ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
Tome XIII [2015] – Fascicule 2 [May]
ISSN: 1584-2665 [print]; ISSN: 1584-2673 [online]
a free-access multidisciplinary publication of the Faculty of Engineering Hunedoara

[1.] Carmen BRĂCĂCESCU, [2.] Dumitru MILEA, [3.] Iulia GĂGEANU, [4.] Bogdan IVANCU

EXPERIMENTAL RESEARCHES ON WEIGHING AND AUTOMATION MANAGEMENT OF AGRICULTURAL PRODUCTS IN RURAL MILLING UNITS

[1-4.] National Institute of Research - Development for Machines and Installations Designed to Agriculture and Food Industry (INMA), ROMANIA

Abstract: Using automatic weighing and dosing methods in small and medium capacity milling units in the rural areas brings an increased economic efficiency, and has an immediate impact on the recording of the supplied materials, leading to increased quantity and quality of sacked products but also to the ease and quality of the weighing process. In this paper there are presented the experimental investigations for the Technological Equipment for Weighing and Automated Management – EWAM, designed at INMA Bucharest with the purpose to optimize and automate the weighing, dosing and sacking process, highlighting the advantages of using this machine in the flow of small and medium capacity milling units.
Keywords: dosing, automated management, sacking, PLC

1. INTRODUCTION

The field of systems and equipments for weighing, dosing and packaging agrifood products is one of the fields with a high economical impact in Romania (especially in the last years), but also in the industrially developed countries.

Weighing, dosing and automated management are processes that eliminate, totally or partially, human intervention in the actual operations. Modern weighing, dosing and automated sacking devices represent ingenious technical solutions that comprise fields from both the mechanics and electronics, being characterized by a high precision and sensitivity. [2, 5, 11].

Usually, operations involving direct action on the processed material are exclusively done by mechanisms or mechanical components, but also the command and dosage adjustment operations are frequently done by mechanical systems, the electronic systems having a surveillance and fine adjustment role. [4, 6, 10]

Technological operations of weighing and dosing are not independent in the manufacturing process of products, but are integrated into various technological processes, so that the result of the operation does not emerge distinctively, but cumulated in the resulted final product, and as a result, the quality of the dosage/weighing directly influencing the quality of the final product. [1, 3, 8]

Aligned with the most modern equipment in the field and encompassing innovative constructive solutions, the *Technological Equipment for Weighing and Automated Management EWAM* (figure 1), developed at INMA Bucharest has a direct applicability in small and medium capacity milling units in the technological processes of packaging finished products in open bags, performing two very important operations [6]:

- ✓ automated bag weighing of the programmed quantity of product with a precision that fits within the prescribed limits;
- ✓ automated management of the quantities of sacked finished products on an indefinite period of time.

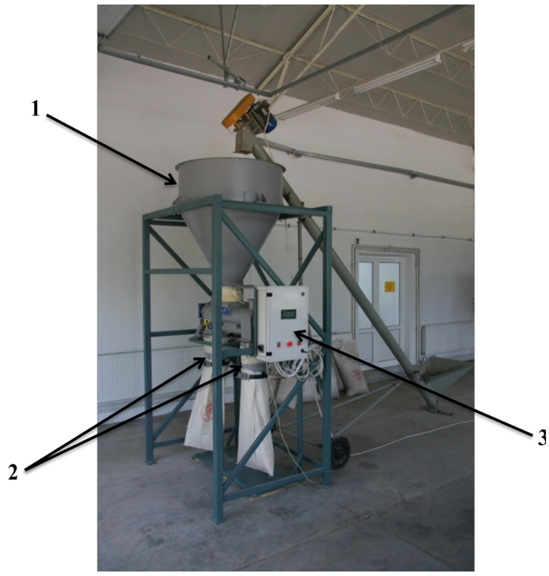

FIGURE 1 – Equipment for weighing and automated management– EWAM - Overview
1 - hopper; 2 – work station1, 2; 3 – automation system

The machine is mounted under a hopper for finished product and is equipped with two workstations served by the same electronic command and management system, thus eliminating equipment downtime when changing the bags. Also, a manual solution was chosen for attaching bags on the filling spout using an adjustable strap provided with a special lock, renouncing at the pneumatic attaching device that takes more time to change the bag and the equipping the unit with a compressed air installation, from this resulting additional investment costs.

