POSSIBILITY OF USING CORN STALKS AS A SOURCE OF ENERGY

El-Soaly I. S.[*], R. R. EL-Bessoumy [**] and A. E. M. Fodah [***]

ABSTRACT

The main objective of the present study is to develop the fundamentals of a technology for energetic utilization of corn stalks aimed to solve the problem of dangerous storing and burning of corn stalks in Egypt and to evaluate some physical properties of corn stalks briquettes, easily storable, and environmentally sound biofuel for rural areas in Egypt. Chopped corn stalks was densified into briquettes using a laboratory model vertical hydraulic press at different formation pressures of (15, 32, 49 and 60 MPa), three temperatures (room temperature (35^{o}C), 75 and 100^{o}C), three levels of moisture content (7.33, 8.72 and 10.52% wb) and different holding time (10, 20 and 30 min).

The results showed that the highest bulk density, compression ratio, durability and water resistance were 1472 kg/m^{3}, 27, 98% and 88 min, respectively, at formation pressure of 60 MPa, temperature of 100^{o}C, moisture content of 7.33% and holding time of 30 min. While, the minimum resiliency obtained was 4.88%. The CO and CO_2 emissions for briquettes were less than these for chopped corn stalks.

INTRODUCTION

Alternative forms of energy need to be used, this is has been necessitated the need to improve on using of agro wastes such as rice-husk and corn stalks as alternatives. Numerous agricultural residues and wastes are generated in the country, but they are poorly utilized and badly managed, since most of these wastes are left to decompose or they are burned in the field resulting in environmental pollution and degradation **(Jekayinfa and Omisakin, 2005)**. In Egypt, disposal of crop residues are one of the main problems facing Egyptian farmers which estimates about 30 to 35 Tg/year.

***Prof. of Agric. Eng., Faculty of Agric. Eng., Al-Azhar Univ.**
****Ass. Prof. of Agric. structures and environmental control Dept., Faculty of Agric. Eng., Al-Azhar Univ.**
*****Demons. of Agric. structures and environmental control Dept., Faculty of Agric. Eng., Al-Azhar Univ.**

Corn stalks is considered as the one of the main environmental problems in Egypt. It is estimated to be around 4.8 Tg every year and these residues are left to rot away or they are burned like other agricultural wastes **(MALR, 2013)**. These residues could however, be used to generate heat for domestic and industrial cottage applications **(Fapetu, 2000)**. Farmers used these residues as fuel resources for the traditional mud ovens in which their families cooked and baked. For this purpose, farmers stored these residues on the roofs of their houses or on the fields. This traditional way of handling these residues caused several problems such as, a good habitat for insects, mice and snakes that developed in the pile and increased the risk of destructive fire in the villages **(El-Saeidy, 2004)**. The burning of agricultural wastes causes air pollution, soil erosion, and a decrease in biological activity, which eventually leads to lower yields however, burning yields smoke and other pollutants which adversely affect air quality, visibility, and human and environmental health. One of the promising solutions to these problems is the application of briquetting technology **(Wilaipon, 2007)**. The technology may be defined as a densification process for improving the handling characteristics of raw materials and enhancing volumetric calorific value of the biomass. Environmentally, pellet biomass fuels provide advantages of less ash, smoke and other compound emissions, including carbon particles, CO, NO_x and SO_x. Because the use of biomass pellets produces much fewer greenhouse gases when the biomass is sustainably harvested, there has been a recent push to replace fossil fuels with biomass fuels **(Panwar, *et al* 2011)**. To make the biomass materials available for a variety of applications, the challenges with the use of biomass materials in their original form must be resolved. Because of high moisture content, irregular shape and sizes, and low bulk density, biomass is very difficult to handle, transport, store, and utilize in its original form. One of the solutions to these problems is densification of biomass materials into pellets, briquettes, or cubes. Densification increases the bulk density of biomass from an initial bulk density (including baled density) of 40–200 kgm^{-3} to a final bulk density of 600–800 kg/m^3 **(Mullen, *et al* 2005)**. Densification process which used to create strong and durable bonding in densified products such as pellets, briquettes, and cubes can be determined by quality testes which include testing the strength (compressive resistance, impact resistance and water resistance) and durability (abrasion resistance) of the densified products These tests can indicate the maximum force/stress that the densified products can withstand, and the amount of fines produced during handling, transportation and storage **(Nalladurai and Morey 2009)**. The briquettes produced from corn stalk would make a good biomass fuels. Corn stalks briquettes will not crumble during transportation and storage because the value obtained for their relaxed density is sufficient enough. There would be minimum environmental pollution and emission of greenhouse gases from corn stalk briquettes **Oladeji and Lucas (2014)**. The process of forming biomass into briquettes depends upon the physical properties of ground particles and the process variables during pelletizing, pressure and temperature. Fuel briquettes were produced under different conditions to have different handling characteristics. These characteristics were found to be strongly affected by raw material properties. Briquette density is one of the most important properties which bear on the combustion characteristics, handling characteristics including the ignition behavior of briquettes. This property depends on several factors therefore, it is crucial to understand the effects of these factors on briquette density. Among the factors, die pressure seems to be one of the most important ones.

The study was carried out to evaluate some physical properties of corn stalks briquettes.

MATERIALS AND METHODS

The objectives of the present work are to evaluate some physical properties of corn stalks briquettes, also producing a cheap, easily storable, and environmentally sound biomass fuel for rural areas in Egypt.

The experimental part of the present work was carried out in the faculty of Agricultural Engineering, Al-Azhar University, Cairo, during summer of 2015.

Raw materials (corn stalks):

Corn stalks were used in this study because this residue is one of the main problems facing Egyptian farmers and the huge amounts of these residues in Egypt which was about 4.8 Tg/year, **(MALR, 2013)**. The corn stalks were collected from fields of EL-Menoufia governorate during harvesting season of 2014/2015.

