PROTECTING THE ENVIRONMENT THROUGH AUTOMATED CONTROL OF WORK INSTALLATIONS IN COMPOUND FEED FACTORIES

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Abstract

The primary purpose pursued by any compound feed factory is that one to obtain and deliver to customers assortments of the finished product as nutritious as possible and at the lowest possible production costs. But, at the same time, compound feed factories must fulfill the environmental protection standards imposed by the European Union regarding the amounts of dust and other polluting substances released into the atmosphere, as well as a limitation of the temperatures released by the working installations during the production process. In order to realize these environmental protection requirements, the compound feed factories must be equipped with modern and high-performance working equipment, which ensures a permanent automated and computerized control of the optimal operating parameters during the entire technological process. In this paper are presented the stages of the production process of compound feed, with accent on the analysis of those critical points on the technological flow route where very high temperatures are released or different amounts of dust are eliminated into the atmosphere. In order to highlight the reliability of automated and computerized control equipment of work installations, experimental measurements of the working technological parameters were carried out for two distinct assortments of combined feeds, depending on the utility of each recipe: for feeding broilers and for feeding cattle.

Key words**: **compound feed, automation, control, temperature, dust

INTRODUCTION

Especially in the last decades, can be observed at the worldwide level both an increase in the need for food and a diversification of these needs of people. These trends are determined both by the accentuated increase of the population and by the diversification of the accepted dishes. The vast majority of the assortments that make up human food come from the animal products processing industry. That is why we can say that the process of producing compound feed is an activity of great interest considering the need to provide food for an ever-increasing number of animals from zootechnical farms. Considering the agricultural potential of our country, it is obvious that Romania could represent in the near future one of the most important producers of compound feed in the European Union. Each compound feed factory has in its portfolio the production of certain recipes based on the use of flours originated from the grinding of grains from different varieties of cereals, which in turn are mixed with different auxiliary ingredients in very well established amounts and concentrations, depending on the animal species which must be fed as well as of their age. That is why there is fierce competition, both nationally and internationally level, among compound feed factories for winning and then keeping the sales markets for the finished products. This competition is beneficial for the upward evolution of profile companies, which make efforts to improve their activity by using the most efficient work equipment, with a high degree of automation and computerization, which ensures the achievement of the most profitable productions at a price of cost as low as possible, but at the same time meet the safety standards imposed by the European Union rules.

Some of the problems that can arise during the technological flow in a compound feed factory refer to the release of dust powders or very high temperatures released by the production installations of steam jets. Dust is released into the air especially during the grinding activity of cereal grains or at the exits of the cooling installation of the granules where air jets are used. The concentrations of dust released into the atmosphere can be controlled by using automated work installations equipped with special filters to retain solid particles from the air. Also, the temperatures released by work installations where steam jets are used at high pressures and very high temperatures can be controlled by using automated control modules, so that these temperatures do not exceed a certain threshold allowed to ensure environmental protection surrounding and of the staff employed located in the premises of the compound feed factory.

This article presents the results of the experimental measurements carried out at different critical points along the route of technological flow regarding the amounts of dust removed into the atmosphere and the temperatures released by the burner from the endowment of work installation for obtain steam jets at very high temperatures necessary for homogenization the mixture required by the desired recipe and for sterilization the granules of the finished product. In order to demonstrate the reliability of the work equipment, as well as the efficiency of the use of installations equipped with automated and computerized control modules for the activities carried out along the technological flow path, were followed and analyzed the production processes of two distinct assortments of compound feed: those used for feeding broilers and those used to feed cattle. In the case of each assortment of compound feed produced must be set other operating parameters for the work equipments from the endowment of the factory. At the end of the researches carried out, through the experimental values measured at the critical points on the technological flow route, it is certified that the operation of the work facilities falls within the range of values allowed by the European norms in force.

MATERIALS AND METHODS

The process of producing compound feeds is very complex because they are obtained from mixing the basic components represented by cereals (wheat, corn, barley, oats, etc.) with other auxiliary ingredients represented by mineral salts, antibiotics, vitamins, enzyme preparations and medicinal substances, dosed so as to meet the physiological needs of different categories of animals. That is why the technological flow from a compound feed factory involves several activities (figure 1): receiving and storing raw materials in special bunkers, transporting raw materials between work installations using horizontal conveyor belts or using vertical elevators, grinding cereal grains, dosing according to the desired compound feed recipe, mixing the ingredients, homogenizing of this mixture, granulating to the desired sizes and shapes and sterilizing them with the help of powerful steam jets at very high temperatures, cooling the granules with air jets, packaging and delivery of the finished product to the beneficiaries.