The equipment can also be successfully integrated in the technological flows of units producing concentrated fodder or in other specific units that practice packaging granular or powdered product in bags.

2. MATERIAL AND METHOD

In figure 2 is presented the constructive scheme for *Technological Equipment for Weighing and Automated Management EWAM.*

The dosing group (pos.2) is the subassembly that performs the dosage of products that will be sacked.

The command and control of the dosing operations, weighing and recording the work parameters is made by the automation installation.

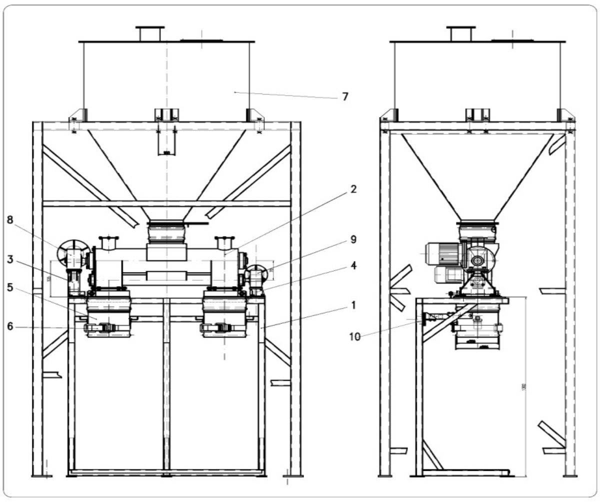

FIGURE 2 - Constructive scheme for the *Technological Equipment for Weighing and Automated Management EWAM* [2]

1. Support frame; 2- Dosing group; 3- Gearmotor holder 1; 4- Gearmotor holder 2; 5- Filling spout; 6- Bag fixing strap; 7- Bunker; 8- Gearmotor 1; 9- Gearmotor 2; 10- Tensometric dose.

In figure 3, the block scheme for the automation installation is presented.

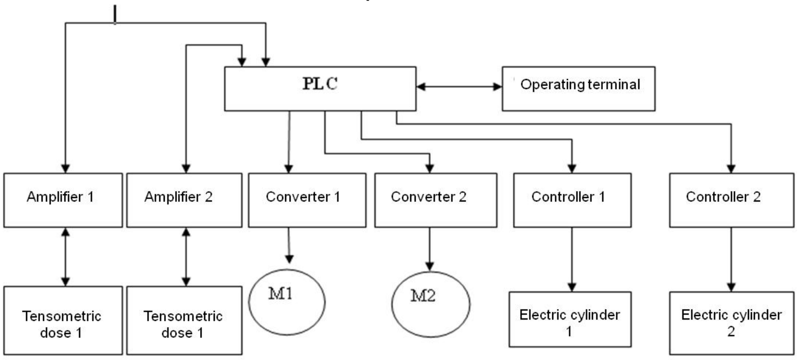

FIGURE 3 - Block scheme for the automation installation [2]

The software component of EWAM is formed by two independent programs installed on the operating terminal and on the installation's PLC. The program loaded on the operating terminal acts as a graphic interface for the user and was developed with the GT Designer 3 graphic programming software. This program has three visualizing windows: Start Page, Parameter Settings and Weighing. In the Settings Page the work parameters of EWAM are established and management data is visualized: number of bags and the quantity of sacked material on each working station.

