compound feed factory and the environment [7; 11-13].

That is why it is absolutely necessary to monitor and rigorously control the dust concentrations eliminated by the grinding, homogenization, sterilization and drying installations, by using filters that collect very small particles. The paper presents such an automated control methodology and measurement of dust concentrations, resulting from the process of obtaining compound feeds.

Materials and methods

This article presents some of the experimental research conducted at a compound feed factory, in order to accentuate the benefits obtained by using automated control equipment, which will ensure a better development of the activities from the technological flow. The initial grinding of cereals is a very important stage in this technological flow, and therefore the automated work equipment that allows obtaining the flour has been analyzed. The ability to retain the dust released in the process of grinding, homogenizing and drying the granules has also been studied, so as to comply with the European environmental protection standards.

The installations in which the grain cereals are ground can be of two types:

1. installations that have two distinct mills: a roller mill for coarse crushing of the grains and a hammer mill for fine grinding;
2. installations equipped with a single mill, which performs in the first stage coarse grinding, then recirculation is made through the sieves with very small holes (that determines grinding of the refusals of these sieves) [1; 3; 4].

For a finer and more homogeneous grinding, the two types of mills were combined in a high-performance installation (Figure 2), which allows both reduction in the grinding costs and compliance with the environmental protection regulations.

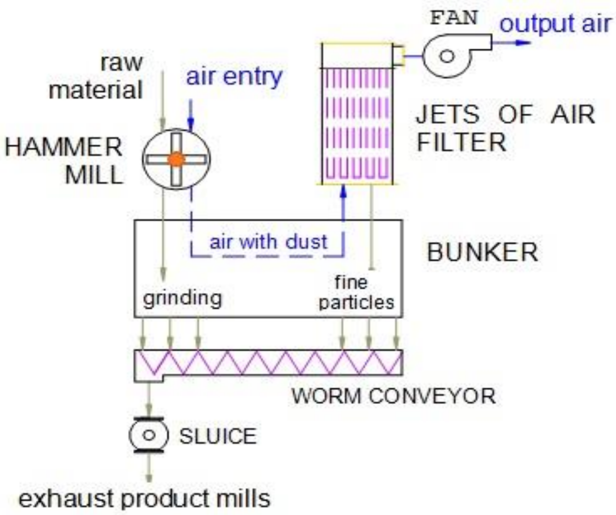

Fig. 2. **Scheme of the grinding installation with integrated suction and filtration system**

Among the activities carried out in the process of producing compound feeds are also those for generating steam under pressure at very high temperatures and then for cooling the obtained granules. The strong jets of steam produced in the combustion installations have an important role for the homogenization of the granules and also for their sterilization. The granules will then be cooled by means of the air jets produced in the cooling system, so that they can be transported to the storage bunkers, or directly to packing for delivery. These high-pressure jets entrain particles detached from the surface of the combined feed grains, thus forming the dust [2; 11; 13].

Figure 3 shows the technological flow from a compound feed factory and indicates the points of the experimental measurements (PM) used to determine the concentration of dust removed from the work facilities.

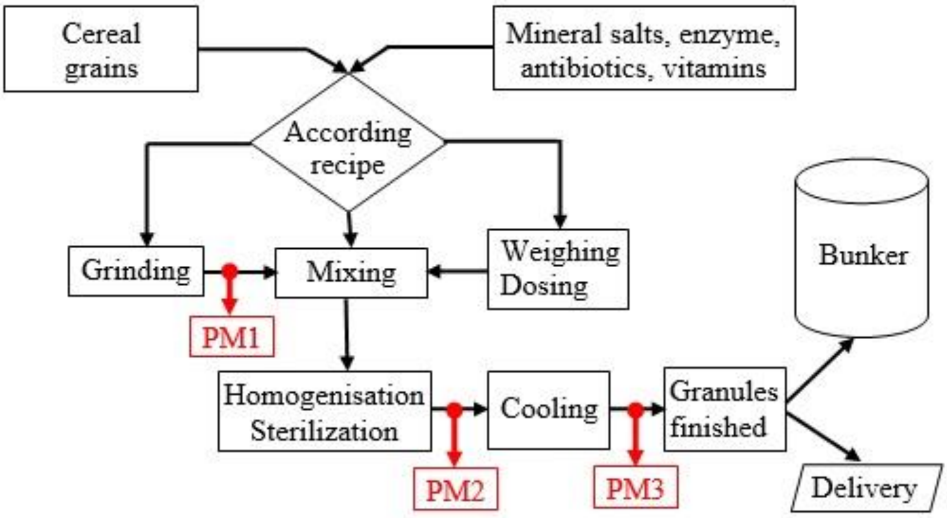

Fig. 3. **Scheme of the technological flow in which the points of measuring (PM) are marked**

The measurement principle consists in the analysis of a representative volume of effluent extracted from the air discharge channels from the grinding installations, as well as from the homogenization and sterilization installations. As shown schematically in Figure 4, in order to obtain the most accurate results, several simultaneous and successive experimental measurements are made.

