THEORETICAL ASPECTS OF THE AERATION DRYING PROCESS WITH APPLICATION IN THE HAY TECHNOLOGY

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ABSTRACT

In the current context of the development of mechanized agriculture in several directions in the field of feed storage needs appear in the effective implementation of the drying method used. In terms of maintaining higher production achieved by reducing losses of fodder harvesting and secondly by increasing the number of cycles of harvest due to reduced time of harvest (representing the time elapsed mowing fodder plant and to store hay), outline the need for a more careful study of the drying process. This paper presents some theoretical aspects that determine and control the drying process used in technology of hay.

INTRODUCTION

Agricultural research and agricultural practice demonstrates that application of the harvesting processes and fodder plant preparation in order to obtain hay, has it a primary role mechanized degree of execution of works and operations required.

The harvesting, preparation and conservation of fodder plants as hay, briefly technology of hay is the basic method of traditional and most common to capitalize feed on meadows and fodder crops, particularly in the areas of hilly and mountainous.

The main objective of the technology for producing hay in feed on pastures and fodder crops is to achieve a final product (hay) with nutritional value as close to the original green fodder, here is based on the premise that it meets under a high-quality fodder, both in terms of its botanical composition (balanced mix of perennial grasses with legumes) and to the time harvesting, [2].

The execution of adequate quality and high efficiency are achieved both increased production and feed a high quality hay. Superior productions is explained on one hand by reducing losses of fodder harvesting and secondly by increasing the number of cycles of harvest due to reduced time of harvest, representing the time elapsed mowing fodder plant and to store hay. Improves quality of hay produced on the one hand, by reducing the duration of the feed to maintain the ground after mowing, and on the other by works in a high quality [7].

During the technology of obtaining of hay are a series of qualitative and quantitative losses even while the green fodder is very good botanical composition and optimal mowing the era. Reducing qualitative losses in the process of harvesting, preparing and preserving fodder plants it is possible by shortening the duration elapsed since the beginning of harvest (mowing) to obtain of hay storage humidity 18%. Green fodder containing large amounts of water, generally between 70 ... 85%.

Shorten the harvest, preparation and conservation fodder as hay is possible by reducing the initial moisture as quickly as possible, from harvesting the forage, so finally it reaches the moisture retention of 18%. Achieving this objective involves actually facilitate evaporation of large amounts of water this green fodder helped by unique drying process, [7, 8].

Drying treated as an ongoing process, is the operation whereby water in solids or liquids is removed by means of air which is to bring (fully or partially) the necessary heat of vaporisation and humidity to evacuate the resultant water vapours by heating.

Natural materials and manufactured products contain the varying proportions of moisture in contact with liquid water or contact with vapours in the atmosphere and resulting from reactions. The reduction or partial or total removal of water is necessary for reasons of: processing, storage, transportation, conservation, convenient use [10], which is applicable in the case of fodder plant preservation order as hay.

The importance of using of hay in feed for ruminants is underscored by feeding normative acts providing, for example, for young bulls ensure digestible protein hay at a rate of 15..50% [2].

Preparation and conservation of hay is among the most important works to increase of livestock production creates new direction that requires meeting the following goals:

- develop technologies and processes that caters to vital whole needs of the animals with a minimum consumption of energy and materials;
- diversification respective technologies and equipment, depending on the animal husbandry;
- finding methods and optimize existing ones to be more efficient and economical for the valorization's hay.

Forage plants represent an important part of crop husbandry and reports to general principles and methods of agricultural technology. They have however biological features, ecological and techniques that distinguish them from other agricultural plants involved in human nutrition, although some of these are used as feed. Is there a direct relation agricultural plants - fodder - animal nutrition [6, 9].

MATERIAL AND METHOD

More broadly, drying is removal operation a liquid (not necessarily water) of a solid material, a suspension or a paste using a gas drying agent some (not only air or flue gas).

The material subjected to drying may present as: solution, pastes, granules, powders, sheets, boards and lumps. When the raw material contains more water, it is reasonable that the first step to remove as much water by mechanical. In the drying process, the partial pressure of water vapors in the gas phase is less than the pressure at which the operation.

The air is a gaseous mixture consisting of 78-1% nitrogen, 21% oxygen and 0.9% other gases, such as argon, carbon dioxide, etc. These are the proportions in which they are major components in a given volume of dry air instead of atmospheric air containing and water vapor, solid particles, other gases arising by accident, bacteria, [10].

