THEORETICAL AND EXPERIMENTAL RESEARCHES REGARDING THE AUTOMATION AND COMPUTERIZATION OF THE MANUFACTURING PROCESSES IN THE FODDER KITCHENS, FNC'S AND MICRO FNC'S

SUMMARY

This paper, structured in 7 chapters, presents a research regarding the automation and the computerization of the processing processes for forages in the forages kitchens, in FNC's and in the micro FNC's from Romania.

The purpose of the research refers to the theoretical and experimental analysis of the forages' automatic processing within the two FNC's well known in our country, SC DIDFARM SRL Sânnicolau Mare and SC VIPROMAX Craiova, in order to obtain proper results within the conditions of fuel's rational use, by obeying the food security norms and the proper practice rules regarding complex forages' production.

Starting with the previous exposed aspects, the main objective of the doctoral dissertation has been settled, objective which refers to: searching the automated control for the functioning of the transportation and optimization trains regarding the automatic processing regime of the forages by using the method of automatic leveling of the work process, taking into consideration the temperature, the humidity and the steam's pressure, by obeying the European norms regarding the environment's protection and the fuel's consumption reduction.

The process of solving the proposed objectives regarding the research topic has been focused on two directions: a theoretical one and an applicative-practical one.

The theoretical research direction refers to the following aspects:

- Preparing a synthesis regarding the necessity of efficiently producing and using the forages and the combined nutriments used for the animals' feeding;
- The actual stage of knowledge regarding the theoretical research of the forages production installations;
- The structure and the actual stage of the knowledge regarding the forages production installations;
- The necessity of using the automation and computerization systems for a mixing installation of the cereals used for the production of the combined forages;
- The identification of the problems specific for the mixing process of the grains in order to reduce the production costs by obeying the food safety norms and in order to reduce the energetical consumptions;
- Monitoring and controlling the parameters (the quantities of raw materials, of the thermal temperatures, dust etc.) during the technological process;
- Presenting the technological flow regarding the combined nutriments' production;

The practical-applicative direction refers to the following aspects:

- Experimental researches and theoretical contributions regarding the automation and computerization of the processing processes for forages inside a FNC;
- The analysis of the constructive, functional and work factors of the forages processing installation;

- The determination of the technical-functional parameters of the magnetic sensors for revolution and proximity, used in the automated monitoring system of the transportation bands;
- The direct determination, towards measuring the thermo-dynamic parameters of the thermal agent and of the environment's agents, during the forages producing process;
- The determination of the pollution emissions coming from the burning gases of the agent used for drying;
- The measurements regarding the automatic functioning of the installation during the forages' production for the Boiler type chickens (starter phase, growing, finishing);
- The measurements regarding the automatic functioning of the installation during the forages' production for hens, milk cows and rabbits;
- Checking the mathematical models elaborated in the theoretical research.

The paper is structured in 7 chapters in which 160 figures and graphics, 59 tabels, 86 mathematical relations and 135 bibliographical references.

Chapter 1 ,,The necessity to produce and use fodder for forage"**,** presents a short characterization of the preoccupations regarding the combined nutriments industry's dynamic from the national and international point of view regarding the installations' construction for forages made from cereals' mixture.

In this chapter a successive presentation of the installations that exist in the country and abroad regarding combined forages plants has been made. So, taking into consideration the operations developed during the technological process from the FNC's, a wide scale of cereals mixing equipments, drying devices, etc. has been presented, according to the mentioned figures and attachments. Also, other installations and machines have been mentioned, that can do important operations inside a FNC: machines for cereals' cleaning, machines used for granulation of the obtained products, installations used for the transportation and storage of the cereals and of the finalized products.

One of the important operations inside a FNC is represented by the cereals grains' mixing. The grains represent the raw material in order to obtain the desiderate recepies made out of combined cereals. The machines that execute this process are called mills and can be of various types: with stones or with metallic disks, with roll and with hammers. Out of these, inside the FNC's, the widest spread is represented with the hammer mills.

