

Monitoring Noxious Substances From Combined Feed Factories for Environmental Protection

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Compound feeds are an important source of food for the animals from zootechnical farms, because in addition to ground cereals they also contain vitamins, minerals, proteins, amino acids, and sometimes even drugs, energizers, or flavors. The process of obtaining different varieties of compound feeds involves a complex technological flow, with specific stages of production. Mixing, sterilization, and granulation activities, where steam jets are used at very high temperatures, determine the elimination of different types of noxious substances in the air. This article presented the experimental measurements performed at the critical points of working installations from a compound feed factory, on the entire duration of the assortment lot. Considering the purpose of the performed researches, the critical measurement points were established at the exit of steam generator, where steam jets are obtained at very high temperatures, with values of approximately 150-180 °C. Using a TESTO 350 M/XL gas analyzer, the measured values allow a complete analysis of the types of noxious eliminated. The results of experimental measurements show that the fluctuations obtained during the measurements are very small, of the order 2 mg/m³_N for each type of noxious substances, CO, NO_x, CO₂ indicate compliance with European environmental quality standards. The use of high-performance instalations, with a high degree of automation allows rigorous control over the different types of pollutants released into the atmosphere by the work installations from compound feed factories.

Keywords: compound feeds, noxious substances, environment, control, automation

Introduction

Demographic growth and diversification of human needs have led to an upward evolution of activities in the field of livestock. Thus, the use of compound feeds for the feeding of animals on livestock farms has become very necessary, both for the supply of good quality nutrients and for reducing the costs of animal products. Depending on the age of the animals or the species of animals fed, certain compound feed recipes are used, with different compositions, shapes, and weights of the granules (Mihaila, 2001; Gaceu, 2006; Şara & Odagiu, 2005).

During the technological flow, in a compound feed factory the cereals and mineral substances that make up the desired recipe are mixed, homogenized, granulated, and sterilized with the help of high-performance equipment and work facilities. From the combustion equipment producing the steam necessary for the sterilization and homogenization in various forms of compound feeds and also from the cooling installations of the final product, different types of pollutants are released into the atmosphere (Roden et al., 2006). These

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pollutants can affect the health of people working in these factories and also the environment.

That is why it is absolutely necessary to monitor and control rigorously the concentrations of noxious substances from the gases emitted by the work installations which have combustion sources or internal combustion engines (Heinsohn & Kabel, 1999; Lailer et al., 2005; Franke & Rey, 2006). At critical working points, that is, at the outlet of the hot steam generator, samples were taken and various experimental measurements were made in order to analyze the functional parameters of the work installations.

The paper presents a complex methodology for measuring the concentrations of different types of pollutants resulting from the process of obtaining compound feeds. Experimental analyses and measurements for the determination of flue gases emissions from the steam generator outlet were performed using the TESTO 350 M/XL gas analyzer over a period of 100 minutes (which represents the minimum duration for making a batch of compound feed assortment). The experimental studies carried out propose an analysis of the functional parameters of the working installations in the compound feed factory, in order to automate the control of the steam temperature and implicitly of the combustion installation (that determines the elimination of noxious substances in the air). For this purpose, separate locations for experimental measurements were used in the burner area of the steam generator.

Given that each compound feed recipe requires different operating parameters of the work facilities, samples obtained during the technical process for the production of two compound feed recipes were analyzed: for the feeding of broilers, respectively for the feeding of swine.

Materials and Methods

One of the stages of the technological flow from a compound feed factory is that in which the necessary ingredients from the recipe are mixed, which will be performed under the action of steam jets with very high temperatures. These jets are produced by a steam generator and are needed to obtain granules of different shapes and sizes (Bond et al., 2002). Also, the steam jet at very high temperatures has other important purposes in obtaining the final product: homogenization of granules and their sterilization. An essential work equipment from the compound feed factory where the experimental measurements were performed is the steam generator (Certuss Junior), having as primary fuel the liquefied petroleum gas (LPG).

Given the purpose of the research conducted, samples were taken at the outlet of the steam generator and experimental measurements were performed in order to analyze the working parameters of the equipment and installations used (Bollen & Brink, 2014). Thus, at this critical working point, the pollutant emissions from the flue gases resulting from the process of obtaining the steam jet were measured. During researches on flue gas, the TESTO 350 M/XL gas analyzer was used, in order to obtain the measured values for the noxious substances released at the outlet of the steam generator. This device operates according to the following principle: the change of the current intensity generated by a galvanic cell whose electrolyte changes its properties is analyzed (due to interaction with the gaseous component removed in the air to be detected and whose concentration is to be measured). Thus, the cells used to perform the measurements are in fact galvanic elements, which generate a current proportional to the number of ions that dissociate in the electrolyte solution (as a result of the reaction obtained between the electrolyte and the noxious substance analyzed at that time). Analyzers built according to this principle have a great advantage represented by a low construction cost and are used for short or medium duration measurements. With their help, concentrations can be determined for the following gases: O₂, CO, H₂S, NO, NO₂, SO₂, etc.