Temperature, humidity and degree of harmfulness are the most important characteristics of atmospheric air thus having direct influence on the health and effectiveness of processes.

Green fodder containing a large amount of water (70...85%). Shorten the harvest to feed conservation as hay as possible by reducing the initial rapid dry feed, so ultimately it reaches below 18%. Achieving this objective involves actually facilitate evaporation of the huge amounts of water from green mass.

The objective of drying is to reduce the moisture content in the feed to the mass balance at the preservation time can be lengthy without loss [1]. Drying representing the process of removal by heating, in the form of vapors, the humidity (water or other liquid) of the material, the mechanism drying operation is a process of diffusion, passing of humidity in the material in the environment which is based on evaporation of moisture on the surface material and diffusion of moisture from interior layers to the surface of the material.

The condition of the drying operation, namely, the drying takes place only when the pressure of the vapours on the material is higher than the partial pressure of their environment. Drying is a process of mass transfer and heat simultaneously is influenced by factors related to material subjected to drying, the drying agent, and the related factors the drying operation.

Drying agents most commonly used are: air, gases, the superheated steam and mixtures thereof, and drying modes: the most common are natural drying, performed outdoors and artificial drying, performed with a heated drying agent.

Water retained in products humid it is present in various forms (osmotic, capillary and adsorbed) and during drying as it evaporates water phenomenon that starts from the product surface creating a gradient of humidity, directed from the centre to the outside which produces water transport by mass. On the contrary there is a temperature gradient that produces heat transmission to the interior. Depending on the energy that is retained in the drying process the water can move in the form of liquid or vapour. Under the influence of osmotic water diffuses humidity gradient, the liquid from the interior to the surface because of the difference in concentration. At the beginning of the drying liquid in the capillary is in a state of saturation and capillary pressure is minimal. The drying part of the water evaporated from the surface and the capillaries are filled only partly, in the central part to form the isolated voids containing air saturated with vapour.

In this situation water is located around the contact points of the granules and form a continuous network which is called bound water captive air or water film. In this case, the capillary pressure is greater than water saturation. By penetration air, water capillary system redistributes the material. The moisture content less water around the contact points of the granules is less and there is no more continuous network. Water distribution in this state is called abstracted water and has maximum capillary pressure.

The fraction of water that moves in vapour form is divided into two parts. The first part is evaporated in the atmosphere of lowering the humidity of the material. The second part of the capillaries evaporates and condense large diameter in the smaller diameter. In this way creates a stream of vapours diffusion gradient of humidity in reverse. Migrates adsorbed water vapour diffusion form due to the concentration gradient. However, it should be noted that the prevailing drying process of moving under the influence of the moisture gradient which is advantageous from a technical point of view, [3].

Given all those mentioned so far can be considered fodder layer subjected to drying by aeration as has the quality, composition and structure similar to porous materials. Thus continuing the study of the drying methods may be used, setting parameters and determinants in the process.

Movement of water in the porous materials is naturally limited by the size and form of the pores, which in its turn is governed by the physical properties of the mass. If the evaporation rate from the surface exceeds that diffusion from the inside will be free from damage, cracking of the surface [3]. It is clear that the rate of diffusion is critical, and must be closely controlled to achieve results.

The diffusion rate of water is a function of temperature and mass diffusion characteristic. Drying depends on maintaining a certain rate of evaporation from the surface equal to the diffusion. Essentially, three factors determine the success of drying: *air circulation*, *temperature control*, *humidity control*.

RESULTS AND DISCUSSIONS

A humid material containing an amount of bound water in different ways and it is considered dry when it is in balance with the environment or atmosphere or plant dryer for drying.

Final humidity may be zero, that is, the material is taken to dryness, if the environment of the dryer / plant have *a relative humidity φ* and the material contains an amount of residual water (moisture balance). The term "dry material" is relative and if a hygroscopic substance, artificially dried to a final moisture content very low, it is not protected during storage of its counter water absorption of ambient humidity to increase relative to that of the atmosphere.

Like all hygroscopic materials and for fodder plants, contained in fodder, there is a strong correlation between moisture content and humidity of the environment. The hygroscopicity of the air is inversely proportional to its relative humidity and temperature is directly proportional to [5].

