FACTA UNIVERSITATIS
Series: **Working and Living Environmental Protection** Vol. 6, N° 1, 2009, pp. 39 - 47

A STUDY OF IMPACT TECHNOLOGICAL PARAMETRES ON THE BRIQUETTING PROCESS

UDC 006.82:662.8.055

Peter Križan[1], Ľubomír Šooš[1], Đorđe Vukelić[2]

[1]Slovak University of Technology, Faculty of Mechanical Engineering, Institute of Manufacturing Systems, Environmental Technology and Quality Management, Námestie Slobody 17, 81231 Bratislava, Slovakia
[2]University of Novi Sad, Faculty of Technical Sciences, Laboratory for meterology, quality, fixtures and ecological engineering aspects, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia
E-mail: peter.krizan@stuba.sk, lubomir.soos@stuba.sk, vukelic@uns.ns.ac.rs

Abstract. *In modern briquette production it is very important to know the impacts of all the factors which have an influence on the final briquette quality. Briquette quality is evaluated mainly by briquette density. Briquette density is very important from the viewpoint of manipulation, burning speed, briquette stability, etc. During our research, theoretical analyses of parameters which have an impact on briquette quality, were conducted. After the completed analyses, an experiment was done to explore the behaviour of important factors. In this paper the results of the analyses and a segment of the experiment results are presented.*

Key Words: *compacting process, briquette density, technological parameters, compacting pressure, pressing temperature, material humidity, fraction largeness*

1. INTRODUCTION

After the analyses of the briquetting process, it was concluded that attention has to be focused on the impact of technological parametres (compacting pressure, pressing temperature, fraction largeness, material humidity, etc.) and constructional parameters (length of the pressing chamber, conicalness of the pressing chamber, impact of the friction coefficient, impact of the cooling chamber, final shape of the pressing chamber, etc.). Also, both of factor groups have a great impact on the final briquette density. The goal of this analysis is to obtain more knowledge about the impacts of all the parameters. The interaction and relations between particular parameters has to be known, and that should be the base for the optimisation of briquetting process.

Received February 12, 2009

2. BRIQUETTE QUALITY REQUESTS

Briquettes must be consistent or otherwise cracks, scratches could appear, and fine elements would separate, which is not acceptable. Briquettes with higher density have a longer burning time. The standard Ő-Norm M 7135 defines the briquette density value for the HP group (wood briquettes) and for the RP group (crust briquettes) at more than 1,12 kg/dm3 (g/cm3), and for other briquettes this value must be more than 1 kg/dm3 (g/cm3). The standard DIN 51731 defines the interval of briquette density values from 1 to 1, 4 kg/dm3 (g/cm3) [1, 3].

The standard DIN 52182 (additional standard DIN 51731) also describes the testing method for briquette density. A piece of briquette has to be weighed and its diameter and length measured. Briquette density has to be evaluated before and after stabilization of these values according to the following ratio (1).

$$\rho_N = \frac{m_N}{V_N} \text{ [kg/dm}^3\text{]} \quad (1)$$

where:

- V_N – briquette volume [dm^3]
- m_N – briquette weight [kg]

Briquette strength is maximal pressure on the die, which is developed by a pressure test under predetermined conditions. In order to examine the strength in pressure for cylindrical briquettes, there are two suitable ground tests - test by cleft (pressure affecting a briquette which is in a horizontal position) and a strength test with simple pressure (pressure affecting a briquette which is in a vertical position) [1, 5].

It is also possible to evaluate briquette quality by means of briquette hardness. Stronger briquettes have essentially better quality. Briquette hardness and thereby briquette quality can be checked very easily by inserting the briquette into water. A quality briquette should fall to the bottom in a moment because it has a higher specific density than water. After that, when the briquette is dipped into the water, if it falls to pieces in under 5 minutes, and that usually represents very low briquette quality. When the briquette falls to pieces in under 15 minutes, it shows medium briquette quality and in under 20 minutes, it is sign of good briquette quality. However, this method is only of an informative character [1, 2].