The corn stalks variety used was single cross 10 from season 2014. The stem average length was 1960 mm and stem diameter ranged from 28 mm **(El-Khateeb et al., 2012)**. The corn stalks were chopped using a regular wheat threshing machine in Menoufia governorate. The chopped corn stalks were collected and put in plastic bags until it will be used. Random samples were taken after grinding process for measuring lengths distribution by using four standard sieves. The selected sieves series were based on the range of particles in the sample, the lengths distribution of these chops as show in Table (1). The particles size was determined according to **ANSI/ASAE standard S319.3JUL97-** ***1996*****.** The bulk density for chopped corn stalks was 54 kg/m^3.

Table (1): Distribution of grinded corn stalks lengths.

Particle size (mm)	**≤ 1**	**>1 ≤ 1.4**	**>1.4 ≤ 2.8**	**> 2.8 ≤ 3.35**	**> 3.35 ≤ 5**	**total**
Mass of Particle (g)	2.85	10.88	3.36	17.35	5.56	40
Percentage of Particle lengths (%)	7.12	27.20	8.40	43.38	13.90	100

A pressing apparatus:

The pressure was used in this study an important variable to perform briquettes from corn stalks. The hydraulic pressure as shown in Fig. (1) was used in this study as a pressing apparatus.

Pressing cylinder:

A cylinder was used to compress samples inside it which manufactured from mild steel in workshop of Faculty of Agricultural Engineering, Al-Azhar University, The cylinder's inner diameter of 70 mm, outer diameter of 75 mm and length of 200 mm. In order to compress the sample inside the pressing cylinder, two disks of steel were used. The diameters of disks were 69 mm. The upper and lower disks thicknesses were done to be 20 mm. Fig. (2) Illustrates the isometric of the pressing cylinder and disks.

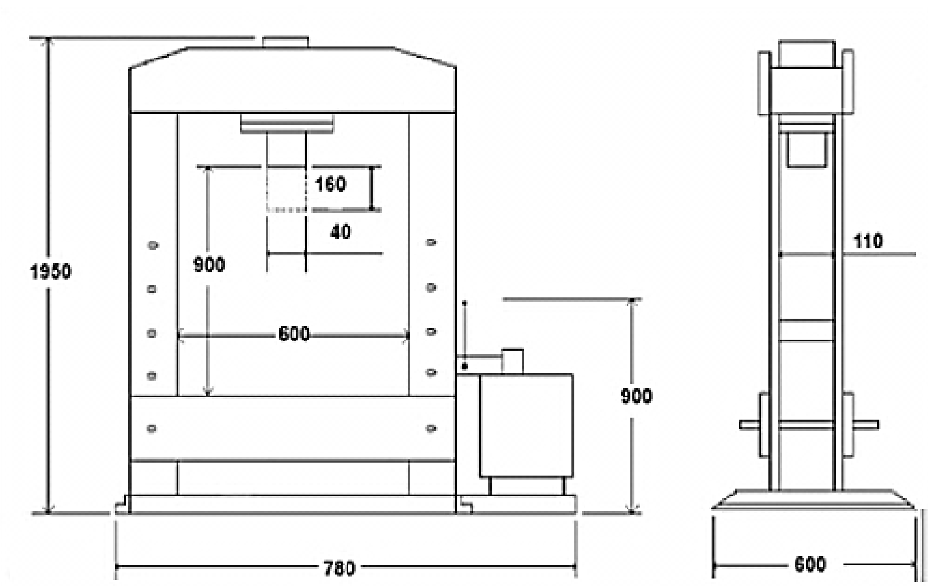

Fig. (1): Schematic diagram of pressing apparatus dimensions in mm, (EL Bessoumy, 2005).

Heating unit:

Two cylindrical heaters were used; each one of the used heaters had the same dimensions and electrical specifications. The heater diameter of 70 mm, thickness of 20 mm, height longed 100 mm and power requirement of 300 watt. Fig. (2) illustrate the isometric diagram of the heating unit.

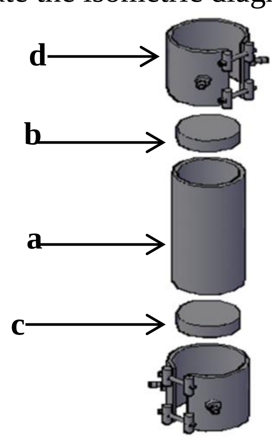

Fig. (2): Pressing cylinder, disks and heating units. (a) Pressing cylinder, (b) Upper disk, (c) Lower disk, (d) Heating units.

Briquettes durability instrument (DU):

Durability of briquettes was measured because the durability is one of the main properties that described the physical quality of densified solid biofuels briquettes. This type of fuel is a susceptible to mechanical wear, which leads to production of fine particles or dust during transport, transshipment and storage. Durability of briquettes was measured according to the standard method of **ASAE S269.4 (1996)**. The briquettes durability instruments consist of an electrical motor and tumbling box. The tumbling box was rotated around an axis, which was perpendicular to and centered in the 300 mm side. A long baffle of 230 mm was affixed symmetrically and diagonally to a side of the box (300 x 300 mm),

Fuel gas analyzer:

The gases emissions were measured by using analyzer IMR 1400. The estimated gases emissions were carbon monoxide (CO), carbon dioxide (CO_2) and oxides of nitrogen (NO_X).

Sample adjustment for pressing:

Each sample had a constant weight of 40 g. The sample was put inside a pressing cylinder and compressed between two disks by hydraulic pressing at a selected loading level. The thickness of sample was recorded after pressing process to calculate the bulk density. Fig. (3) Illustrated the specimens of corn stalks after pressing and before testing.