The drying conditions imposed on the relative humidity and temperatures during drying are critical for the transfer of water to the plants. Plant cell gives the more water the stronger is the slope of evaporation of water inside plant and outside air saturated with unsaturated water. If there is this slope, then there is a of equilibrium state with no drying action, which is reflected by a hygroscopic equilibrium (Figure 1).

Following the example of Figure 1, the grass hay must, at a temperature of 30 ° C air to lower the relative humidity of at least 67%, in order to make it possible to obtain 20% moisture. So it may happen that almost dry hays to absorb water from atmospheric air again, if its relative humidity is too high.

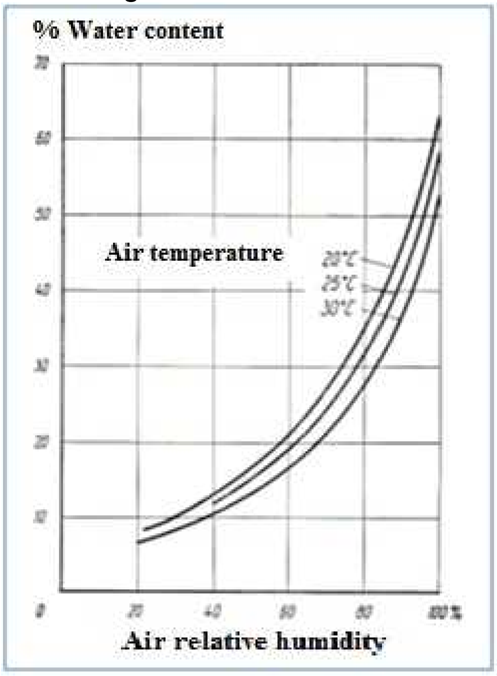

Fig. 1. Absorption equilibrium grass meadow
Temperature of 20 ... 30 ° C, *[5]*

The relative humidity of the air, also called the degree of saturation is the water which it contains air as compared to that which would have an air temperature prevailing in the saturation state, then to 100% relative humidity. A powerful action of the extraction of moisture is, in particular, at low air saturation, so at low relative humidity and high air temperature

In the following to a careful and thorough study as the drying process will make use of theories (literature) that underlying namely, static and kinetics of the drying.

Static drying relates the initial and final parameters of substances (materials) involved in drying. This is determined through mass balance equations and heat balance, Figure 2. Static drying allows determination: material composition, consumption of desiccant and heat consumption, [10].

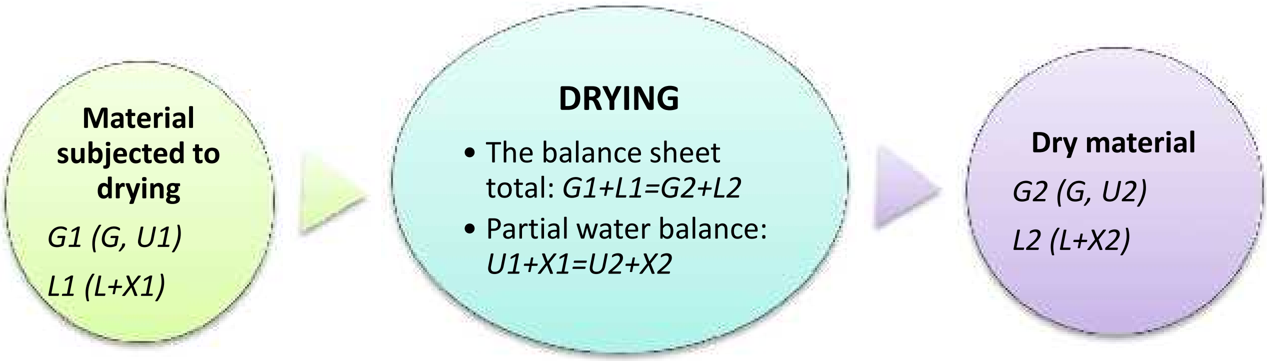

Fig. 2. The material balance in the drying process, *data source [12]*

Where:

G1 - humid material debit, kg/h
G2 - dried material debit, kg/h
L1 - debit of the input air, kg/h
L2 - airflow rate output, kg/h
U1 - flow of humidity material input, kg/h
U2 - debit of material humidity output, kg/h
X1 - debitul de umiditate din aer la intrare, kg/h
X2 - flow of moisture from the air input, kg/h
G - anhydrous material flow, kg/h
L - dry air debit of the necessary drying operation, kg/h

We note*: U = U1-U2*, debit or the amount of moisture, kg/h

$$U = X2 - X1 = L\ (X1 - X2) \tag{1}$$

X1, X2 - is the moisture content at the dryer input and output, kg/h.