3. TECHNOLOGICAL PARAMETERS OF THE BRIQUETTING PROCESS

3.1. Material humidity

If the production of briquettes with standard defined quality is required, it is necessary to know the impact of the material humidity on the quality. For a growing tree water has a very positive effect, because it is a necessary prerequisite for every vegetal organism to exist. For a cut tree, water is unacceptable. Here are some experiences related to the behavior of material humidity during the briquetting process. Material humidity depends on the type of material. Every material has its own specific nature. However, it is difficult to determine the optimal value of humidity for briquetting. After analysis, the optimal value of material humidity for briquetting is from 10 % to 18 %, which can be calculated according to type of material. If the humidity of the pressing material is very low or very high (beyond the 10-18% interval) material elements are not consistent and a briquette falls to pieces. Material humidity has an impact on lignin plastification. The lignin softening temperature depends on the type of material and lignin isolation method. The relations between material humidity, compacting pressure and pressing temperature are very interesting. Pressing the material where temperature, pressure and material humidity values are not in optimal interval results in a briquette that is not compact and which can fall to pieces. It is possible to combine temperature effects on lignin plastification with pressure briquetting. Nevertheless, when the material humidity is very high it causes the excess water to turn into steam that tears a briquette to pieces. When the material humidity is very low (lower than 10%), for a quality briquette very high pressure is required and it is very expensive and uneconomic. Finding the optimal value of material humidity will be one part of this experiment [1, 2, 5].

3.2. Compacting pressure

This factor is the most important factor with the main influence on briquette strength. Briquette strength is higher when there is higher pressure. Briquette strength increases to the strength limit of the compacting material. Briquette strength has an impact on briquette durability because when the strength increases, the absorption of atmospheric humidity decreases. Compacting pressure, seen from the viewpoint of complex analysis or research, is a very interesting and very complicated parameter. Various parameters have an impact on compacting pressure e.g. type of pressing material, temperature in the pressing chamber, pressing material temperature and of course also the length, diameter and shape of the pressing chamber and the manner of briquetting. The manner of briquetting has an impact on layer distribution in briquettes and so on briquette strength. When warmed material is pressed, the briquettes have a better density and better quality at lower pressure. Material warming during the briquetting process reduces the needed pressure for briquetting of briquettes for the required quality. The briquettes then have consistent shape and volume without cracks and scratches [1, 2].

3.3. Pressing temperature

Pressing temperature has an expressive impact on briquette quality and strength. This parameter determines the segregation of lignin from the cellular structure of the wood. Lignin is very important in the briquetting process because its function in material pressing is to join the fibers. In addition, lignin acts as a stabilization factor for the cellulose molecules in the cell wall. The more lignin is included in the material the more the material can release it and then the briquette quality is higher because lignin causes higher material strength. Lignin is released only at specific pressing temperatures that have to be provided during the briquetting process. The optimal value for pressing temperature for lignin plastification is approximately 120ºC, but optimal temperature depends on the type of pressing material. It is not important to increase the pressing temperature. When the temperature is out of optimal value range the briquette is unstable, it has low strength that causes faster decay in burning, and the briquette burns for a shorter time. Lower temperatures do not lead to high quality briquettes. Higher temperatures cause the occurrence of highly volatile elements or pressing material to burn. With an increase in the pressing temperature by constant compacting pressure, briquette strength is also increased, but only to a specific value [1, 2].

3.4. Fraction largeness

Fraction largeness has a very high impact on the briquetting process. The bigger the fraction is, the more power is needed for briquetting. A briquette has lower homogeneity and stability. An increase in fraction size results in the decrease of binding forces which lead to faster decay in burning (the briquette burns faster and that is not an advantage). Increase of the fraction size results in the increase of needed compacting pressure and a decrease of briquette quality. After analysis, it was concluded that by decreasing the fraction size we provide the required briquette stability [1, 2].

3.5. Type of material

One of the basic factors is the type of briquetting material. It is the most influential factor because during the briquetting process there are many types of factors which have an impact on briquette quality (temperature, pressure, humidity, size, and the like). However, these factors are changing with the change of material type. When wood sawdust is processed there are different values of factors (temperature, pressure, humidity, size) when compared to straw, grass, rattan or wood crust. Every type of material has its own specific nature such as heat value, ash content, humidity, chemical and trace element content. With a higher specific gravity of the incoming material, better compression of the final briquette can be obtained [1, 6].

4. Experiment and Results

An experiment was carried out on the experimental pressing stand designed at the Faculty of Mechanical Engineering in Bratislava. On this stand, it is possible to measure the impact of all the named parameters.