Measurements:

Bulk density (ρ_b):

The bulk density of the briquettes is the most important factor that must be study because its effect on the regularity of the combustion process. The samples thickness was recorded after pressing to calculate the bulk density at different conditions using the following equation (1), **(Jha *et al* 2008):**

$$\rho_b = \frac{M}{V} \qquad \text{.................} \quad (1)$$

$$V = \pi r^2 * t \qquad \text{…………..} \quad (2)$$

Where:

ρ_b: Bulk density, kgm^{-3};

V: Volume of briquette, m^3;
M: Mass of briquette, kg;
r : Radius of briquette, m; and
t : Thickness of briquette, m.

Compression ratio (CR):

The compression ratio indicates the volume reduction during compression. It was obtained from the ratio of bulk density of briquettes to the initial bulk density of chopped corn stalks before pressing process using the following equation (3), **(Jha *et al* 2008).**

$$CR = \frac{\rho b}{\rho_{raw}} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where:

CR: Compression ratio;
ρ_b : Bulk density of corn stalk and corn stalks briquettes, kgm^{-3};
ρ_{raw} : Bulk density of chopped corn stalks and corn stalks, kgm^{-3}.

a b c

Fig. (3): Specimens of corn stalks briquettes (a: without heat, b and c are heated at 75°C and 100°C, respectively) after pressing and before testing.

Resiliency ratio (R):

At the end of the compression process and after releasing the samples from the compression cylinder, the resiliency (samples thickness recovery) was measured at different durations; varying from 5 min to 1440 min. Resiliency indicates the elastic property of the material. It was determined as the ratio of increased thickness to the initial thickness of the briquettes. The thickness of the briquettes was measured after duration of 5 min, 30 min and 1440 min, respectively, using the following equation (4), **(Jha *et al* 2008).**

$$\mathbf{R = \frac{T - Ti}{Ti} * 100} \quad \ldots\ldots\ldots\ldots \quad (4)$$

Where:

R : Resiliency ratio (%);

T : Thickness of stabilized briquettes, mm; and

Ti : Initial thickness of briquettes, mm.

Water resistance:

The water resistance of the briquettes was achieved by immersing them in a glass container filled with cold tap water at 20- 25^{o}C. The required time (min) was recorded for dispersion the briquettes in the water, **(Yamnan, *et al* 2001 and Debdoubi, *et al* 2004).**

Durability (DU):

Before carrying out this test, samples of the medium and high moisture content (8.72 %, 10.52%), respectively, were not used for corn stalks, due to that the previous medium and high moisture content briquettes didn't gave desired values of bulk density, compression ratio, resiliency and water resistance. The durability (Du) of the produced briquettes was determined according to **ASAE Standard S269.4, 1996.** Sample of 500 g briquettes was tumbled in the box at 50 rpm for 10 min. Durability is expressed by the percent ratio of mass of briquettes retained on the sieve after tumbling (*mpa*) to mass of briquettes before tumbling (*mpb*) in accordance with the following equation (5) **(El-Saeidy, 2004).**

$$\mathbf{Du = \frac{\mathit{mpa}}{\mathit{mpb}} * 100} \quad \ldots\ldots\ldots\ldots \quad (5)$$

Where:

Du : Durability %;

mpa: Mass of briquettes retained on the sieve after tumbling, g; and

mpb: Mass of briquettes before tumbling, g.

Gases emission:

This test was carried out for chopped corn stalks and corn stalks briquettes (raw material), as well as for the produced corn stalks and corn stalks briquettes. The samples characteristics that used in this test are shown in table (3.4). Gasoline was used as an assistant in the begin of the burning process. The sample was put inside the stove after regularity of the ignition process. The gases emissions were recorded from the chimney height of 160 cm. the gases emissions, (CO, CO_2 and NO_x), were recorded each 15 min during incineration process**.**

Table (2): Characteristics of samples that used for combustion test.

Parameter	**Corn stalks**	
	stalks	**Briquette**
Length mm	1 to 5	7.06
Diameter mm	----------	70
Moisture content %	7.33	6.78
Bulk density kg/m^3	54	1472
Mass g	80	80

RESULTS AND DISCUSSION

Effect of studied variables (formation presser, moisture content, temperature and holding time) on bulk density for corn stalks briquettes:

The bulk density for the briquettes is the most important property that must be studied because they affect the regularity of the combustion process and an indicator for the compression ratio. It also, helps to solve the problems of biomass storage. The measured density of the chopped corn stalks was about 54 kg/m^3. On the other hand, the briquette density of 7.33% moisture content was 1472 kg/m^3. The increasing density was more than 2600% that means one ton of the loose material will take a storage place of about 18.5 m^3. On the other hand, one ton of the briquette of 7.33% moisture content will take a storage place of about 0.68 m^3; the change in the storage place briquettes than the loose materials is about 96%.

Fig (4) illustrates the relationship between bulk density (kg/m^3) and formation pressure (MPa) at different holding time (min), moisture contents (%) and temperatures (^{o}C) for corn stalks briquettes. The data indicated that the bulk density increases with formation pressure, temperatures and holding time increasing. While, the bulk density decreases with moisture contents increasing.