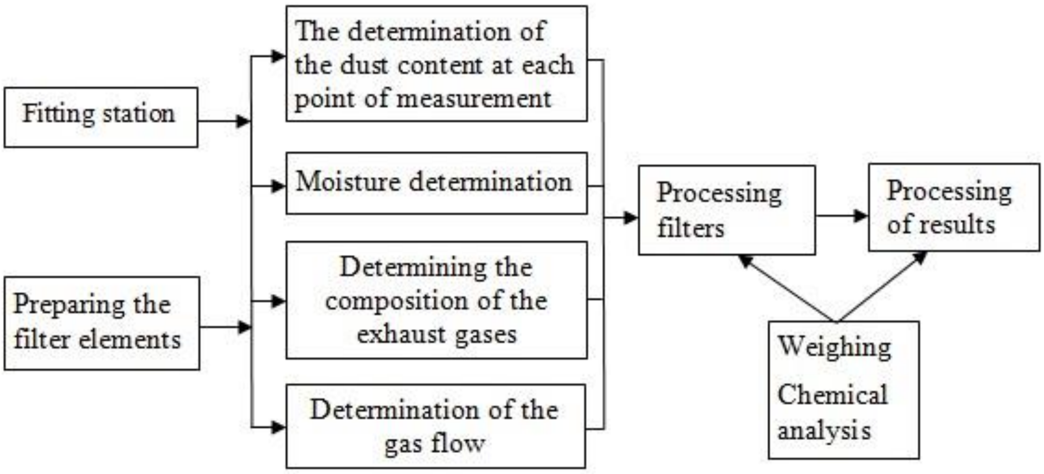

Fig. 4. **Process of determining of dust concentrations from removed gases**

The device for measuring the concentrations of dust from the flue gases, (STROHLEIN STE4 type) is shown in Figure 5 [4; 14].

The jets removed at the outputs of the analysed installations (1) will be aspirated through the calibrated nozzle (2) and from here can be processed with the Strohlein device as follows: they will pass through the filters from a filter cartridge (3), where large solid particles will be retained, then through the electrically heated probe at 180°C (5) to the condensate tank (8). To protect the active elements of the device, the gas is passed through the drying tower (9) with silica gel. Then the gas passes through the measuring device, where the flow (10), the pressure (11), the temperature (12) and the volume of aspirated gases (13) are determined (this being regulated by means of the valve R1). After absorption of the effluent necessary for the experimental analysis, the aspiration of the gases discharged from the working installation and the power supply of the probe sleeve are stopped. Then the aspirated gas flow rate and the time of performing that measurement are noted.

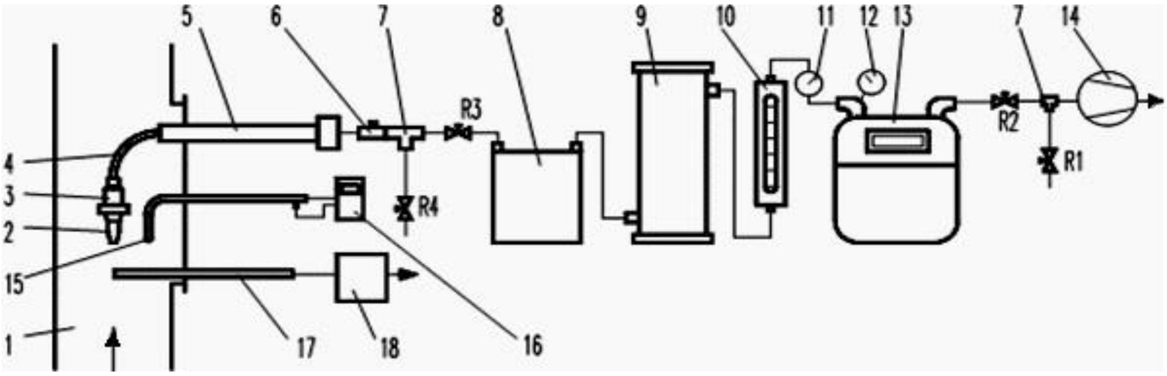

Fig. 5. **Assembly scheme *Strohlein*:** 1 – gas channel; 2 – calibrated nozzle; 3 – filter cartridge; 4 – fitting; 5 – electric heating sleeve; 6 – thermoelement; 7 – T-fitting; 8 – condensate tank; 9 – silica gel drying tower; 10 – flow meter; 11 – manometer; 12 – thermometer; 13 – vacuum pump meter; 14 – drain channel; 15 – Pitot tube-Prandtl; 16 – electronic micromanometer; 17 – probe; 18 – gas analyser TESTO; R1-R4 – taps

To obtain the final results concerning the concentration of dust in the eliminated gases, the following operations must be performed: the amount of water collected in the condensate tank and the weight of the moistened silica gel will be measured; after cooling the probe, the filter element will be removed and stored in a specially prepared container; then they will both be weighed - the filter cartridge and the flat filter. Automated installations from compound feed factories have a special filter that ensures dust removal, namely, the separation of the gaseous part of the technological air jet from the solid elements contained, so that clean air can be removed into the atmosphere and solid materials can be recovered and possibly reintroduced into the work process [4; 5; 6; 13].