The experiment was carried out in laboratory conditions at room temperatures of around 23°C. At the beginning, parameters were chosen for finding the significance of the impact of compacting pressure and pressing temperature. The chosen parameters were the following: the type of material was pine, fraction size 2 mm and fraction humidity 10%. For one value inserted into the graph made 10 briquettes were always made, which were measured and weighted. After 24 hours, the stabilization weighing and measuring was repeated. Every following dependency was executed in the same way and the tendency was to retain equal compacting conditions during the full experiment. Figure 3 presents the dependence of briquette density on compacting pressure at various temperatures. The pressing was done for 3 reference values of pressing temperature: 25ºC, 85ºC and 115ºC. In addition, the pressing was done for other values of the pressing temperature but in this paper, only partial results presented are presented [2].

Dependence shows a clear impact of pressing temperature. The increase of pressing temperature decreases compacting pressure, which is necessary for squeezing out briquettes of standard declared quality. This fact is very important for engineers because of the design of compacting machine construction: it is easier and cheaper to provide higher compacting temperature than compacting pressure [2].

Fig. 1 Experimental pressing stand with heating equipment

Fig. 2 Briquette production – final phase of the compacting process

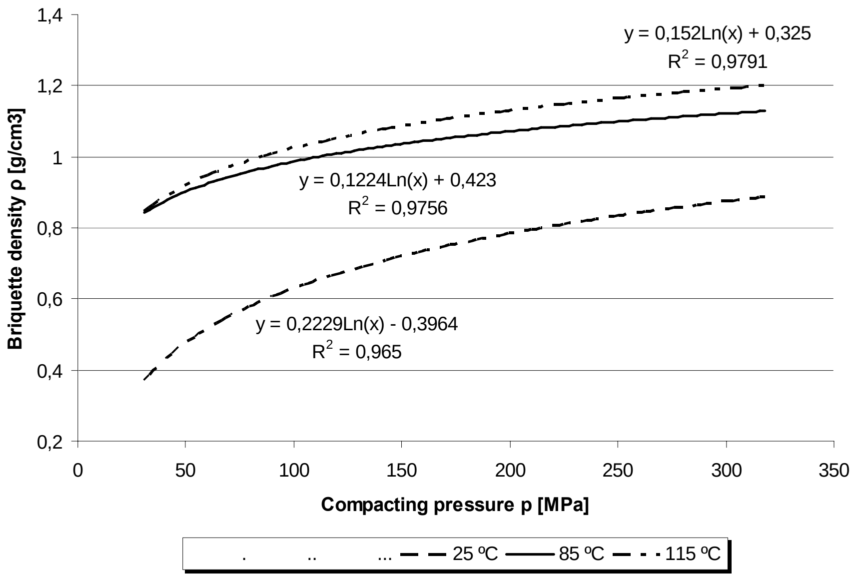

Fig. 3 Dependence of the briquette density on compacting pressure at various pressing temperatures

The dependence in Figure 3 was created from briquettes after stabilization. As it has already been stated, after the briquettes were squeezed out, they were in stabilization for a certain period of time. During this time the briquette is still working, its size and parameters are changing. This change is influenced by escaping humidity and material elasticity, i.e. dilatation. Stabilization time, according to the DIN 52182 standard, takes about 24 hours in determined climate conditions and the briquette weight changes mostly by 0,1 %. Briquette quality is evaluated, in this case, by briquette density after stabilization, therefore this period is also considered in this experiment. Following this, the briquette is compact [2].

Compacting pressure goes side by side with pressing temperature in the briquetting process. When the compacting pressure increases, the pressing temperature can decreases and vice versa.

Compacting pressure is a factor which influences mainly on briquette strength. Figure 4 shows briquettes from same type of material with the same fraction size, material humidity and same pressing temperature. However, the compacting pressure was different in every case. At lower pressures, the briquettes fell to pieces. At higher pressures, the briquettes are consistent and compact. It is not necessary to discuss the differences between briquettes density. This is clear from Figure 4.

31 MPa 63 MPa 159 MPa 191 MPa 254 MPa

Fig. 4 Impact of resizing of applied compacting pressure

Figure 5 shows the dependence of the compacting pressure on the pressing temperature. This dependence was created from the previous results. Compacting pressure and pressing temperature were used for the processing of briquettes with a density of 1 g/cm3. This dependence proves the mutual interaction of temperature and pressure. This dependence indicates the value of compacting pressure and the value of the pressing temperature needed for the compacting of briquettes with a density of 1 g/cm3 for pine sawdust with a fraction size of 2 mm and with material humidity of 10 %. With an increase in pressing temperature, a decrease is needed in compacting pressure and vice versa.