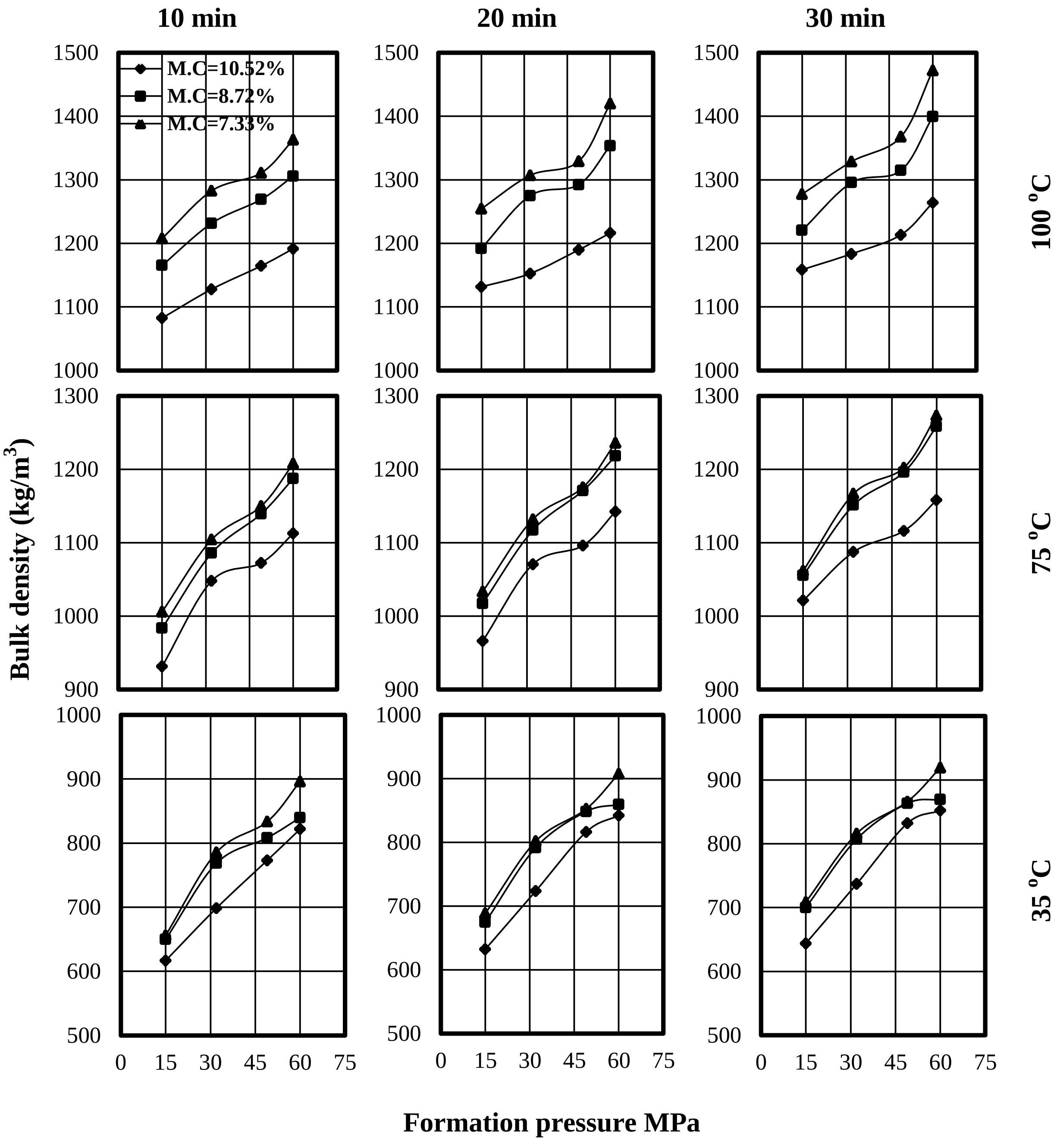

Fig. 4: Effect of formation pressures (MPa) on bulk density (kg/m^3) at different holding time (min), moisture contents (%) and temperatures (^{o}C) for corn stalks briquette.

The maximum bulk density obtained was about 1472 kg/m^3 at formation pressure 60 MPa, moisture content 7.33%, temperature 100^{o}C and holding time 30 min. While, the minimum bulk density obtained was about 617 kg/m^3 at formation pressure 15 MPa, moisture content 10.52%, room temperature (35^{o}C) and holding time 10 min. This result is in agreement with that published by **El-Saeidy (2004)**.

Effect of studied variables (formation presser, moisture content, temperature and holding time) on compression ratio for corn stalks briquettes:

Compression ratio was calculated depending on the bulk density for all experimental results. Fig (5) illustrates the relationship between compression ratio (kg/m^3) and formation pressure (MPa) at different holding time (min), moisture contents (%) and temperatures (^{o}C) for corn stalks briquettes.

The data indicated that the compression ratio increases with formation pressure, temperatures and holding time increasing. While, compression ratio decreases with moisture contents increasing.

The maximum compression ratio obtained was about 27 at the formation pressure 60 MPa, moisture content 7.33%, temperature 100^{o}C and holding time 30 min. While, the minimum compression ratio obtained was about 11 at formation pressure 15 MPa, moisture content10.52%, room temperature (35^{o}C) and holding time 10 min.

Effect of studied variables on resiliency for corn stalks briquettes:

Fig (6) illustrates the relationship between resiliency and formation pressure (MPa) at different holding time (min), moisture contents (%) and temperatures (^{o}C) for corn stalks briquettes. The data indicated that the resiliency decreases with formation pressure, temperatures and holding time increasing. While, resiliency increases with moisture contents increasing.

The maximum resiliency obtained was about 29.33% at formation pressure 15 MPa, moisture content 10.52%, room temperature (35^{o}C) and holding time 10 min. While, the minimum resiliency obtained was about 4.88% at formation pressure 60 MPa, moisture content 7.33%, temperature 100^{o}C and holding time 30 min.