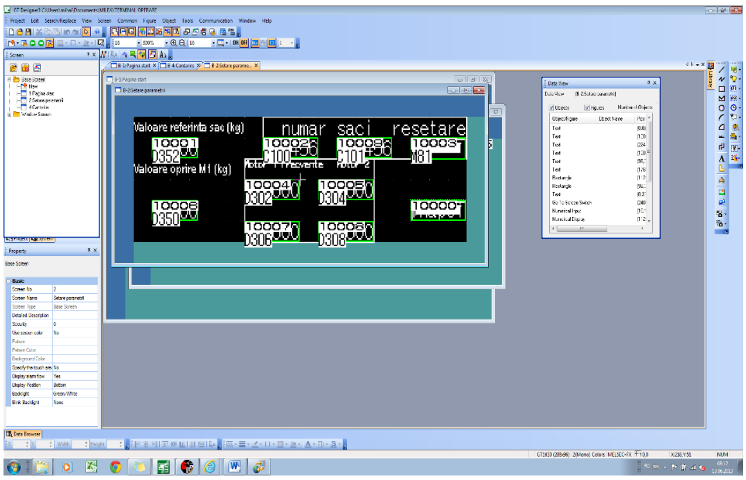

FIGURE 4 - Parameter Settings Page [2]

The program loaded in the PLC of the automation installation is developed with the GX developer software program, being structured in the form of logic instructions presented as a ladder diagram, and the transmission of signals to and from the PLC is made both analogically and digitally.

The testing of the EWAM equipment was made at INMA Bucharest, in laboratory and exploiting conditions, using its own experimental methods, carrying out the following activities: preliminary checks, initial technical expertise, experimenting operating without load, calibrating the weighing system, checking the functioning of the automation installation in simulated mode, experimenting operating under load [7, 9].

TABLE 1 - The constructive and functional characteristics of weighing and automated management equipment

Crt. no	Parameter	Value	
1.	Overall dimensions, mm: - length - width - height	without bunker 1300 560 1739	with bunker 1640 1200 3000
2.	Dosing auger speed, rot/min	60...560	
3.	Coarse dosing auger gearmotor drive power, kW	0.75	
4.	Fine dosing auger gearmotor drive power, kW	0.37	
5.	Productivity, bags /min	3-4	
6.	Weighing precision, %	± 0.1	
7.	Dosed quantity, kg	15 -60	

For the experiments in working conditions, two types of combined fodder and 650 type flour were used. The active power consumed by every motor was determined using the following relation:

$$P = \sqrt{3}\, U * I * cosp \qquad (1)$$

where: P - active power consumed; U - tension of electric power; I - intensity of electric power; cosp – power factor for the electric motor (can be read on motor label).

The total consumed power will be calculated summing the active electric powers for each motor and the power of the stabilized tension source inside the electric control panel.

The weighing precision was determined with the relation [4]:

$$P = [(mc - mp)/mp]\% \qquad (2)$$

where: P – weighing precision (deviation from the programmed value); m_c – product quantity introduced in the bag determined by weighing; m_p – product quantity programmed and recorded in the system.

3. RESULTS

The results obtained after testing the equipment in operating conditions are shown in tables 1 and 2 and their graphic representation in figures 5 and 6.

TABLE 2 – Functional and energetic parameters [2]

		$m_{bag\ prog.}$ (kg)	$m_{weighed}$		Motor loading frequency (Hz)	Filling time		Nb. bags/min pcs		Weighing precision (%)	
			$m_{weig.bag\ I}$ (kg)	$m_{weig.bag\ II}$ (kg)		t_I	t_{II}	PI	PII	PI	PII
With load	$Auger_M$	25	25.02	25.01	5	14	12	4	4	+0.08	+0.04
	$Auger_m$		25.02	25.01		12	13	4	4	+0.08	+0.04
	$Auger_M$		25.01	25.02	10	15	12	4	4	+0.04	+0.08
	$Auger_m$		25.02	25.02		13	16	4	3	+0.08	+0.08
	$Auger_M$		25.02	25.01	15	12	13	4	4	+0.08	+0.04
	$Auger_m$		25.02	25.02		12	12	4	4	+0.08	+0.08
	$Auger_M$	35	30.03	30.02	5	17	16	3	4	+0.1	+0.07
	$Auger_m$		30.03	30.01		15	16	3	3	+0.1	+0.03
	$Auger_M$		30.00	30.03	10	14	17	4	3	0	+0.1
	$Auger_m$		30.02	30.03		14	16	4	3	+0.07	+0.1
	$Auger_M$		30.02	30.02	15	16	15	3	4	+0.07	+0.07
	$Auger_m$		30.01	30.03		17	17	3	3	+0.03	+0.1
	$Auger_M$	35	35.01	35.03	5	19	19	3	3	+0.03	+0.08
	$Auger_m$		35.03	35.02		19	18	3	3	+0.08	+0.06

