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SIZING THE IVF-o INSTALLATION FOR DRYING OF GRASSY PLANTS BY AIR VENTILATION

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ABSTRACT: *This paper presents the technical solutions of an installation for completion of drying hay up to the humidity of 17 ... 18%, by ventilation with cold air or hot air. The installation is constructed from assemblies developed within a modular structure so that users can configure their drying installation according to the needs of the farm. Specific to the installation is the solar panel constructed from a number of solar collectors Nc made of light materials, painted inside with paint or solar lacquers of black color for having an as higher as possible absorption degree of the solar radiation. For the sizing of the drying installations depending on the needs of the feedingstuffs farm were developed tables based on the interdependence of drying platform dimensions, the necessary flow to the fan and the amount of conserved forage material.*

KEYWORDS: *completion hay drying, necessary of feedingstuffs, solar panel*

INTRODUCTION

Ensuring feedingstuffs necessary of good quality for feeding the animals from livestock farms during winter is a matter that concerns particularly the farmers, especially those from hilly and mountainous areas.

The most famous and used feedingstuffs harvesting and conservation technologies which satisfy nearly totally the requirements of the livestock sector are:

- *technology of and obtaining the hay harvesting;*
- *harvesting and conservation technology of feedingstuffs in the form of semi-silage;*
- *technology of harvesting and preservation in form of silage.*

Although in recent years has developed the technology of grass and maize conservation by ensilage, drying as hay remains one of the most used methods, being an excellent complement of the corn silage.

By the drying process is carried out the moisture reduction of feedingstuffs from 70 ... 80% as field green mass, up to 17 ... 18%, allowing the long term storage without mold [1, 2, 3, 5].

The hay has a significant weight in the forage balance during winter, especially in hilly and mountainous regions where there are large areas of grasslands. In the plain regions, hay is produced on agricultural lands planted with annual or perennial forage plants, the natural grasslands occupying smaller areas. The importance of hay is determined by the large share that it has in the animal feeding and of the increased content in nutrients and vitamins.

The nutrient-rich of hay depends primarily on the chemical composition and the nutritional value of green fodder from which it come, appropriate to harvest time and secondly on the conditions of harvesting, handling and storage.

To reduce drying time and implicitly of the loss of nutrients were developed several methods of harvesting, preparation and conservation of hay. The known methods for feeding stuffs drying are: traditional drying (natural) on stubble; drying on supports; drying feeding stuffs by ventilation with cold air; drying of feedingstuffs by venting with hot air; drying of green fodder by thermal dehydration in special drying and briquetting stations etc.

The biggest losses of nutrients are obtained at the traditional drying of hay on stubble. These losses reach in case of bad weather, even to 50 ... 60%, the drying time rising to over 6 ... 8 days [1].

Collection of pre-dried hay with a dry matter content of 60 ... 70% and drying it with special equipment by cold or hot air ventilation, can reduces the losses by up to 15 ... 20% [5].

In the paper will be presented the technical solutions of an installation for ventilation of hay, in which the air is heated in solar collectors.

MATERIALS AND METHODS

To meet the requirements of farmers in the conservation of fodder plants as hay were conducted researches to achieve a hay drying installation by ventilation of cold or hot air, friendly with the environment, affordable and easily adapted to the specific of farms.

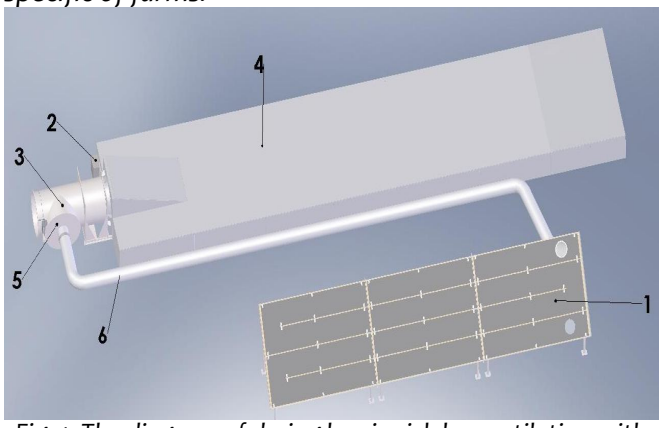

Fig. 1. The diagram of drying hay in rick by ventilation with cold or hot air, solar collectors variant, IVF - o
1. solar panel assembled, 2. electrical installation, 3.ventilation equipment, 4. drying and storage platform; 5.flange connection with the piping, 6. pipe for hot air circulation