The impact of fraction humidity was measured also. Some problems occurred with humidity because material humidity changed very quickly. The fact that the material was dried in a laboratory dryer in one room and the briquetting was performed in another, much cooler room - caused problems. Nevertheless, some results were obtained. It has to be pointed out that this experiment was carried out in laboratory conditions. This allowed us to obtain values for briquette density compacted from material with a higher humidity (25% and 30%). The graph shows that the optimal range of material humidity values lies in the range from 10% - 20%. These values are found in various studies as suitable values of material humidity for briquetting of wood biomass. Figure 6 shows the dependence of the briquette density on briquette humidity. In the presented interval of humidity, the obtained values are shown with standard listed density, including the state before and after stabilization. Nevertheless, it is necessary to say that the humidity of 1 g/cm3 is at the lower limit of the listed interval and it would be good to obtain higher density values. Briquettes with a humidity value lower than 10 % and higher than 20% are not suitable. Weaves in cellular structures do not exist because of higher humidity and thereby higher water content, or vice-versa.

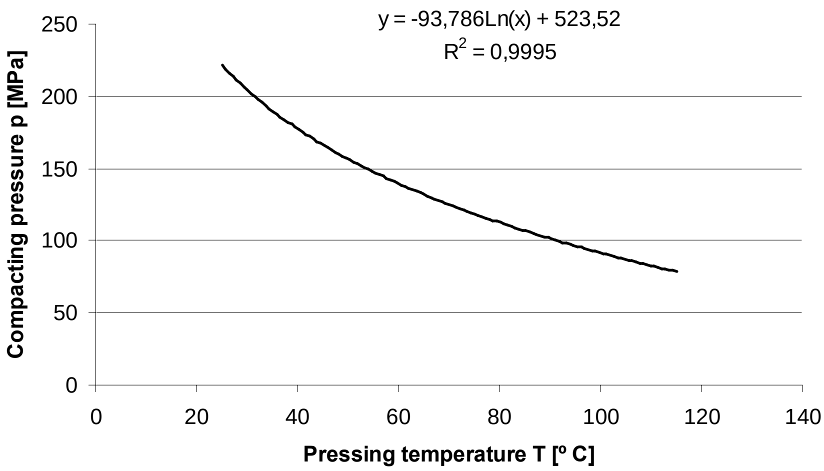

Fig. 5 Dependence of the compacting pressure on the pressing temperature

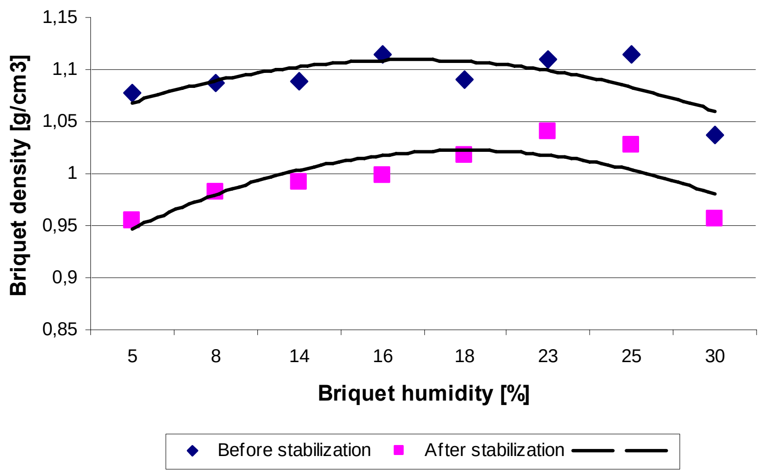

Fig. 6 Dependence of the briquette density on briquette humidity

Figure 7 presents the dependence of briquette density on fraction size. There were 5 various fractions and from each of the fractions 10 briquettes were made. The values were inserted into the graph before and after stabilization. Once again it was confirmed that it is necessary to let the briquette stabilize because of dilatation. Before the stabilization, the standard listed density of the briquettes was achieved, but after stabilization it was not achieved. This dependence shows that the optimal fraction size is 2 mm. However, in practice, it has been our experience that when the fraction is smaller - the briquettes have higher density. It can be assumed that with lower fraction size plastification will be more continuous than with higher fraction size.