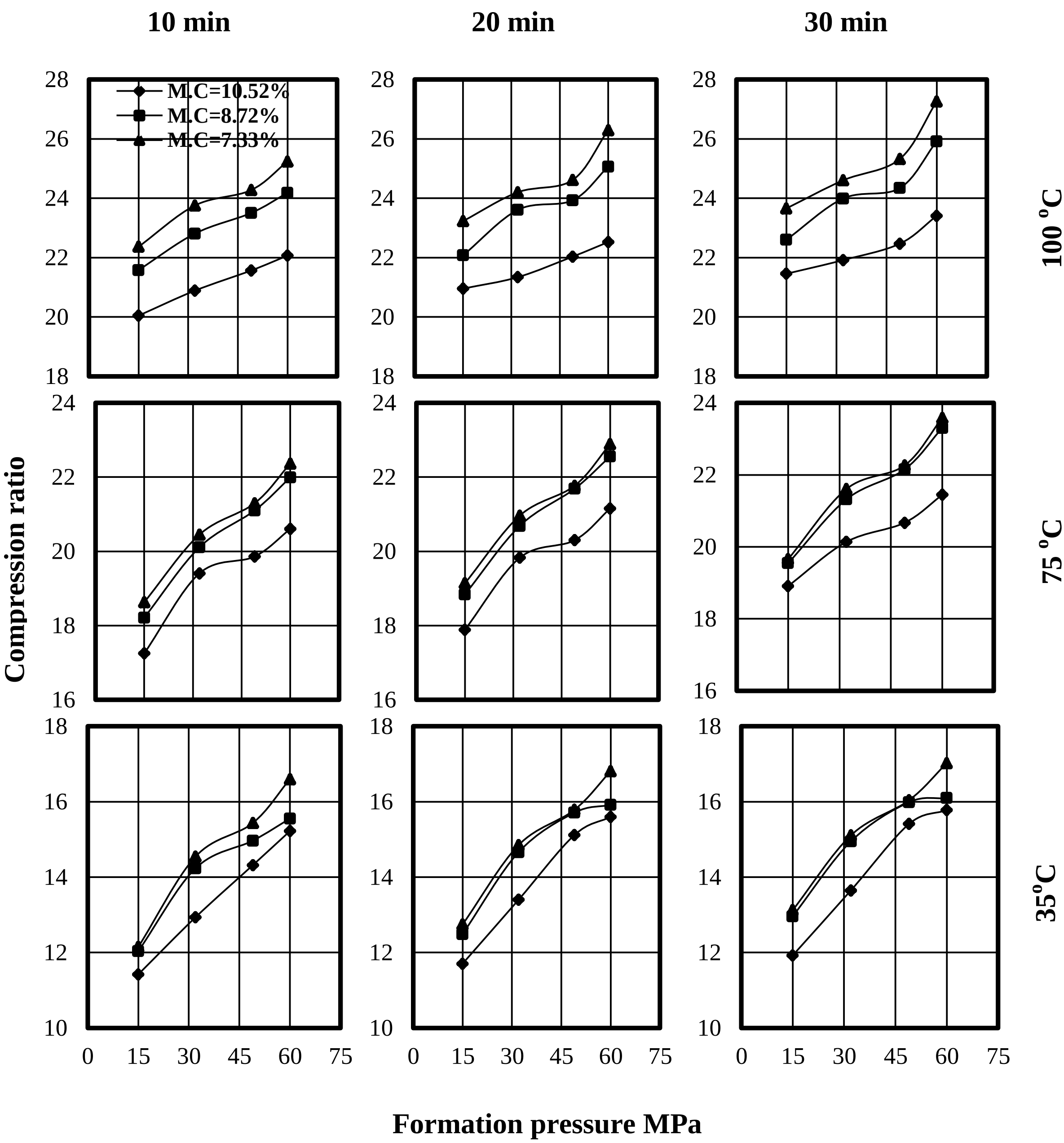

Fig. 5: Effect of formation pressure (MPa) on compression ratio at different holding times (min), moisture contents (%) and temperatures (^{o}C) for corn stalks briquettes.