$Auger_M$ –big auger (coarse dosing auger), **$Auger_m$** –small auger (fine dosing auger)

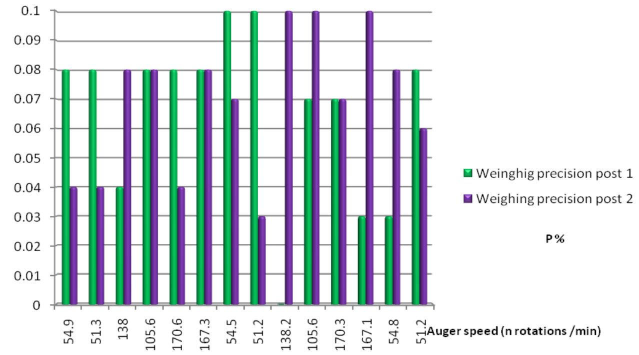

FIGURE 5 – Variation of weighing precision depending on auger speed

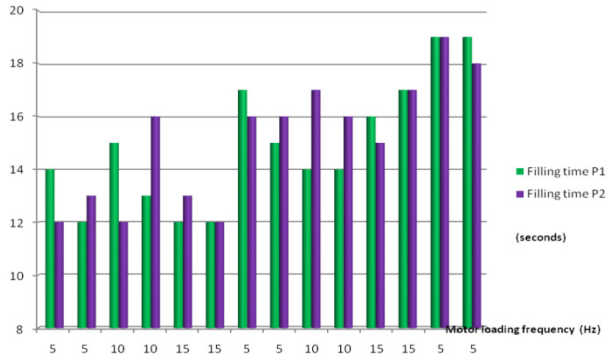

FIGURE 6 – Variation of filling time depending on the motor loading frequency

TABLE 3 – Operating indices [2]

		$m_{bag\ prog.}$ (kg)	Motor loading frequency (Hz)	Noise A(db)	Auger speed N (rot/min)	Tension U_I(V)	Power I_I(A)	Tension U_{II} (V)	Power I_{II}	$P_{post\ I}$ (W)	$P_{post\ II}$ (W)
Without load	$Auger_M$	-	5	64	54.7	35	2.8	35	2.6	137.32	127.51
	$Auger_m$				51.3	34	1.36	34.8	1.26	61.59	58.40
	$Auger_M$		10	67.2	138.2	55	2.34	55.3	2.35	180.34	182.10
	$Auger_m$				105.3	55	1.32	55.3	1.32	96.710	97.237
	$Auger_M$		15	69.1	170.4	75	2.36	75	2.37	248.03	249.08
	$Auger_m$				167.4	75	1.34	75	1.33	133.87	132.87
With load	$Auger_M$	25	5	65.7	54.9	35	2.8	35	2.6	137.32	127.51
	$Auger_m$				51.3	34	1.36	34.8	1.26	61.59	58.40
	$Auger_M$		10	69.4	138	55	2.34	55.3	2.35	180.34	182.10
	$Auger_m$				105.6	55	1.32	55.3	1.32	96.710	97.23
	$Auger_M$		15	70.1	170.6	75	2.36	75	2.37	248.03	249.08
	$Auger_m$				167.3	75	1.34	75	1.33	133.87	132.87
	$Auger_M$	30	5	65.2	54.5	34	2.34	34	2.33	111.48	111.01
	$Auger_m$				51.2	34	1.34	34	1.39	60.69	62.95
	$Auger_M$		10	67.8	138.2	54	2.4	55	2.4	181.60	184.97
	$Auger_m$				105.6	54	1.33	55	1.33	95.67	97.44
	$Auger_M$		15	69.5	170.3	74	2.37	74	2.37	245.76	245.76
	$Auger_m$				167.1	74	1.33	74	1.33	131.10	131.10
	$Auger_M$	35	5	65.2	54.8	34	2.8	34	2.8	133.40	133.40
	$Auger_m$				51.2	34	1.37	34	1.37	62.04	62.04