Efficacy of dedusting (degree of dust removal) is defined as follows:

$$\eta = \frac{G_t - G_r}{G_t} \cdot 100 = \frac{G_e}{G_t} \cdot 100, \qquad (1)$$

where η – yield or degree of dust removal, %;
G_t – amount of dust in the air entering into the separator, g;
G_r – amount of dust remaining in the air leaving the separator, g;
G_e – amount of extracted dust, g.

Results and discussion

The analyses and experimental measurements presented in this paper were performed for the assortment of combined fodder used to feed laying hens. Following the technological flow shown in Figure 2, the dust concentrations were measured at the flour exit from the grinding installation (PM1), as well as at the outlets of the exhaust channels of the jets used for homogenization, sterilization (PM2) and cooling (PM3) of the finished product granules. According to the standards for measuring dust concentrations, the minimum volume required to take a sample (under isokinetic conditions) is 1m^3.

In order to verify the efficiency of the automated work installations regarding the protection of the environment, several tranches produced from compound fodder were monitored. Table 1 shows the values of dust concentrations measured at the first tranche, as well as a number of other parameter characteristics of the sample taken for experimental analysis.

Measurements were made for each of the 5 tranches of produced combined feed (each tranche has run 35-39 minutes). The results obtained for the values of dust concentrations are presented in Table 2.

Figure 6 shows graphically the evolution of the measured values for the concentration of dust from the jets eliminated at the outputs of the analyzed working installations.

Table 1

Measurement of dust concentrations at the first tranche of compound feed for laying hens

Name	Unit	Laying hens		
		PM1	PM2	PM3
Initial mass of cotton wool filter	g	51.4587	51.4587	51.4587
Initial mass of paper filter + box	g	10.2564	10.2564	10.2564
Final mass of cotton wool filter	g	51.4598	51.4601	51.4596
Final mass of paper filter + box	g	10.2569	10.2569	10.2572
Initial meter	m^3	511.6790	512.6840	513.6892
Final meter	m^3	512.6840	513.6892	514.6948
Start time	-	10:01	10:18	10:32
End time	-	10:16	10:29	10:37
Mass of collected dust (m_{dust})	g	0.0016	0.0019	0.0017
Volume of gas passed through the meter (V_{gas})	m^3	1.0050	1.0052	1.0056
Dust concentration (C_{dust})	mg/ m^3_N	1.746	1.835	1.793
Efficacy of dedusting (η)	%	89.65	90.17	89.81

Table 2

Values of dust concentrations (C_{dust})

Sample of measurement		Time interval	C_{dust}, mg·m$^{-3}_N$	η, %
Tranche 1	PM1	10:01-10:37	1.75	89.65
	PM2		1.84	90.17
	PM3		1.79	89.81
Tranche 2	PM1	11:05-11:42	1.75	89.58
	PM2		1.83	90.26
	PM3		1.79	89.73
Tranche 3	PM1	12:02-12:39	1.74	88.97
	PM2		1.84	91.04
	PM3		1.8	89.86
Tranche 4	PM1	13:09-13:46	1.75	89.95
	PM2		1.84	91.02
	PM3		1.8	89.88
Tranche 5	PM1	14:01-14:40	1.74	88.93
	PM2		1.84	90.27
	PM3		1.8	89.94