In the figure 1 is presented in a very suggestive graphic form the sequence of activities carried out during the technological process of obtaining compound feed. Also in figure 1 are marked the critical points where the experimental measurements presented in this article were carried out, regarding the concentrations of dust powders removed into the atmosphere and the values of temperatures released by the installations of steam jets production:

a) the first critical measurement point (PM1) regarding the dust released into the atmosphere was located at the exit of the grinding installations of cereal grains;

b) the second measuring point (PM2) was located at the exit of the steam generator, when the steam jets at very high pressures and very high temperatures are used to homogenize the mixture obtained according to the preparation recipe;

c) the third point where experimental measurements were performed (PM3) was established at the sterilization installation of the obtained granules, which is done with the help of steam jets with very high temperatures;

d) the fourth critical point for performing experimental measurements (PM4) was established at the outlet of the granule cooling installation, where air jets are used at ambient temperature.

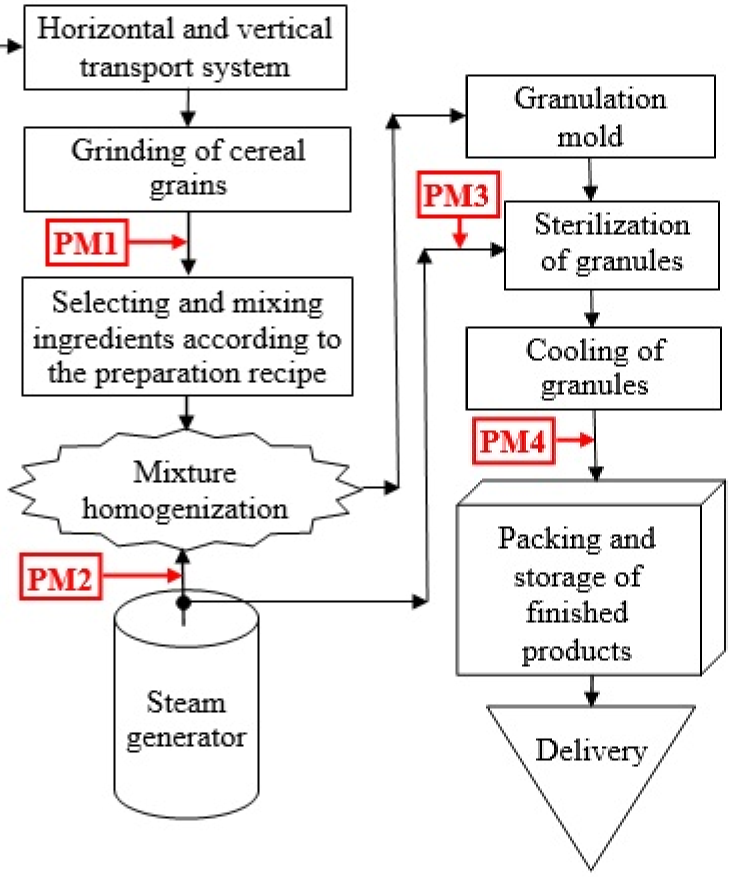

Figure 1: Process flow activities from a compound feed factory

On the route of the technological flow shown in figure 1, small amounts of dust are released at the exits of the granule sterilizing and cooling facilities, due to the use of hot steam jets, respectively ambient air jets, in both cases with very high pressures. They cause the detachment of small particles from the mass of the mixture or from the surface of the granules, which will form dust powders that can spread in the atmosphere. But the place where the largest amount of dust is released is represented by the hammer mill, more exact at the work equipment used in the activity of grinding cereal grains. Thus, the dust resulting from the production of flour that comes out of the hammer mill has a tendency to be released into the atmosphere, and if it is not retained immediately with the help of special filters, it will spread very quickly in that area and cause the pollution of the work hall and air contamination, endangering the health of operators. Then, by exhaust into the atmosphere, the air with dust in suspension can cause the pollution of larger areas and endanger the health of a large number of people. That is why, both at the national level and at the level of the European Union, there are very strict norms, which limit the emission of dust into the atmosphere to achieve an adequate protection of the environment.

The collection of samples from the air at the critical points mentioned on the technological flow route and the performance of experimental measurements to determine the concentrations of dust powders released by the work facilities is done with the help of a special device, namely the Strohlein STE4 dust analyzer.