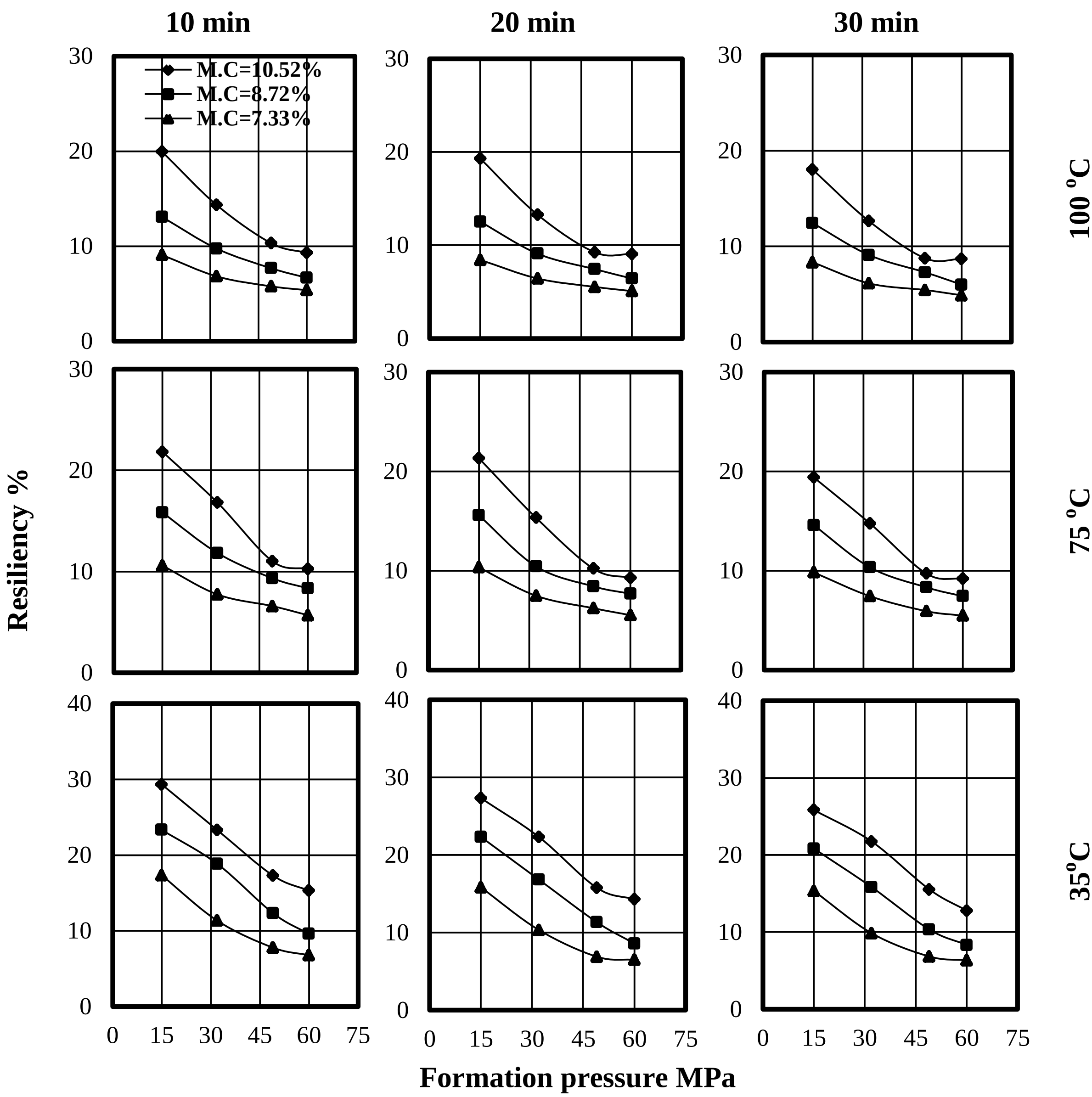

Fig. 6: Effect of formation pressure (MPa) on resiliency (%) at different holding times (min), moisture contents (%) and temperatures (°C) for corn stalks briquettes.

Effect of studied variables on water resistance for corn stalks briquettes:

Fig (7) illustrates the relationship between water resistance and formation pressure (MPa) at different holding times (min), moisture contents (%) and temperatures (°C) for corn stalks briquettes.

The data indicated that the water resistance increases with formation pressure, temperatures and holding times increasing. While, water resistance decreases with moisture contents increasing.

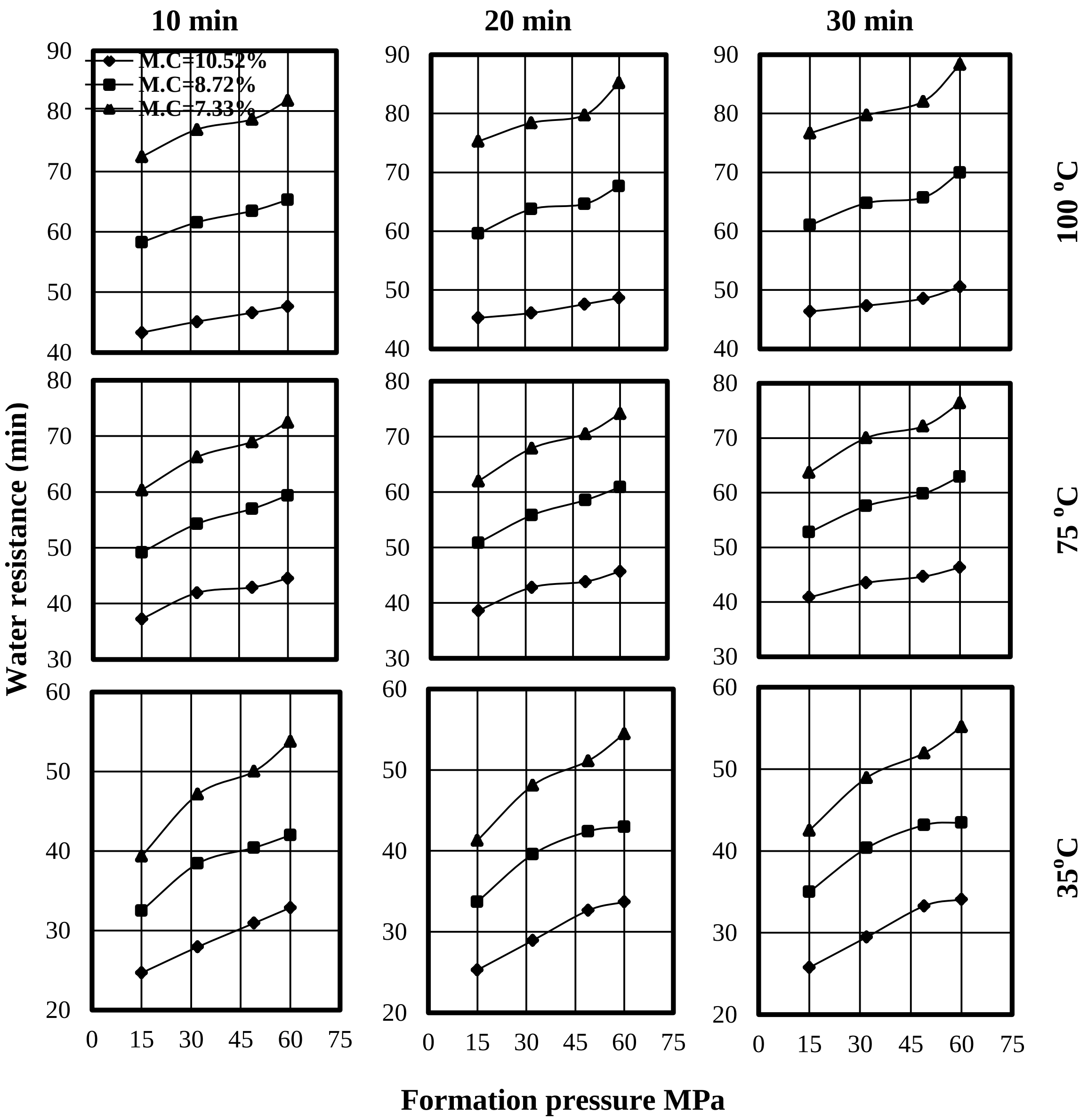

Fig. 7: **Effect of formation pressure (MPa) on water resistance (min) at different holding times (min), moisture contents (%) and temperatures (°C) for corn stalks briquettes.**

The maximum water resistance obtained was about 88 min at formation pressure 60 MPa, moisture content 7.33%, temperature 100^{o}C and holding time 30 min. While, the minimum water resistance obtained was about 25 min for corn stalks briquettes at formation pressure 15 MPa, moisture content 10.52%, room temperature (35^{o}C) and holding time 10 min. This result is in agreement with that published by **Oladeji and Lucas (2014).**

Effect of formation pressure, temperature and holding time at moisture content 7.33 % on durability (%) for corn stalks briquettes: Fig (8) illustrates the relationship between durability (%) and formation pressure (MPa) at different holding times (min) and temperatures (^{o}C) for corn stalks briquettes.