$Auger_M$ –big auger (coarse dosing auger), **$Auger_m$** –small auger (fine dosing auger)

4. CONCLUSIONS

Through the constructive and functional solutions adopted after the experimental investigations it was found that the Technological equipment for weighing and automated management– EWAM ensures:

- ✓ increased productivity due to reduced service time by overlapping some activities in the packaging process, which is made possible by the fact that the machine is equipped with two workstations served by a single operator;
- ✓ easy and fast management of quantities of finished agricultural products resulted from the manufacturing process;
- ✓ safe storage in the memory of the equipment for a certain period of time of the data regarding sacked product quantities, data that can be made available to interested parties;
- ✓ securing the packaging process by the fact that the programming and work parameter modifications, as well as the system configuration, can only be made by authorized persons based on access passwords only known by those persons;
- ✓ increasing operator's yield due to the reduction of supplementary physical effort.

Therefore, the authors can conclude that the usage of methods and technologies for weighing and automated dosage brings a growth in the economic efficiency and has an immediate impact on the evidence of supplied materials, also leading to the growth in the quantity of products packed in bags and in the weighing precision.

REFERENCES

[1.] Adewuni B.A., Ogunlowo A.S., Ademosun O.C. (2006) – Material classification in cross flow systems, Proceedings from the International Conference on Advances in Engineering and Technology, 321-325;

[2.] Buium GH. F. (1999) - Researches on mechanisms in the structure of dosing systems, "Gh. Asachii" Technical University Publishing, Iaşi;

[3.] Clarke B., Salyani M., Nithianandan T. (1990) - Flow Properties of Fluidized Seeds and Grains**,** Journal of Agricultural Engineering Research, vol. 47, 123-132;

[4.] Melcion J.P. , Ilari J.L. (2003), Technologie des Pulvérulents dans les IAA, TEC & DOC, Paris, France, 433–467;

[5.] Merticaru V (1997) – Packings and packaging mechanisms. The Office for Documented Informing for the Machine Building Industry, Bucharest;

[6.] Milea D. and others (2013) – Innovative technology and achieving a complex technical equipment for sacking finished agricultural products in small and medium capacity milling units – Experimenting report for the Equipment for weighing and automated management EWAM, contract no. 15 N / 27.02.2009 / Add. no 1/2013, INMA Bucharest;

[7.] Ola D (2005) - Experimental Researches Upon the Dosing Accuracy of Screw and Vibration Dosing Systems destined for Agro-Foods Bulk Solids, The Bulletin of University Transilvania from Braşov, vol 12, 42-47;

[8.] Ortega-Rivas E., Juliano P., Yan H. (2005)- Food Powders: Physical Properties, Processing, and Functionality, vol. XVI, 352-368;

[9.] Popescu S. (2005) - Influence of functional parameters of the gravimetric dosing process of granular agro-food material, Buletin of The Transilvania University of Brasov, serie A, vol II (47), 169-176;

[10.] Rhodes M. (1998) - Mixing and segregation, Introduction to Particle Technology, John Wiley & Sons, West Sussex, England, 224–240;

[11.] Vetter G. (1994) – The Dosing Handbook – Vulkan-Verlag, Essen.