Table 1

The main characteristics of hammer mills

Type of mill	**k = D/L**	**Working capacity, kg/h**	**Specific flow, kg/h x m^2**	**Specific energy, kWh/t**
MC-3	1,6	2500-2800	$(14,2\text{-}18,2)10^3$	11-8,7
MCE-2	3,2	800-1000	$(10,4\text{-}13)10^3$	
MCU-2,3	3,8	4500-4600	$(14,5\text{-}100)10^3$	5.6-5
MCF-5	1,2	4500-5000	$(15\text{-}16,5)10^3$	
MCU-3B	1,1	1000-1200	$(14,7\text{-}17,6)10^3$	9,6-5,2
MCMC-16	4,5	10^4-14x10^3	$(25,2\text{-}35,3)10^3$	

As we previously stated, the mixers are included also in the technological flow regarding the forages flours. Towards mixing, the homogenization and the uniform distribution of each component regarding the grains' mass mixture is being followed.

The mixers can be, depending on the work method, with continuous and periodical functioning. From constructive point of view, they can be horizontal and vertical.

Table 2

The technical characteristics of certain types of mixers

Characteristic	**UM**	**Mixer type**						
		AF 500	**AF 1000**	**AF 1500**	**AF 500M**	**AF 750M**	**AF 1000M**	**AF 1500M**
Equipment capacity	m^3	0,96	1,7	2,5	0,96	1,25	1,7	2,5
Productivity	kg/h	450÷500	900÷1000	1400÷1600	450÷550	750÷850	900÷1000	1400÷1600
Installed power	kW	1,5	4	5,5	1,5	2,2	4	5,5
Power supply	V	380	380	380	380	380	380	380
Engine speed	rot/min	3000	3000	3000	3000	3000	3000	3000
Mixing time	min.	7-20	7-20	7-20	15	20	20	20

Based on the documentation, a series of prospects have been studied, studies regarding the hammer mills, homogenization devices and installations for forages flours made by SKIOLD (Denmark), RAKO (Germany) and ECO - RENE TOY (France), according the Annexes.

Chapter 2 ,,The need to use automation equipment for obtaining a compound feed plant", presents some aspects and theoretical considerations regarding the cereals' mixing process and also the compound feed production technology,coupled with specific problemsof cereals grain milling process, reducing production costs, temperature controlduring the technological process, emission control dust and noise for aconstructive solution of the automated milling facilities cereals.

It has been underlined the fact that the main steps of the combined nutriments technological process are the following:

- Reception and storage of raw materials
- Transportation of the raw materials and of the obtained products
- Mixing the raw material
- Dosage according to recipe
- Homogenization of the combined forage
- Granulation (for the plants that have also this technological step)
- Packing and delivery of the finite product

A careful attention is to be paid to the theoretical considerations regarding the grains mixing process. For this purpose, the functioning of a hammer mill is being shown The process of grinding grain cereal lasts until the particles reach a size small enough to pass through the holes in the sieve hammer mill equipment. In thiscontext they were presented mathematical equations that allow the study oftechnical indicators crushing characteristics: degree of fineness, granularity, the fineness of milling, the specific energy consumption and energy consumption index.

Also, in this chapter, there are presented specific problems that may occur during the process of grinding grain cereals and grain quality indexes. Given the quality ofthe final product offered to the beneficiaries of the livestock, all grainprocessors, including those

producing compound feed must constantly pursue the following objectives, if they want to keep its market profile:

- ♦ Reduction of the production costs of the finite product;
- ♦ Maintaining the product's quality standard, according to the clients' norms or demands;
- ♦ Obeying the regulations regarding health and safety and environment's protection;
- ♦ Diminishing the noise level, noise produced by the fans that ensure the dust filtration in the mixing installations.

Also here there are some important aspects regarding the legislation- methods, standards, criteria and mathematical formula used by the specialists in order to appreciate the cereals' quality.

Taking into consideration all these requests, at the end of Chapter 3, a constructive solution is being presented, regarding an automated installation for cereals' mixing.

Chapter 3 ,,The opportunity and the objectives of the doctoral dissertation" presents the evolution of the forages' processing technologies from the earliest times and the dynamic of the main cultures and seeding surfaces regarding the augmentation of the interest for the utilization in more domains of the cereal based products and their importance for the mankind.