The TESTO 350 M/XL gas analyzer is an advanced equipment for determining the noxious substances eliminated by the flue gases, their determination being made in specialized measuring cells (in which Peltier type electrochemical reactions take place). The device used to perform analyses in the compound feed factory where the research took place, consists of three working components: the analysis unit, the control unit, and the gas sampling probe. The effective interaction between the electrolyte and the flue gases takes place in the unit of analysis, because this is where the reaction cells are located (Figure 1). Also here are the supply batteries of the device, the filters for retaining solid impurities from the flue gases, the condenser decanter, and the electropneumatic connections with the other components.



Figure 1. The analysis unit. 1—electrical contacts; 2—control LEDs; 3—solid particle filter; 4—filters for retaining particles from the aspirated air; 5—condensate collection; 6—analysis cells; 7—integrated system for determining the gas velocity and pressure; 8—connections.

Due to the Peltier type electrochemical reactions that take place inside the analysis unit, an electrical signal is emitted to the control unit of the device, thus displaying the concentration value corresponding to the type of noxious substance analyzed (Ionel, 1994). The TESTO 350 M/XL analyzer has a control unit (Figure 2), which is a device that can be operated with the help of the built-in keyboard, or with a special contact pencil (touch-pen).



Figure 2. Control unit. 1—printer; 2—touch-pen; 3—system information bar; 4—display of measured values; 5—bar for operation information; 6—function operation keys; 7—keyboard; 8—pressure probe connection; 9—sample connection; 10—analysis unit connection; 11—serial interface.

The analyzer can be equipped with several types of gas sampling probes, depending on the characteristics of the sampled gases. To perform the experimental measurements, a probe was used with tubing heated at 180 $^{\circ}$ C, operating at temperatures up to 1,200 $^{\circ}$ C.

After the three components are interconnected, the analyzer will be switched on by connecting to the 220 V mains or using its own batteries. At this point the device enters automatically in the procedure of "zero calibration" and washing of the reaction cells (Figure 3). At the time of "zero calibration", the probe of the device must not be inserted into the flue.



Figure 3. Zero calibration procedure of the Testo 350 M/XL analyzer.

After the analyzer enters in normal operation regimen, it must be programmed to acquire and display the data of interest for the analysis performed (Vasile, 2018). Also now the setting is made for the studied noxious type, from the device database (Figure 4).



Figure 4. Setting the display of the desired values and the studied noxious type.

After setting the parameters we want to measure, the probe is inserted into the gas channel and the activity of measuring the monitored parameters is started (Vasile, 2018). The values obtained from the analysis and measurements carried out will be compared with the limit values provided in the legislation in force (in order to confirm compliance with the rules imposed by the European Union). The measurements of the noxious concentrations eliminated by the flue gases from the steam generator were performed during the combined fodder production processes for two species of animals, with a large share in the livestock farms: broilers and swine. During 100 minutes (in which an assortment of combined fodder is produced), 10 distinct measurements were performed for the noxious substances eliminated in the air (at an interval of 10 minutes between them).

If the TESTO 350 M/XL analyzer is connected to a computer, it can be used for long-term measurements (days, weeks) by running a special program: TESTO Easy Emissions.

Results and Discussion

The thermodynamic parameters of the steam generator in the case of the production of compound feeds for broilers are: steam temperature in the installation 140 °C; thermal agent temperature 170 °C; nominal steam pressure 6 bar. The results of the measurements for the released emissions are presented in Table 1.

