[1.]Iulia GĂGEANU, [1.]Petru CÂRDEI, [2.]Gheorghe VOICU

EXPERIMENTAL RESEARCHES ON THE EVOLUTION OF THE LENGTH OF FIR TREE SAWDUST PELLETS

[1.]National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, ROMANIA
[2.]University Politehnica of Bucharest, ROMANIA

Abstract: The paper presents the results obtained from the experimental researches conducted for tracking and monitoring the evolution of the length of fir tree pellets obtained using an experimental single pellet installation. The changes in pellet length represents an important quality parameter for biomass pellets used as biofuels. The evolution of pellet length was monitored for a period of 91 days and the results showed a strong connection between the changes in length or disintegration (rupture) of pellets and some of the input parameters characteristic for the raw material used. The results obtained in this paper offer an understanding on the factors affecting pellet quality and their durability in time.
Keywords: biomass sawdust, compression, pellet length

INTRODUCTION

The evaluation of the performances of the products obtained in a technological process represents an important stage for the appreciation of the applied technology and at the same time, for its improvement or even optimization. In general, in this stage we analyze the quality (output) parameters of the system that models the technological process, depending on the input and command parameters of the same system, (Cardei et al., 2019). The analysis is performed on the experimental data obtained in observations for pellets obtained for each combination of input and control parameters used in the 243 experiments conducted for each of the dies used (straight circular cylindrical dies), 8 and 10 mm diameter die (Gageanu et al., 2019). The observation in time was limited to the measurement of the length of the pellets.

According to the systemic model of the technological process of obtaining pellets from fir tree sawdust, the quality assessment of pellets could be made by following the evolution of four quality parameters in time: the length, the density, the moisture and the volume of the pellets. The fifth parameter of output and quality, the energy consumed per unit mass of the pellets, is a parameter of mechanical and economic character, which is considered in separate optimization calculations. Out of these qualitative parameters, we focused on tracking the behavior of pellet length over time. The density of pellets was examined as a qualitative parameter at when exiting from the working process, as well as moisture and the other qualitative parameters.

Obviously, there are other interesting features from a qualitative point of view: the variation in time and especially with the storage conditions, the calorific power, the external and internal appearance regarding cracks or breakages, etc.

The globalized importance of biofuels has led to the emergence of a huge volume of specialized literature dedicated to their manufacture, conservation and exploitation, (Marian G., 2016; Berkesy et al., 2012). In addition to a specific vocabulary, there has also been dense legislation in the field of biofuel manufacture and exploitation, (Marian G., 2016).

An analysis of quality parameters for pellets used as biofuels is given, for example, in (Berkesy et al., 2012). The quality indicators considered were taken from the standard EN ISO 17225–2. The pellets studied in this article belong to class A1, according to ISO 17225–2, table 1. In (Berkesy et al., 2012), a series of standards were used to analyze the quality parameters: moisture, bulk density, ash, caloric power. The use of European standards on a large scale in the quantitative evaluation of pellets for biofuels are also illustrated in (Marian et al., 2011), where specific quality requirements for pellets from different categories are listed and the authors examine a wide range of pellets with different compositions (energy willow, acacia, straw and mixtures).

A similar approach to the quality problem of biofuels from different biomass sources is presented in (Gaber et al., 2014), where quality assurance systems and quality control measures for these product categories are presented. The role of quality control of raw materials is emphasized in order to obtain superior qualities for the final products. It also addresses a large category of wood chips: fir, beech, birch, etc. The authors give a precise and very dense terminology, whose respect is necessary for facilitating the dialogue between specialists in the current era.

(Smaga et al.) also deal with the description of the qualitative parameters of some biofuels, taking into account in particular the caloric power, the humidity and the sulfur content, as well as the amount of ash resulting by combustion. Values of these parameters are given for mowed grass, weeds, walnuts, pistachios, miscanthus, Jerusalem artichokes, sawdust, etc.

The relation between the quality of the raw material and the quality of the finished product of biofuels is also addressed by (Gillespie et al., 2013), in the sense of prediction, which we also try to achieve in our researches dedicated to fir wood pellets. Specifications and references to specialized literature on pellet characterization, from the physical point of view (including mechanical qualities) and chemically, but also thermally, are also conducted by (Hernandez et al., 2017). Calculation formulas for some mechanical properties, for the gross calorific value, etc. as well as the statistical qualitative characterization of some batches of pellets, are presented in (Artemio et al, 2018). Besides the technical aspect of pellets manufacturing and their use, the economic aspect is a very important one, a reference work through the concrete data being represented by (Purohit & Chaturvedi, 2016). The profitability of acquiring raw materials, but also the optimum time of storage for sale (therefore having a controlled production), are very important aspects for the production of biofuels from vegetable waste.

A large technical–economic stdy of wood pellet production technologies was conducted by (Sjoding et al., 2013). In addition, because, in fact, time does not destroy the stored pellets, but the storage and handling conditions (temperature, moisture, pressure, mechanical shocks, etc.), there are works that are especially concerned with the storage phase of the pellet life (Stelte W., 2013).

Directly interested in the production of wood biomass pellets, the producers have a wide range of indications for the production process. These indications, in general, are normal to be compared with the conclusions of experimental results. An interesting source in this regard is (http://www.lidapelletmill.com/newsshow–Factors–that–affect–the–pellet–quality–219–93–1.html).

MATERIALS AND METHODS

In order to determine the long–term durability of pellets obtained from the experiments conducted, each pellet sample was allowed to cool and was then individually introduced in a closed bag, the sample number and the values of the control and control parameters being noted. The bags were stored in a single layer in boxes, at a temperature of 20–25 °C, an air moisture of max 75%, and a pressure between 86–106 kPa.