Following this objective, it have acted to achieve of an installation (fig. 1) adaptable to the needs, with the main assemblies developed in a modular structure so that the users to configure their drying installation according to the needs of the farm and to the purchasing power.

Since the method of feedingstuffs drying by ventilation with hot air proved to be expensive in terms of energy consumption (electrical, mechanical) it have resorted to the use of non-conventional energy (solar, geothermal) for heating of air, in our case was made the installation with solar collectors assembled as a panel (Fig. 2).

The simplest construction of a solar panel consists of two end type solar modules (1), (3) and an intermediary solar collector (2) (Fig.2).

The intermediary cells were designed so that the solar panel can be constructed with „N" intermediary module, without any constructive changes, in order to increase the area exposed to the sun and of the air volume heated.

Drying of fodder plants stored on the hay drying and storage installation platform, begins at the time when the ventilation plant will be put into operation by pressing the starting button of the power panel and the air aspirated by the fan will be spread in the mass of forage layer stored on the drying platform.

The paper presents the technical methods approached for the sizing of forage drying installation by ventilation with cold or hot air, in accordance with the requirements of forages and the climate characteristics in the area of placement.

Also, the solar panel was designed in modular construction, of collectors with the dimensions that allow the transport and the safe handling and with simple means.

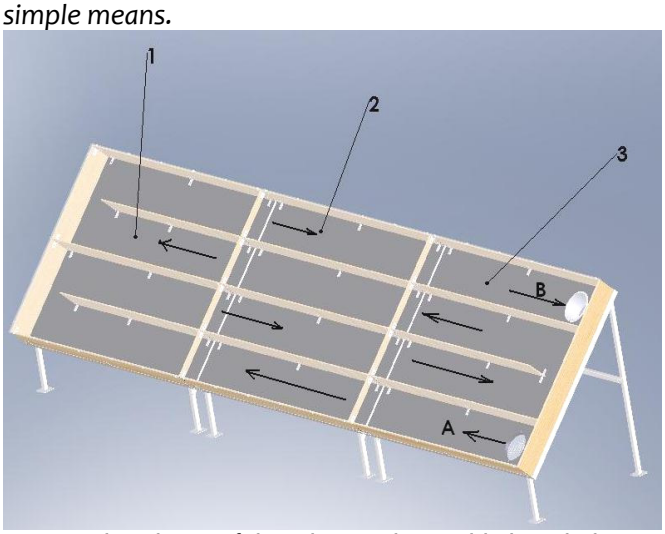

Fig.2 - The scheme of the solar panel assembled , with three solar collectors. 1. solar collector I, 2. intermediary solar collector 3. solar collector II

Each captor is built from a welded metal frame equipped with attachment points of the components. Onto the frame shall be mounted the thermal insulated panel for the cell isolation and capturing the heat, the side walls and end beams. The modules are isolated on top by a glass or plexiglass cover.

The intermediate collectors are differentiated between them by the fact that these have the windows at the connecting ends, through which the air communicate from one module to another.

The sizing of drying installations with air is made starting from the cold air flow necessary for the drying of one ton of forages, or knowing the necessary air flowrate for a base area of 1m^2.