For determination of the temperatures released by the production installation of compound feed are used temperature sensors and calibrated thermocouples of type Cromel Alumel (type K). The thermocouple (figure 2) consists of two metal wires, called thermoelectrodes, welded at one end. The welded end (the common one) is called a "hot" weld. The other two ends, called the free ends of the thermocouple (or "cold" weld) are connected by connecting leads to a millivoltmeter (mV), which measures the overall thermoelectromotive force, which is proportional to the temperature difference between the two welds.

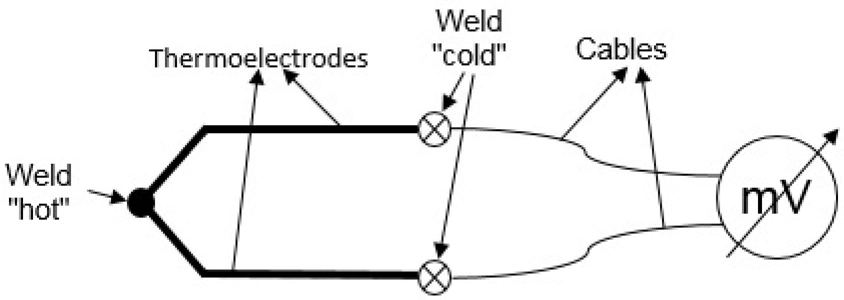

Figure 2: The scheme of K-type thermocouple

The values taken over with the temperature sensors and K-type thermocouples were then transmitted to a analog-to-digital converter Pixsys ATR 243 ABC. This is the electronic component intended to equalize, filter and amplify the signal transmitted from the thermocouples (signal in the form of a voltage expressed in mV). The data thus obtained in an experimental way are then transmitted to the NI-PCI-6224 acquisition board (figure 3).

Figure 3: NI-PCI-6224 type data acquisition board

RESULTS AND DISCUSSIONS

This article presents the results of experimental measurements carried out at the outlet of the cereal grain milling installation and at the outlet of the compound feed granules cooling installation using air jets at ambient temperature in order to determine the quantities of dust removed into the atmosphere. Also, the results of the experimental measurements performed at the exit of the burner from the endowment the steam generator, at the exit of the installations for homogenizing the mixture and sterilizing the granules with steam jets at very high temperatures are presented in order to monitor the temperatures released by these work equipment. The work installation from the compound feed factory where these experimental researches were carried out has automated and computerized modules for monitoring and controlling the dust and temperatures released during the production process, so as to comply with the norms imposed by the European Union regarding environmental protection. Precisely in order to demonstrate the reliability of the working equipments used, experimental measurements were carried out during the production of two distinct assortments of compound feed: for broilers and for cattle.

For the compound feed used when feeding broilers, the recipe from which the mixture is obtained contains 67% corn and the remaining 33% is represented by soybean meal, vegetable oil, premix, vitamins. During the production of this assortment of compound feed, the thermodynamic parameters of the steam generator are as follows: steam temperature: 140°C; heat agent temperature: 170°C; nominal steam pressure: 6 bar. The second type of compound feed is the one used to feed cattle, with a recipe that contains corn in a proportion of 20%, wheat in a proportion of 21% and the remaining 59% is represented by soybean meal, bran, complete premix and vitamins. The thermodynamic parameters of the steam generator in the case of the production of this assortment of compound feed are: steam temperature: 160°C; heat agent temperature: 180°C; nominal steam pressure: 8 bar.

The experimental measurements of the dust quantities removed into the surrounding atmosphere were carried out at the critical point PM1 (at the hammer mills used to grind cereal grains) and at the critical point PM4 (the air jets used to cool the grains detach very small particles from their surface which are then carried to outside into the atmosphere).

Table 1. Dust concentrations measured during the production of the two types of compound feed

Parameter name	U.M.	Broilers	Cattle
Initial mass of cotton filter	g	51.8925	51.9137
Initial mass of paper filter + box	g	10.5483	10.5723
Final mass of cotton filter	g	51.8936	51.9149
Final mass of paper filter + box	g	10.5486	10.5728
Temperature of effluent at chimney	°C	67.00	68.50
Initial value of counter for aspired air	m^3	479.6180	480.6250
Final value of counter for aspired air	m^3	480.6250	481.6330
Mass of dust collected	g	0.0014	0.0017
Volume of air passed through the analyzer	m^3	1.0070	1.0080
Dust concentration removed in the air	mg/ m^3_N	1.3903	1.6865

As part of these experimental analyses, the temperatures were measured in 3 different working points on technological flow route: in the working point PM2 (to monitor the temperatures released by the steam generator burner, but also at its exit to monitor the temperatures of the steam jets under pressure), at the working point PM3 (for monitoring the temperatures released by using very hot steam jets for sterilizing the granules), at the working point PM4 (for monitoring the temperatures released by the air jets used to cool the granules of the finished product). These 3 points where the experimental measurements were performed were not chosen at random, because they are strategically located in the technological flow and indicate the reference values according to which the automated system of the installation adjusts the manufacturing process of compound feed according to the desired recipe.