Samples were measured using electronic callipers with a measuring range between 0–100 mm, 0.01 mm resolutions, 0.03 precision, action roller and depth rod.

Figure 1 – Detail during measurements

The measurements were performed over a period of 91 days, performing a measurement every 7 days, thus resulting in a total of 14 measurements for each pellet sample. For the pellets that have broken during the 91 days of performing measurents, the value 0 was recorded begging with the moment of breakage.

Figure 2 – Examples of broken pellets (in the first day – up, and in the day they broke – down)

RESULTS

— Pellet length variation in time

The variation of the length of the pellets in time, from exiting the formation process (the initial zero time), to the last day of tracking their evolution, is an important parameter to give a global picture of the tendencies of stabilization of the pellets. In figure 3 are presented the evolution time curves for five of the two hundred and forty–three curves in the database.

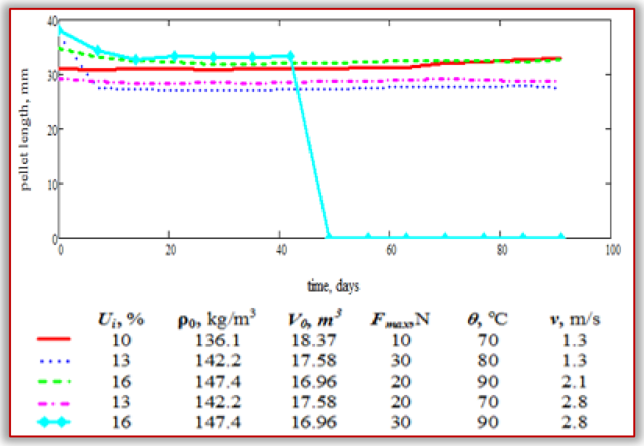

Figure 3 – Variation in time of the length of some pellets whose production data are provided in the caption

It is observed that most curves show a decrease in length (a longitudinal contraction) in the first 10 days, after which some have a weak tendency to decrease or increase towards the end of the tracking period. The curves remain bordered in the range of 25 – 40 mm.

Figure 3 shows a single exception from this behavior, the curve that according to the graph reaches zero length, in the formal sense established by the experimenter for the pellets that disintegrate during the tracking period. As a result, some of the pellets lose their consistency and become unusable.

— **Observation on pellets that disintegrate completely during the tracking period**

In this paragraph, we will try to characterize the causes that lead to the failure of pellets in the post–formation stage that is, after leaving the compression process. Specifically, we try to find the main possible causes for the failure of the pellets (disintegration or irreversible deformations that make the pellets unusable for the proposed purpose).

By applying a simple algorithm for counting the failures, in the batch of pellets from the experiments conducted using the 10 mm diameter die, we found 25 pellets that became unusable during the 91 days during which their behavior was tracked. Comparing to the number of 243 pellets, a failure rate of 10.288% results.

This percentage can be used to estimate the durability of the batch of manufactured pellets (without considering the durability determination in accordance with European norms, leading to an estimated durability value of 89.72%. In general, the durability values for marketable batches of pellets are higher than 96.5%. Considering the experimental production mode and the non–standardized estimation method for durability, we consider that a satisfactory approximation has been made.

Table 1. Repartition of broken pellets in the 91 days after production, on the cases used for obtaining them (according to the input and command parameters used)

Initial moisture, %	10	13	16
Number of broken pellets	1	0	24
Raw material density, kg/m³	136.1	142.2	147.4
Number of broken pellets	1	0	24
Initial raw material volume, cm³	16.9	17.58	18.37
Number of broken pellets	24	0	1
Maximum compression force, kN	10	20	30
Number of broken pellets	10	8	7
Temperature, °C	70	80	90
Number of broken pellets	5	9	11
Pelleting speed, mm/s	1.3	2.1	2.8
Number of broken pellets	6	3	16

The analysis of table 1 shows that the moisture of the raw material, its density and volume produce the phenomenon of disintegration of pellets in time. The maximum moisture and density and the minimum volume of raw materials are the most likely causes of pellet disintegration because 24 of the 25 cases of disintegrated pellets were formed under these conditions. The maximum pressing force, the piston advancement speed (pelleting speed) and the die temperature do not seem to greatly influence the behaviour of pellets after they are obtained.

A graphical representation of the occurrence of pellet failures depending on raw material moisture and relative density is given in Figure 4.

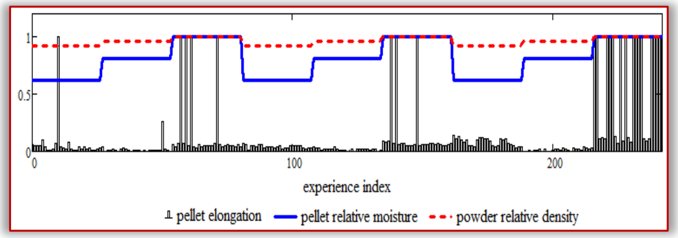

Figure 4 – Elongation variation of pellets obtained depending on raw material moisture and relative density for the 243 experiments conducted

CONCLUSIONS

Tracking the evolution of the physical characteristics of pellets over time is a mandatory test for estimating their quality. These tests have been standardized for several years and include the characterization of mechanical properties, caloric power, moisture, etc.

The study whose results are presented in this paper only deals with the evolution in time of one of the dimensions that define the geometry of the pellets obtained from fir tree sawdust.

An important conclusion is that the high moisture of the raw material leads to a high moisture of the pellets, which causes most of the pellets to disintegrate. In the same situation is the density of the raw material. Its growth leads to pellets with higher density, but which can disintegrate more easily.

Another important conclusion is that not the direct time is the one leading to pellet depreciation after production, but the evolution in time of physical storage and transport parameters.

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