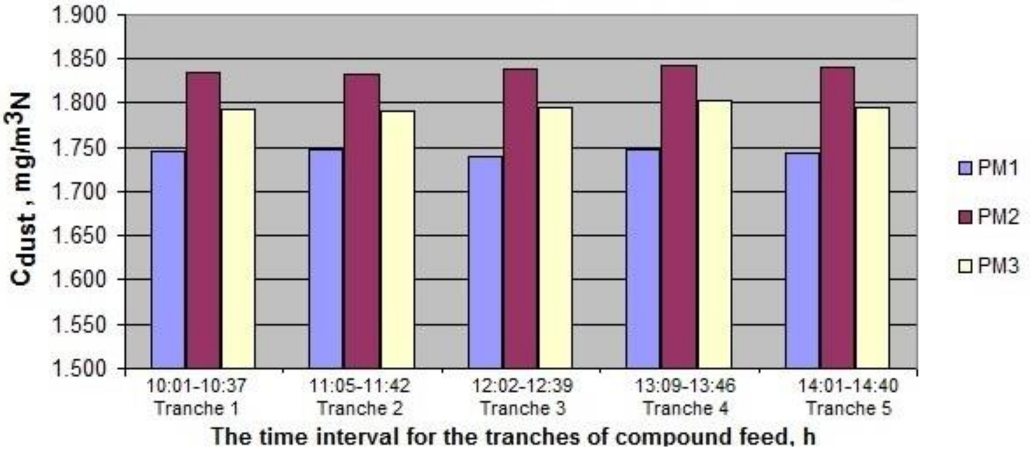

Fig. 6. **Dust concentration by the jets eliminated from the analysed installations**

The dust removal efficacy by the filters from the endowment of the working installations of the compound feed factory, where the experimental measurements were made, is shown in Figure 7, over the minimum filtration value of 85%, which is accepted by the norm of the environment protection.

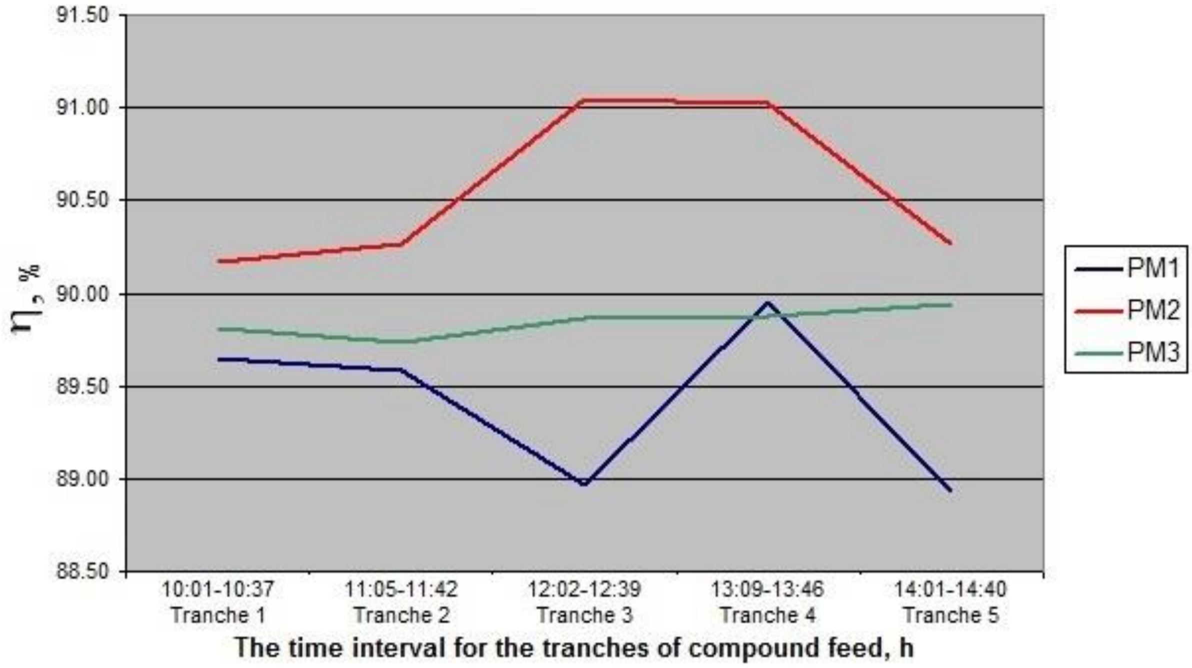

Fig. 7. **Efficacy of dedusting (η) of the analysed working installations**

Conclusions

1. Of all the technological stages performed in the compound feed factory (CFF), the activities that determine the elimination of dust in the atmosphere were analyzed: grinding grain cereals in order to obtain the flour needed to prepare the desired combined feed recipes, homogenizing, sterilizing and cooling the finished product granules.
2. The dust concentrations determined by the experimental measurements presented confirm proper functioning of the automated work installations and their ability to retain a large amount of particles removed by the technological air jets.
3. The measured values between 1.744 mg/m^{3}N and 1.843 mg/m^{3}N demonstrate that the dust emission limit (which is 5 mg/m^{3}N, according to Order 462/193) for installations for the production of feed and compound feed did not exceed, thus respecting the European rules in force.
4. The efficacy of dedusting was between 89.58% and 91.04%, thus confirming the ability of these installations to retain a large part of small solid particles.
5. The paper highlights some of the advantages of using automated and computerized facilities for command and control of activities in compound feed factories (CFF), to ensure compliance with the existing European rules concerning safety and environmental protection.

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