The temperatures measured during the complete technological flow of production of an assortment of compound feed are: T1 - the temperature released by the burner of the steam generator; T2 - exit temperature of the steam jet from the boiler; T3 - steam temperature at the sterilization installation; T4 – temperature of air at the cooling installation; T5 - ambient temperature.

The temperature measurements in the 3 working points were made with a frequency of one reading every 30 seconds. So during the 10 minutes it takes to produce an assortment of compound feed, in the file with final experimental results were obtained 20 values corresponding to the five analyzed temperatures, presented in table 2.

Table 2. Temperatures measured for the two assortments of compound feeds

Reading time t[s]	The assortment "Broilers"					The assortment "Cattle"				
	T1 [°C]	T2 [°C]	T3 [°C]	T4 [°C]	T5 [°C]	T1 [°C]	T2 [°C]	T3 [°C]	T4 [°C]	T5 [°C]
30	36	33.4	32.8	27	24	39	37	36.2	26	24.3
60	129	106	92	31	24	137.5	129	114	26.5	24.4
90	205	132	114	36	24.1	219	148	132	34.8	24.5
120	247	140.5	137	39	24.3	245	156.7	145	38	24.7
150	261	161	142	40.5	23.8	263.8	163	146	39	24.8
180	274	163	147	41	24	277	164	148.3	40	24.6
210	270	165	151	41	24	293	167	150	40.7	24.9
240	268	167	154	40.3	24.2	298	166	151	40.1	24.6
270	269	171	157	40.8	24	299	168	152	40	24.5
300	276	173	158	40.9	24.1	301	169	153	40.5	24.7
330	279	174	155	41.7	24.2	300	168	153.7	40.6	24.6
360	283	176	156	42	24.4	303	170	155	41	24.7
390	279	173	155	41.2	24.2	305	171	157	41.5	24.8
420	282	174	157	41.7	24	307	172	158	41.7	25
450	285	176	158	41.5	24	306	171	157	41.2	24.7
480	281	175	155	41.3	24.1	304	170	156.5	41.4	24.8
510	282	175	156	42	24.3	305	172	157	41	24.9
540	286	176	154	42.8	24.1	307	174	158	41.8	25
570	282	174	155	43	24.3	306	175	157.4	42	24.6
600	284	175	156	43.6	24.4	305	176	158	42.5	25.1

The figures 4 and 5 show in graphic form the temperature evolutions monitored at the critical points located on the route of the technological flow for the production of the two distinct assortments of compound feed.