Flow dry material (G2, kg/h):

$$G2 = \frac{G1(100 - U1)}{(100 - U2)} \tag{2}$$

Balance partial anhydrous material:

$$G = \frac{G1(100 - U1)}{100} = \frac{G2(100 - U2)}{100} \tag{3}$$

The amount of water removed (u, kg/h):

$$U = \frac{G1(U1 - U2)}{100 - U2} = \frac{G2(U1 - U2)}{100 - U1} \tag{4}$$

Dry air flow necessary drying operation (l, kg/h):

$$L = \frac{U}{X2 - X1} \tag{5}$$

The kinetics of drying relating the variations in time of the material moisture and parameters process, [10], which are as follows:

- Properties and material structure;
- Material dimensions;
- Enveloping hydrodynamic conditions of the material by the drying agent.

Kinetic equations allow drying time calculation and determination of drying regime.

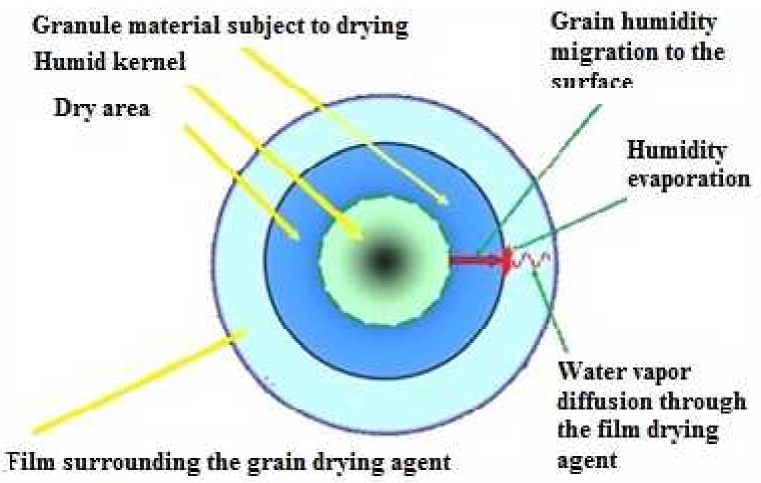

Fig. 3. Drying mechanism, *[10]*

Drying mechanism, Fig. 3 is based on two distinct processes all deriving simultaneously, namely:

- *Water transfer through the material, complicated process of internal diffusion;*
- *Vaporization using outdoor air, external diffusion*.

The transport of water (moisture) through which the dried resulting after several mechanisms, depending on how it is connected to the water and because of that causes the carriage. Existing water originally came from the interior surface of the material or in ambient air passes through the speakers. Water transport can occur through: capillary diffusion in the liquid and vapour diffusion.

The drying speed is the speed of the slowest process of the two processes simultaneously. The amount of moisture (*dW*) removed per unit area of the material (*A*) subjected to drying, per unit of time (*dt*) is the rate of drying (*w*).

$$w = \frac{dW}{A \cdot dt} \quad (6)$$

Theoretically derived equations for drying speed are complicated and difficult to implement, so it resort to experimental data at laboratory scale at industrial scale transposed.

The drying curve is the graphic representation of variation in time of material moisture, the most important factors influencing the speed of drying, [11]:

• Nature of the material subjected to drying, expressed through composition, structure and moisture binding;

• The shape and dimensions of the material to be dried;

• Initial moisture and final moisture content of the material to be performed;

• Characteristics of the drying agent;

• Particularities drying system.

The variation of the drying rate during drying curve is shown for instance in the drying of a porous material capillary Figure 4.