The values recommended by [1, page 70], for the specific air flow, Qu, necessary for the ventilation of one m2 of the drying platform surface, of a layer with a height of approx. 2 m, are different, depending on zone:

- *for dry climates zons: Q_u = 200 ... 250 m^3/h on each m^2 (0,005... 0,069 m^3/s)*
- *for wetter climate zones (hilly or mountainous area): Q_u= 300 .... 450 m^3/h on each m^2 of drying surface (0,08 ... 0,125m^3/s).*

Higher air flow rates are necessary when the system has no side walls sealed and air leaks occur.

The airflow necessary for ventilation was calculated with the equation (1):

$$Q_{necesar\_ventilare} = Q_u \bullet S_p \qquad (1)$$

where: S_p – the surface of drying and storage platform;

Q_u - airflow necessary for surface of the platform of 1 m^2,

The value of the airflow necessary for ventilation calculated with formula (1) is necessary for choosing the ventilator from the installation endowment.

It is recommended according to [5, page 24] the following:

- linear velocity of airflow through a layer of withered forage to be of 0.1 m / s;

- the intensity of airflow through a layer of dry forage to be 0,1 m^3 air per m^2/s;

Tyhe analysis and establishment of the dimensional characteristics of the forage store and of the solar air heating panel will be done in conjunction with the necessary flow for ventilation, the necessary mass forage for the number of animals of the farm.

On configuring the solar panel and establishing the number of collectors it is recommended that the volume of resulted solar panel to be at least double that of the ventilator flowrate which will be chosen according to the necessary ventilation flowrate value.

RESULTS AND DISCUSSION

The project developed for the storage platform imposed the following initial data:

S_p - the drying platform surface is determined by two end modules and n intermediate modules with the following dimensions:

$$S_p = L \bullet B\ [m^2] \qquad (2)$$

L – platform length [m]

$$L = \sum_{i=1}^{n} l_i + 2l_c\ [m] \qquad (3)$$

l_i – the length of an intermediate module, [m],

l_i = 2 m

l_c – the length of the end module, [m],

l_i = 2,1 m

B – the platform width, B=3 m

V_d - the deposit volume was calculated for the hay layer height of 4 m.

M_f – the feeding stuffs weight [kg].

$$M_f = \psi \bullet V_d \ [kg] \qquad (4)$$

ψ – volumetric weight from the alfalfa hay at 17% moisture, according to [2].

Ψ = 60 kg/m^3

The interdependence between the drying platform dimensions, the necessary flowrate to the fan and the quantity of forage material conserved is presented summarized in Table 1.

Table 1 (1). Sizing of drying platform and necessary flow at the fan

Surface of drying platform	The volume of forage deposit	The necessary flowrate to the ventilator depending on the climate of the area	
S_p	Vd	$Q^{a)}_{ventilator}$	$Q^{b)}_{ventilator}$
[m^2]	[m^3]	[m^3/s]	[m^3/s]
18.6	74.4	1.16	1.94
24.6	98.4	1.54	2.56
30.6	122.4	1.91	3.19
36.6	146.4	2.29	3.81
42.6	**170.4**	**2.66**	**4.44**
48.6	194.4	3.04	5.06
54.6	218.4	3.41	5.69
60.6	242.4	3.79	6.31
66.6	266.4	4.16	6.94
72.6	290.4	4.54	7.56
78.6	314.4	4.91	8.19
84.6	338.4	5.29	8.81
90.6	362.4	5.66	9.44
96.6	386.4	6.04	10.06
102.6	410.4	6.41	10.69

Table 1 (2). Sizing of drying platform and necessary flow at the fan

Surface of drying platform	The forages weight at the humidity of 17%		The number of cows fed in the winter months
S_p	M_f		E_{vaci}
[m^2]	[kg]	[t]	[cap]
18.6	4464	4.464	3... 4
24.6	5904	5.904	4... 6
30.6	7344	7.344	5...7
36.6	8784	8.784	6... 9
42.6	**10224**	**10.224**	**7... 10**
48.6	11664	11.664	8... 12
54.6	13104	13.104	9... 13
60.6	14544	14.544	10... 15
66.6	15984	15.984	11... 16
72.6	17424	17.424	12... 17
78.6	18864	18.864	13... 19
84.6	20304	20.304	14... 20
90.6	21744	21.744	14... 22
96.6	23184	23.184	15... 23
102.6	24624	24.624	16... 25

a-The air flowrate necessary to the ventilator, calculated for dry climate zones, considering the specific air flowrate Qu=225 [m^3/h]

b-The air flowrate necessary to the ventilator, calculated for wetter climate zones, considering the specific air flowrate Qu=375 [m^3/h]