The obtain data shows that, for all experimental conditions, durability increases with formation pressure increasing from 15 to 60 MPa under all experimental conditions. Also, increases temperature from room temperature (35^{o}C) to 100^{o}C and holding time from 10 to 30 min increasing durability dramatically**.**

The maximum durability obtained was about 98 % at formation pressure 60 MPa, temperature 100^{o}C and holding time 30 min. While, the minimum durability obtained was about 66.5 % corn stalks briquettes at formation pressure 15 MPa, room temperature (35^{o}C) and holding 10 min.

Measuring gases emissions:

Table (3) shows the combustion results of chopped corn stalks and corn stalks briquettes. The data indicates that, the CO values of corn stalks briquettes were lower by was 95% than the CO values of chopped corn stalks. The CO_2 values of corn stalks briquettes were lower by 46% than the CO_2 values of chopped corn stalks. As well as NO_x values of corn stalks briquette were lower by 50% than the NO_x values chopped corn stalks. The combustion efficiency was 98% and 50% for corn stalks briquettes and chopped corn stalks, respectively, and the burning time was about 90 and 20 min for corn stalks briquettes and chopped corn stalks, respectively.

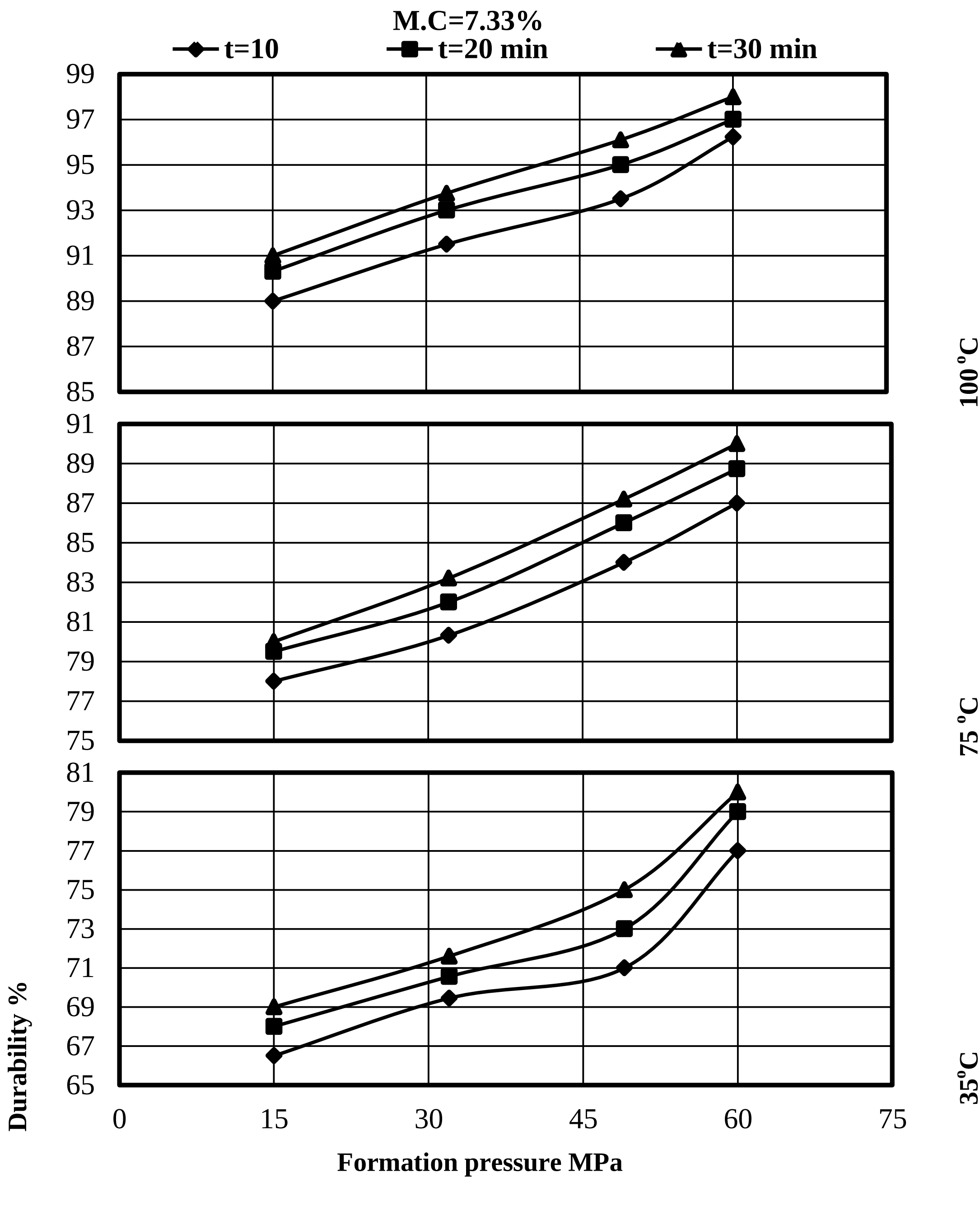

Fig. 8: Effect of formation pressure (MPa) on durability (%) at different holding times (min) and temperatures (°C) for corn stalks briquettes.

Table (3): Results of the combustion experiment.

Item	Gas emissions			η	Burning time
	CO	CO_2	NO_x		
	mg/m^3	mg/m^3	mg/m^3	%	min
Chopped corn stalks	6356	76010	136.5	50	20
Corn stalks briquettes	290	41096	68.3	98	90

CONCLUSION

Densification of biomass materials into briquettes could reduce problems with handling, transportation, storage, and utilization biomass materials to produce a good quality biofuel.