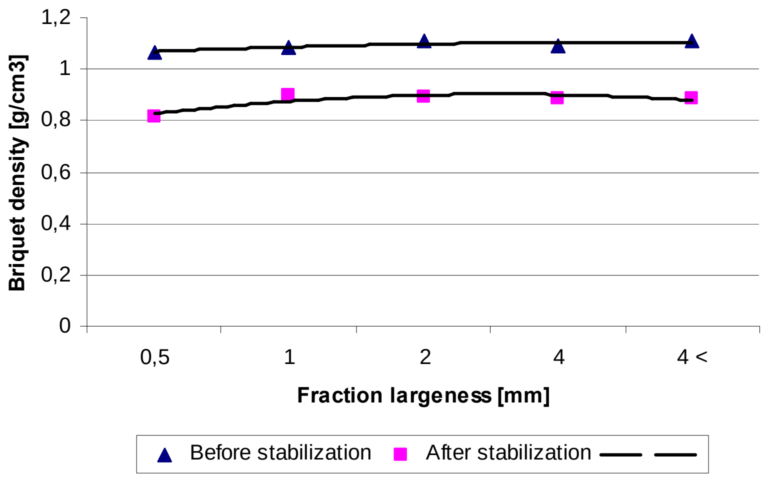

Fig. 7 Dependence of the briquette density on fraction size

Figure 8 presents the samples of briquettes from different fraction sizes. Figure 8 shows that briquettes have different densities.

fraction largeness >4 mm	fraction largeness 4 mm	fraction largeness 2 mm	fraction largeness 1 mm	fraction largeness 0.5 mm

Fig. 8 Briquettes with different fraction sizes

5. Conclusions

This experiment was of great importance and its results can be used in the future for designing new constructions of compacting machines. It is very important to continue with this experiment so it could allow us to obtain new results and a complex and real view of the briquetting process. The next task would be to design a mathematical model for briquetting that includes the impact of all the eminent parameters on briquette quality. In addition, a new task would involve measuring the impacts of some constructional parameters and their implementation in the designed mathematical model. This is made possible with the design of application software that will present a helping tool for briquetting machine engineers or will act as technical support for briquettes producers.

Acknowledgement: *This contribution was created by realization of project "Development of progressive biomass compacting technology and production of prototype and high-productive tools"(ITMS Project code: 26240220017), on base of Operational Programme Research and Development support financing by European Regional Development Fund.*

REFERENCES

1. Križan, P.: Research of factors influence on quality of wood briquettes, Journal Acta Montanistica Slovaca, Vol. 12, No.3, pp. 223-230, 2007.
2. Križan, P.: Impact of factors at biomass compacting process, 13. International conference TOP 2007, Senec, Slovakia, pp. 381-386, 2007.
3. Lehtikangas, P.: Quality properties of pelletised sawdust, logging residues and bark, Biomass and Bioenergy, Vol. 19, pp. 351-360, 2001.
4. Hodolič, J., Vukelić, Đ., Agarski, B., Huđik, C.: Briquetting of biomass and environmental engineering, 2.Conference About Quality of Life, Kragujevac, Serbia, pp. 8-11, 2007.
5. Janković, S.: Mechanical properties of light compositive biobriquettes, Facta Universitatis - Series Working and Living Environmental Protection, Vol. 1, No. 2, pp. 59-64, 1997.
6. Mitić, D., Nešić, B.: Light compositive biobriquettes – Phisical characteristics, Facta Universitatis - Series Working and Living Environmental Protection, Vol. 1, No. 2, pp. 51-58, 1997.
7. Singh, R. N., Bhoi, P. R., Patel, S. R.: Modification of commercial briquetting machine to produce 35mm diameter briquettes suitable for gasification and combustion, Renewable Energy, Vol. 32, pp. 474–479, 2007.
8. Drzymała, Z.: Industrial Briquetting: Fundamentals and Methods, Elsevier, pp. 442, 1993.

ISTRAŽIVANJE UTICAJA TEHNOLOŠKIH PARAMETARA NA PROCES BRIKETIRANJA

Peter Križan, Ľubomír Šooš, Đorđe Vukelić

U savremenoj proizvodnji briketa veoma je važno znati uticaj svih faktora na kvalitet gotovog briketa. Kvalitet briketa se uglavnom vrednuje prema gustini briketa. Gustina briketa veoma je važna sa gledišta manipulacije, brzine sagorevanja, stabilnosti briketa itd. Tokom istraživanja izvršene su teoretske analize parametara koji imaju uticaj na kvalitet briketa. Nakon izvršenih analiza sproveden je eksperiment za izučavanje uticaja značajnih faktora. U radu su prikazni rezultati analize i segment dobijenih eksperimentalnih rezultata.

Ključne reči: *proces sabijanja, gustina briketa, tehnološi parametri, pritisak sabijanja, temperatura sabijanja, vlažnost materijala, veličina čestica*