Chapter 4 ,,Contributions for preparing, designing and making automated modules for controlling the transportation lines during the forages processing processes inside a FNC", characterizes the theoretical fundamental part of the automation system regarding the obtainment of the combined forages. In the beginning of the chapter there is a brief presentation of the two FNC's that represented the research object of the elaboration of this paper: SC DIDFARM SRL Sânnicolau Mare and SC VIPROMAX Craiova, here being actually the place where practical experimental tests have been performed.

Then, the stages of the technological phase regarding the combined nutriments' production are being mentioned, briefly presenting the main operations that are being performed and the used installations. In order to ensure an optimal activity inside the FNC's, the main deficiencies, which can appear during the process of combined forages' production, are being analyzed.

The chapter continues with the presentation of the automated control system's design regarding the transportation of raw materials, the electrical scheme's functioning of the designed control module and also the design of the automated monitoring system for elevator loading. The electrical schemes of the transportation bands control automated system are being presented in detail and their functioning is described also by using some control functions, with 5 variables of command, based on the Boolean algebra logic. After explaining the functioning manner, a computerized simulation of the transportation bands automated control functioning system inside a FNC. Also in this chapter is presented and the design of computerized monitoring module loading bunker, which allows tracking the level of filling materials. To write this program we use C++ programming language and its data acquisition and storage using Microsoft Excel.

In Chapter 5, experimental research on automating the processing of feed and fodder kitchens FNC's "presents in detail the steps that have been the choice ofexperimental methods of measurement equipment used during investigations, and some theoretical aspects characteristics, the use of work equipment and performance measurement points established under experimental methodology.

Table 3

Measuring Characteristics

No.	Device	Measuring principle	Comments
1	TESTO 350 M/XL	Continuous analysis of electrochemical combustion (Peltier principle)	Calibrated device by INM
2	STROHLEIN STE 4	Determination of dust concentration by continous isocinetic sampling in sieves	Calibrated device by INM
3	PC data aquisitions NI-PCI 6224	Measurement of continous analog data aquisition channels with frequency (250 ks/s)	
4	Digital analog convertor PIXSYS ATR 243 ABC	The measurement of strength given by thermocouple (mV).	
5	Type K thermocouple temperature sensors	Sending an electrical signal in mV, directely proportional to the temperature to digital analog convertor	
6	Electronic tachometer EBRO DT/2236	Electronic determination of the number of turns. It has a internal memory.	

Also, there are mentioned the possibilities of performing practical tests and of preparing the installations and the measurement devices for work (figure 1).

Figure 1 – Training facilities and measuring equipment for practical examinations

In conclusion, there were presented the equipments used for the determination of the magnetic sensors work parameters, for the measurement of the polluted emissions caused by the burning gases, for the determination of the dust contain from the burning gases, for measuring the dust content in flue gas and steam temperature measurement and how to prepare for work and taking measurements at pointsof measurement. In the last part of the chapter is presented the data acquisition system, comprising: temperature measurement sensors, analogue and digital data acquisition card.

Chapter 6, experimental results obtained during the automatic operation of the manufacturing process of feed and compound feed, the results obtained from making measurements at four measurement points: the conveyor train, the steam generator at the granulation plant and cooling plant. It then presents the analysis and interpretation of research results for the two measurement campaigns for each variety of feed and analyzed in order to produce feed and forage, combined with a minimum consumption of fuel, emission compliance and food safety.

Experimental researches made at the horizontal conveyor in a measuring point (PM1), aimed at determining the technical and functional parameters of magnetic speed sensors and proximity, comprising the installation of automatic monitoring of the conveyor train.

The experimental researches performed on feed processing plant and compound feed were made to assess in terms of environmental impact and optimize the production of feed. To highlight suggestive conduct in-service processing facility, originally designed an action plan. Action plan developed for the installation process was developed in close accordance with the manufacturer's specifications. Measurements were performed in two campaigns.

The first campaign was aimed at the manufacturing process of race feed Broiler chickens as follows:

- Broiler chickens, starter phase;
- Broiler chickens, growth phase;
- Broiler chickens, finishing phase.