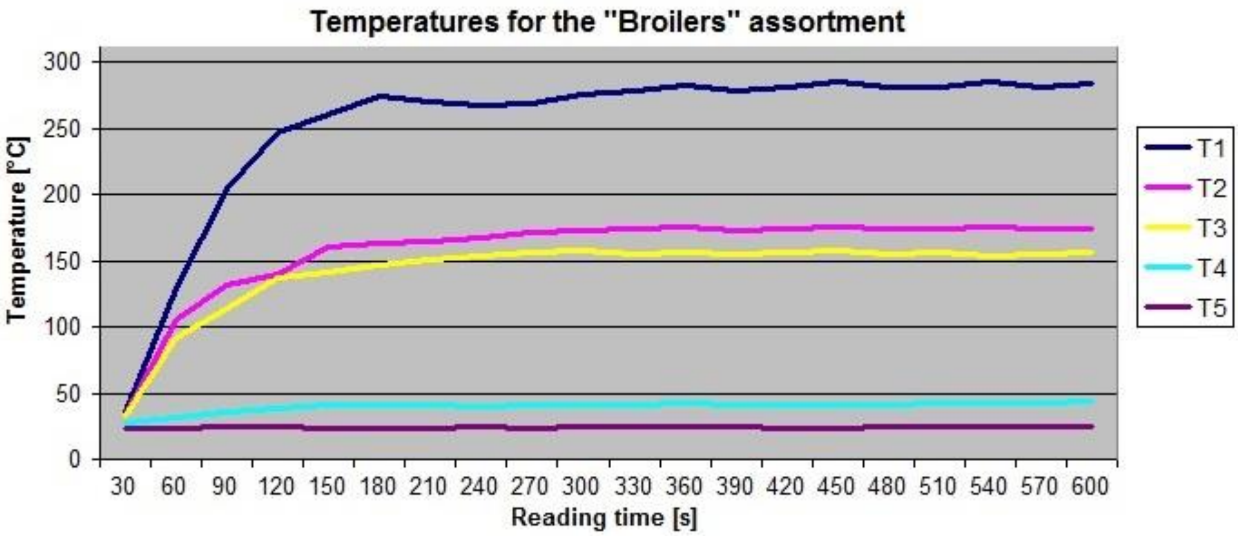

Figure 4: Temperatures measured during the production of compound feed for broilers

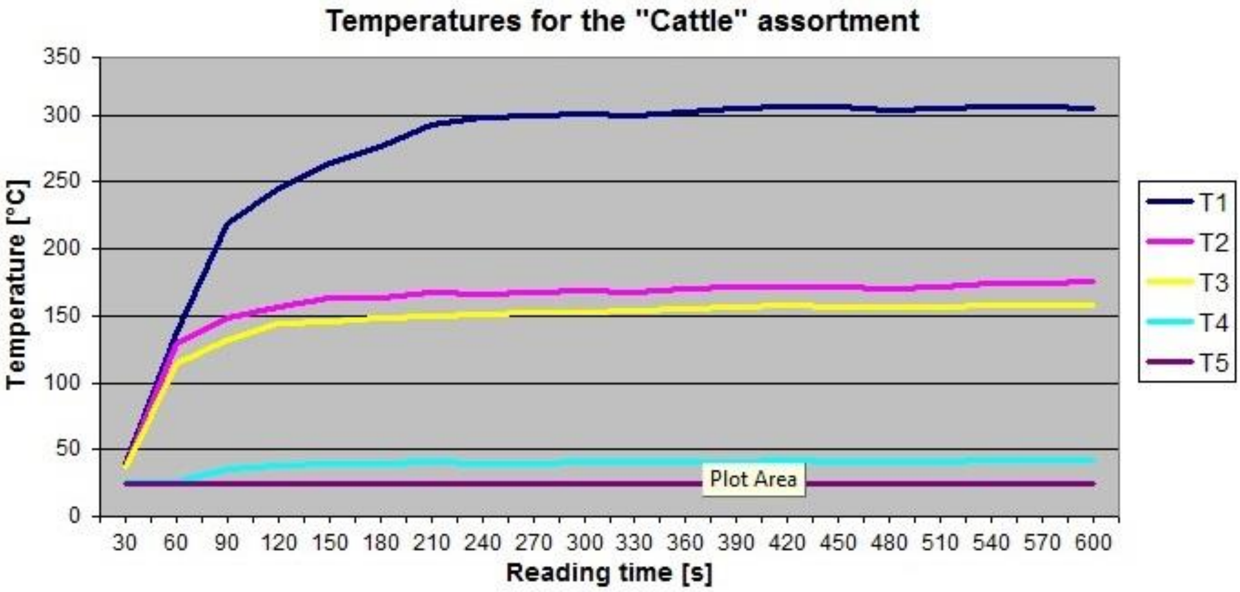

Figure 5: Temperatures measured during the production of compound feed for cattle

CONCLUSIONS

The experimental researches presented in this article was based on the monitoring of the dust quantities released into the air and the monitoring of the temperatures released by the work equipment and steam jets during the production processes of two assortments of compound feed. Although the operating parameters of the work installation change depending on the recipe produced, the measured values fell within the limits required by European legislation for the protection of the environment.

The two distinct assortments of compound feed produced during the experimental measurements met all the quality requirements, which confirmed the reliability of the working installation from the analyzed factory.

The studies and analyzes presented in this article confirm the need to use high-performance work installations, with a high degree of automation and computerization, which allow the permanent adjustment of the technological parameters of the equipment's operation, so as to obtain finished products conforming with the requirements of the beneficiaries at a cost price as low as possible.

The results of the experimental measurements carried out at the critical points established on the route of the technological flow for the production of the two assortments of compound feed confirmed the correct operation of the work equipment by fully complying with the standards imposed by the European Union rules regarding the safety of operators and the protection of the environment.

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