Based on these data and the categories of animals in the household, the farmer can check if the stock is enough for a period of 6 months, such as might take the winter. It is considered that a 600 kg cow consumes about 5 ... 8 tons of silage, 1 ... 1.5 tons of hay and 0.5 ... 1 tone of concentrate feed in a normal winter of around 4 ... 5 months.

Sizing of solar panel of drying installation by ventilation with hot air will be done in conjunction with the necessary flow to the fan. It is recommended that the solar panel volume to be at least double compared to the airflow required for ventilation of feeding stuffs, expressed in m^3/s.

The solar panel proposed to study will consist of N_c solar collectors made of lightweight materials, painted inside with dye or solar varnishes in black colour to have the as possible highest absorption rate for the solar radiation.

The main assemblies are shown in Figure 2, and the inside dimensions are the same for the three types of collectors.

The technical characteristics of the solar panel depending on the number of collectors are summarized in Table 2.

The construction of solar panel modules and the information from Tables 1 and 2 allow users the hay drying installation configuration after the necessary in feedingstuffs, the farm size and the financial possibilities.

Table 2 (1). The characteristics of solar panels depending on the number of collectors

The inside dimensions of the solar collectors			The number of solar collectors	The inner volume of a solar panel
h_c	L_c	l_c	Nc	Vi
[m]	[m]	[m]	[Buc.]	[m^3]
0.254	3	2.05	3	4.67
			4	6.23
			5	7.78
			6	9.34
			7	10.90
			8	12.46
			9	14.01
			10	15.57
			11	17.13
			12	18.68
			13	20.24
			14	21.80
			15	23.35
			16	24.91
			17	26.47
			18	28.02

Table 2 (2). The characteristics of solar panels depending on the number of collectors

The inside dimensions of the solar collectors			Solar Panel length	The solar panel surface
h_c	L_c	l_c	L_{pc}	S_{ps}
[m]	[m]	[m]	[m]	[m^2]
0.254	3	2.05	9	18.389
			12	24.518
			15	30.648
			18	36.777
			21	42.907
			24	49.036
			27	55.166
			30	61.295
			33	67.425
			36	73.554
			39	79.684
			42	85.813
			45	91.943
			48	98.072
			51	104.202
			54	110.331

For example, in a farm with an effective of 10 cows, to ensure of food in the winter months, according to Table 1, it is necessary a quantity of approx.10 tons of hay stored on a platform with an area of approx. 43 m2 and a height of 4 m. The constant flow ventilator from the installation endowment, will ensure a flowrate of 4,5 m^3/s in the wet climate zones.
The necessary solar panel will be made of N_c solar collectors with a volume of at least 9 m^3.

CONCLUSIONS

Following the research can formulate the following conclusions and assessments:

- *To reduce the loss of nutrients at the traditional drying on stubble of hay, it is recommended application of technology of harvesting and storing of herbaceous forage plants at the humidity of 30...35% and finalizing the drying by the air ventilation;*
- *In the case of completion of hay drying in deposits there are necessary special drying installations by ventilation with cold air or hot air, properly sized depending on the necessary in feedingstuffs of the farm;*
- *For the small farms are recommended the driers of hay by ventilation with air warmed with panels made of solar collectors, for cost reduction under the aspect of electrical or mechanical energy.*
- *The parameters analyzed in Tables 1 and 2, provide to beneficiaries the information necessary to configure a drying installation of hay, constructed of lightweight solar collectors.*

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