The second campaign aimed at the feed manufacturing process:

- Laying hens;
- Cow milk;
- Rabbits.

According to the diagram of the experimental method, leaving the steam boiler was a point measurement (PM 2). At this point measurements were performed the following measurements:

- emissions, using gas analyzer TESTO 350 M / XL [120]
- temperatures of critical points of the installation system using National Instruments data acquisition.

The homogenized product gets into the mold. This point is the measurement point 3 (PM 3) and thermodynamic parameters were measured using the facility data acquisition system.

This temperature resulting from the pressing mold material through the channels, because of compression and friction to which it is subjected to steam temperature, but also due to participate in cleaning the finished product, resulting in measurement point 4, PM 4, which is measured as follows:

- thermodynamic parameters of the plant,
- dust concentration of the effluent that is discharged into the atmosphere.

The operating principle is based on the airflow path passing technological flow of feed grains. This air can take more moisture and will lose moisture grains.

Chapter 7 presents the main findings related to studies and results obtained during two campaigns of measurements on different types of compound feed products and the problems that can occur on route conveyor belts. This research was conducted in two stages, and this recital was adopted from the tender conditions of the livestock farmers. Thus, two separate measurement campaigns for six types of feed.

The first measurement campaign, aimed at monitoring the thermodynamic parameters of the processing plant where it in turn has produced feed Broiler chicken breed. Feed was analyzed for these reasons: Broiler-phase starter-growth phase and finishing phase.

In the second campaign were analyzed feed for laying hens, cows and rabbits. The production of feed has been analyzed from different points of view. A great reason to study the process of feed manufacturing has been the impact on the environment. We have analyzed the production of polluting emissions of these types of feed and dust emissions (figure 2).

Figure 2 - Assessment of concentrations of CO, CO2 and NOx from measurements made with TESTO 350 M / XL

Another consideration in analyzing the feed manufacturing process has been monitoring the temperatures of critical points of the facility to assess the integrated automation system that monitors and adjusts the thermodynamic parameters of the plant.

Analyzing the results of two measurement campaigns can draw the following conclusions:

- installation of automated control of the two horizontal bands of vertical lift transport and ensures a good, eliminating the danger of locking bands because of high quantities of raw materials and eliminates the possibility of mixing different kinds of unwanted materials, which would affect production concentrates desired recipes;
- analyzing the results of CO collected in two measurement campaigns, it can be concluded that all types of feed can be achieved without a major impact on the environment, in terms of CO emissions;
- regarding NOx emissions during the production of such feed were obtained mg/m3N averages of 24.46, 20.84 and 15.58 mg/m3N mg/m3N and The Order 492/1993, the limit imposed by the emission of NOx is 35 mg/m3N. Threshold limit values shown, which proves once again the proper functioning of the automated control of feed processing facility;
- the CO2 emission is observed that the average values obtained in two measurement campaigns have differences that lie between 200-220 g/m3N, which show the ability of control system of steam generator to reproduce the same conditions every time whenever necessary;
- analysis of dust emission levels, ranging from 1.5 to 2.1 mg/m3N, showed that in no case studied were not exceeding their limit imposed by the Order 492/1993, which is 5 mg/m3N ;
- flue gas temperatures are closely related to temperature working medium (steam). Read temperatures during measurement values are approximately equal, with values ranging from 260-315 ° C, giving an additional system automation trust.

Personal contributions regarding the automatic functioning of the forages and combined nutriments' production process

Theoretical contributions:

1. Making a summary analysis on the current state of research in the field, consultation with a broad and topical bibliographies, which shows global concerns for improving manufacturing technologies and means of feed and feed concentrates, and complexity associated with the word Romanian literature is that the field looked pretty poor, so it is necessary to exploit the numerous web sources to supplement the available information considered classics.

2. Establishment and adherence to a program of experiments to study possible influences of key parameters on the performance of the plant feed and compound feed.

3. Foundation and implementation of controls to identify systemic analysis of work functions of different technical equipment in the technological (horizontal conveyors Tr1, Tr2 and lift Ev) to design a simplified driving scheme and optimized to achieve the programmed kinematics.