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No.	CO (mg/m ³ _N)	NO _x (mg/m ³ _N)	SO ₂ (mg/m ³ _N)	CO ₂ (g/m ³ _N)	CO* (mg/m ³ _N)	NO _x * (mg/m ³ _N)	SO ₂ * (mg/m ³ _N)	CO ₂ * (g/m ³ _N)
1	46.25	14.37	0.00	182.44	50.79	15.78	0.00	200.36
2	46.25	14.37	0.00	182.44	50.79	15.78	0.00	200.36
3	42.50	10.26	0.00	182.44	46.67	11.27	0.00	200.36
4	45.00	14.37	0.00	182.63	49.69	15.87	0.00	201.68
5	45.00	16.42	0.00	182.63	49.09	17.91	0.00	199.24
6	41.25	14.37	0.00	182.63	45.55	15.87	0.00	201.68
7	45.00	14.37	0.00	182.63	49.69	15.87	0.00	201.68
8	45.00	14.37	0.00	182.44	49.42	15.78	0.00	200.36
9	42.50	14.37	0.00	182.44	46.67	15.78	0.00	200.36
10	45.00	14.37	0.00	182.63	49.69	15.87	0.00	201.68
Average	44.38	14.16	0.00	182.54	48.81	15.58	0.00	200.78

 Table 1

 Measurement Values During Compound Feed Production for Broilers

*: values relative to the reference oxygen 3%.

The results of the experimental measurements of the noxious concentrations eliminated in the production of compound feed for broilers are presented in graphical form in Figure 5.



Figure 5. Concentrations of emitted pollutants in the case of compound feed for broilers.

The thermodynamic parameters of the steam generator in the case of the production of compound feed for pigs are: steam temperature in the installation 155 $^{\circ}$ C; thermal agent temperature 180 $^{\circ}$ C; nominal steam pressure 7.5 bar. The results of the measurements for the released emissions are presented in Table 2.

Table 2					
Measurement	Values Du	ring Comp	ound Feed P	Production for	or Swine

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No.	CO (mg/m ³ _N)	NO _x (mg/m ³ _N)	SO ₂ (mg/m ³ _N)	CO ₂ (g/m ³ _N)	CO* (mg/m ³ _N)	NO _x * (mg/m ³ _N)	SO ₂ * (mg/m ³ _N)	CO ₂ * (g/m ³ _N)
1	63.20	17.33	0.00	170.20	75.61	20.34	0.00	203.74
2	63.24	17.35	0.00	170.35	75.61	20.57	0.00	203.96
3	63.25	17.41	0.00	171.08	76.60	20.70	0.00	206.28
4	61.85	19.37	0.00	171.31	75.10	23.56	0.00	208.62
5	61.93	19.24	0.00	172.15	75.25	23.73	0.00	208.40
6	61.95	19.42	0.00	172.40	75.30	23.80	0.00	208.54

7	62.15	19.46	0.00	172.69	75.10	23.17	0.00	208.79
8	61.82	17.30	0.00	172.82	74.18	20.61	0.00	206.85
9	63.20	17.18	0.00	170.95	75.61	20.48	0.00	204.12
10	63.30	17.36	0.00	171.26	76.05	20.55	0.00	205.98
Average	62.59	18.14	0.00	171.52	75.44	21.75	0.00	206.53

Table 2 to be continued

*: values relative to the reference oxygen 3%.

The results of the experimental measurements of the noxious concentrations eliminated in the production of compound feed for pigs are presented in graphical form in Figure 6.



Noxes concentrations - "Swine"

Figure 6. Concentrations of emitted pollutants in the case of compound feed for swine.

The measured values of the noxious substances from the flue gases for the two varieties of feed combined indicate very small fluctuations of the order 2 mg/m³N for CO, NO_x, CO₂ and also that SO₂ is not eliminated in the air as an exhaust pollutant.

Conclusions

In order to increase the labor productivity in the combined feed factories, the aim is to increase the degree of automation of the activities in the technological flow, so as to ensure a fast and accurate measurement of the working parameters, required in obtaining the desired combined feed recipe. Meeting the requirements for pollution standards accepted in the European Union requires the use of high-performance work facilities, with a high degree of mechanization, automation, and computerization.

Analyzing the measured values of the noxious substances from the flue gases for the two varieties of feed combined, it can be observed that the fluctuations obtained during the measurements are very small, of the order of 2 mg/m³_N, for each type of noxious eliminated; this indicates a very good regulation of the work process. Another major advantage of the analyzed work installation is that SO₂ is not eliminated in the air as an exhaust pollutant; this consequence is associated with the burning of LPG in the steam generator.

As can be seen from the experimental research carried out, the automated equipment allowed the rapid and permanent control of the temperatures of the steam jets, so that the noxious substances eliminated fall within the accepted limits.

The analyses and experimental measurements performed at the output of the steam generator allowed the automated monitoring of the working parameters of the installation, in order to optimize the production process

of different types of compound feeds. Also, the measured values for the concentrations of the pollutants eliminated in the air by the steam generator burner were within the provided technical limits, fully complying with European environmental protection rules.

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