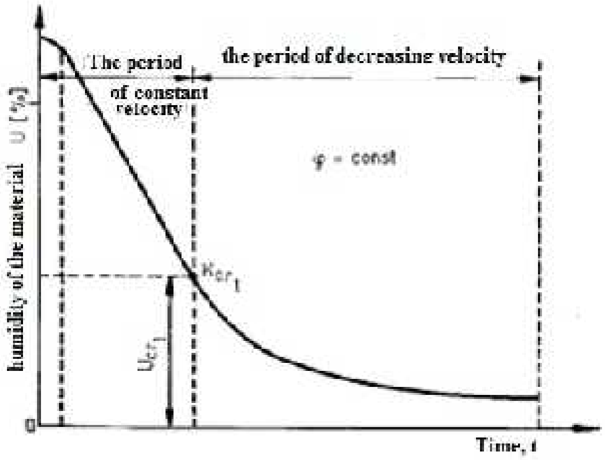

***Fig. 4. Drying curve of a porous capillary material**, [13]*

In a first step the variation of humidity time is linear, the drying rate is constant, and the second stage is outlined by a curve decreasing continuously until cancelled. Switching from one period to another corresponds to the characteristic material moisture - first critical curve speed drying, k_{cr}. The second point of inflection occurs in some cases during the descending speed when its variation occurs after different laws for different materials, [11].

The duration of drying and sizing the plant dryers for drying requires the knowledge of the drying rate and drying time. When it is known the drying speed, drying time was determined by integration of equation 7:

$$t = \int \frac{dW}{A \cdot w} \tag{7}$$

In environment, a wet surface has high moisture content, so it is in dynamic equilibrium with its own vapour; above this area there is a vapour pressure substantially equal to the ambient pressure that depends only on the temperature which is the saturation voltage. If considered forces are balanced by the surface tension is achieved steady-state, in order to eliminate moisture of the material is necessary to destroy this balance of appropriate means.

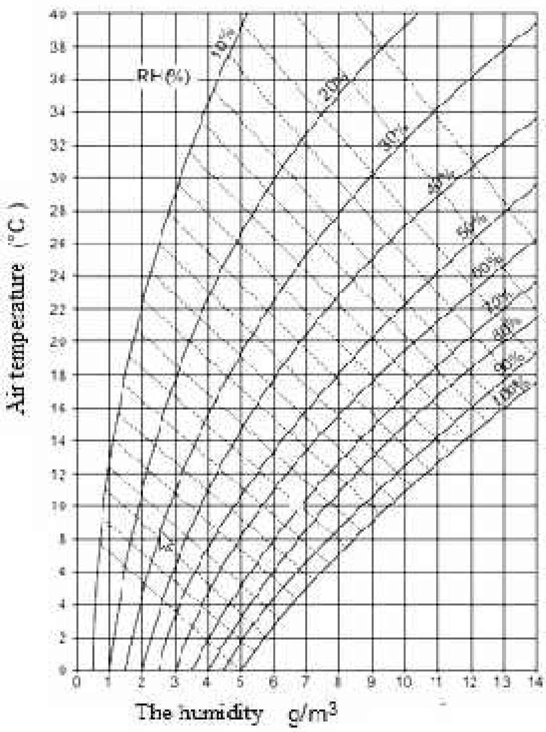

***Fig. 5. The amount of water per 1 m³ of air**, [4]*

All the drying methods based on the removal of excess moisture by means of air. In the specific atmospheric conditions (moisture and temperature) the moisture content of the product decreases to the balance point. This is the point at which moisture can be reduced by drying, so that the feed to achieve optimum storage capacity, the drying process are shown in Figure 5.

CONCLUSIONS

Green forage feed contains a large amount of water, generally between 70% ... 85% to preserve it as hay for the winter it should be subjected to the drying process, so that's humidity is reduced below 18% therefore storage will be achieved under optimal conditions.

During the technology of obtaining hay are a series of qualitative and quantitative losses even while the green fodder is very good botanical composition and optimal mowing era. Reduce loss of quality in the process of collecting, preparing and preserving forage it is possible by shortening elapsed since the beginning of harvest (mowing) to obtain hay moisture retention, 18% in the drying process benefits.

The water content / retained products moist, namely fodder, is in various ways, and during drying as it evaporates the water and how the movement of water, a phenomenon that begins at the product surface creating a gradient of humidity, oriented from inside to outside to produce mass transport of water through and in the opposite direction there is a temperature gradient that causes the transmission of heat to the interior.

In determinant way appear three factors that determine the drying success: air circulation, temperature control, humidity control.

So conclusions that can be drawn to study carrying out the drying effect in the feed preservation technology we can use theories of drying, static drying, drying kinetics. Following are determined relations between initial and final parameters of the materials involved in drying and kinetic equations allow the calculation determining the estimate of drying time and drying regime.

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