4. Theoretical design methods based on the formula attached to logical control schematics, allowing implementation of automated control modules for conveyors in a FNC.

5. The mathematical foundation of the estimated height of loading bunkers monitoring raw materials.

6. Making a mathematical modeling of functioning of the automated installation work from a FNC.

7. Establishing a theoretical method for determining temperature influence on the process of steam pelleting feed varieties analyzed according to experimental methodology.

8. Providing an overview of recommendations regarding the optimal thermal regime in the steam generator to optimize energy consumption and obtaining high quality products according to the formulation.

9. The design of algorithms that allow quick calculation of thermodynamic parameters and operating characteristics in the integrated automatic feed and compound feed produced.

10. Develop a best practice technologies for monitoring the steam boiler automatic operation of the manufacturing process of feed and compound feed.

11. Design an original system of data management (collection, transmission, storage, processing).

12. Systematization and generalization of experimental data to correct conclusions about the effects of automation of manufacturing processes of fodder and mixed fodder.

Experimental Contributions:

1. Building a test platform to determine the technical parameters of functional magnetic speed sensors and proximity, which can be used to implement automated control installation of conveyor belts FNC.

2. Design a monitoring scheme of a drum drive motor speed conveyor belts, with a rotating magnetic sensor.

3. Designing an electronic monitoring system that stops the loading conveyor belts in an emergency, operation of upstream carriers, thereby protecting the tape lifts and train transport. This automated system for monitoring the operation of transport train stops operating bands in a very well-established order: first first carrier silo located near where the acquiring raw materials, intermediate and then the carrier is finally lift off vertically. The order to stop the conveyor train is determined, on the one hand, provided that no amount of raw materials appear to shrink in places and connecting conveyor belts so as not to obstruct the

normal functioning of these bands, and on the other side not to mix different types of recipes ingredients combined feed.

4. Computer simulation, with an application built by ZelioSoft program, monitoring the operation of the automated installation of train transport of two horizontal stripes and a vertical lift.

5. Development of a software program that would allow computer monitoring of loading bunkers with raw materials.

6. Electronic storage disk of the computer that monitors the flow of technology, a file type database, the results of measurements on the high estimated levels of loading bunkers.

7. Making a lot of measurements in two separate campaigns, an algorithm that can be very rich in plant recipients Sannicolau Great granulation processes, in full accordance with equipment manufacturer's specifications.

8. The set of measurements on flue gas compounds, we succeeded in obtaining results that have allowed interpretation of the technological process of grain and forage production combined with emission compliance, which once again confirmed that the activities of the SC Didfarm Ltd., is conducted in full compliance with environmental legislation on emission of pollutants to the basket.

9. Automated control system design of the transport of raw materials majority allowed the very important studies were accomplished by completing a rich data base which allowed confirmation of all cuno?tii?elor practice and theories currently existing.

10. Creating a data acquisition system in real time and continuous, with very high frequency of reading, using graphical programming platform National Instruments PCI-6224 – LABWIEV 8.5 .

11. Conclusions drawn from measurements campaigns confirmed the technical requirements - functional equipment manufacturer.

12. Analysis and interpretation of results from theoretical and experimental research have enabled the development of useful recommendations for the design, use and operation with a maximum output of the plant feed and compound feed.

Future Research Directions

After performing the theoretical and experimental research regarding the automation of the forages processing inside the FNC's, the conclusion is that the domain has a big potential. This thing allows the extension of the research domain towards the identification of new ways and directions in order to continue the researches in the following ways:

1. Extension of the research regarding fabrication processes automated concept for other types of networks- forages and combined nutriments.

2. Extension of researches regarding fabrication processes for other sectors of the food industry, fabrication technological processes, by obeying the food safeties.

3. Diversification of methods of study and optimize the functioning of automated manufacturing facilities combined feed or other food products, aiming at improving both the working parameters and compliance with European environmental protection.

4. Deepening opportunities automated monitoring and control activities during the manufacturing processes of different recipes combined feed and other food products.