This research aimed to study some physical properties of corn stalks briquettes. The quality properties of the produced corn stalks briquettes were affected by formation pressure, moisture content, temperature and holding time.

The optimum quality properties of the briquettes were 60 MPa formation pressure, 7.33% moisture content, 100^{o}C temperature and 30 min holding time.

The maximum bulk density, compression ratio, water resistance and durability were 1472 kg/m^3, 27, 98% and 88 min, respectively. While, the minimum resiliency obtained was 4.88%. The CO, CO_2 and NO_x emissions values for corn stalks briquettes decreased by 95, 46 and 50 %, respectively, of the emissions values CO, CO_2 and NO_x for chopped corn stalks.

REFERENCES

ASAE Standard S269.4 (1996). Cubes, Pellets and Crumbles - Definition and methods for determining density, durability and moisture content.

Debdoubi A., A. Elamarti and E. Colacio (2004). Production of fuel briquettes from esparto partially pyrolyzed, Energy Conversion and Management, 46, 1877–1884.

EL-Bessoumy R. R. (2005). Effect of using agricultural residues in building materials characteristic. MSC, Thesis. Ag. Eng. Dept., Faculty of Agriculture, Al-Azhar University.

El-Khateeb, H. A.; S. K. Geneday; A. A. Soluman, M. A. El-Atter (2012). Modification of Meat Chopper Machine and Possibility of Utilization on Purpose to Briquetting of Corn Stalk. The 19th. Annual Conference of the Misr Soc. of Ag. Eng., 14-15 November, 2012: 473-492.

El Saeidy E. (2004). Technological fundamentals of briquetting cotton stalks as a biofuel (Doctoral dissertation, Humboldt-Universität zu Berlin, Land wirtschaftlich - Gärtnerische Fakultät), Renewable Energy in Agriculture in Egypt, pp: 20-34.

Fapetu, O. P. (2000). Production of charcoal from tropical biomass for industrial and metallurgical process. Nigeria Journal of Engineering Management, 1(2), 34-37.

Gamea, G. R.; E. A. El Saeidy; and S. F. El Sisi (2012). Quality properties for cotton stalks and rice straw briquettes. The 19th. Annual Conference of the Misr Soc. of Ag. Eng., 14-15 November, 2012: 303-324.

Jekayinfa S. O. and O. S. Omisakin (2005). The energy potentials of some agricultural wastes as local fuel materials in Nigeria. Agricultural Engineering International the CIGR E-Journal of Scientific Research and Development Vol., VII Manuscript E.E 05 003: 10Pp.

Jha S. K., A. Singh and A. Kumar (2008). Physical characteristics of compressed cotton stalks. Biomass Engineering, 99, 205 – 210.

MALR (2013). Ministry of Agriculture and Land Reclamation, Agricultural research Centre, The weather monthly report, Egypt.

Mullen, J.; O. O. Fasina.; C. W. Wood.; and Y. Feng (2005). Storage and handling characteristics of pellets from poultry litter". Applied Engineering in Agriculture, 21, 645–51.

Nalladurai, K.; and R. V. Morey (2009). Factors affecting strength and durability of densified biomass products". Biomass and Bio-energy, 33, 337–359.

Oladeji, J. T.; and E. B. Lucas (2014). Densification and fuel characteristics of briquettes produced from corncob. Academia Arena, 3(6), 25-30.

Panwar, V.; B. Prasad.; and K. L. Wasewar (2011). Biomass Residue Briquetting and Characterization. J. Energy Eng.-ASCE 137, 108–114.

Yaman S., M. Sahan, H. Haykiri-Acma, K. Şeşen and S. Küçükbayrak (2001). Fuel briquettes from biomass–lignite blends. Fuel processing technology, 72(1), 1-8**.**

Wilaipon, P (2007). Physical Characteristics of Maize Cob Briquette under Moderate Die Pressure. The 2nd International Conference on Thermal Engineering and Applications. United Arab Emirates, Jan 3-6, 2006. UAE University.

الملخص العربى

امكانية استخدام حطب الذرة كمصدر للطاقة

أ.د إبراهيم سيف أحمد السؤالي*، د. رزق ربيع كامل البسومي و م. أحمد السيد محمود فوده *****

أصبح استخدام الطاقة الجديدة والمتجددة ضرورة ملحة نتيجة للنضوب السريع للوقود التقليدي وتعتبر الكتلة الحيوية من أكبر مصادر الطاقة الجديدة والمتجددة لتوافرها. وينظر اليوم الي الكتلة الحيوية كمصدر من مصادر الطاقة الواعدة لتخفيف انبعاث غازات الاحتباس الحراري وبالتالي يؤدي الي تحسين الظروف البيئية المحيطة. وتعتبر المخلفات الزراعية منتجات ثانوية داخل منظومة الانتاج الزراعي والتي تمثل مشكلة كبيرة لدي المزارعيين وتؤثر بالسلب علي البيئة المحيطة، من بين هذه المخلفات حطب الذرة حيث يتم التخلص منه بطريقة بدائية مثل الحرق أوالتخزين فوق اسطح المنازل مما يؤدي الي الحرائق وزيادة التلوث البيئي. ويمكن تعظيم الاستفادة من حطب الذرة بتحويله الي طاقة نظيفة مما يساهم في حماية البيئة من التلوث وتحسين الوضع الاقتصادي والبيئي. ويمكن استخدام هذه المخلفات كمصدر للطاقة عن طريق تكنولوجيا القولبة أو التكثيف.

الهدف من هذة الدراسة هو قولبة حطب الذرة للوصول إلى الأهداف التالية:

١- المساهمة في حل مشكلة التخزين الضارة، حرق حطب الذرة في مصر ومنع تكون السحابة السوداء.

٢- الحفاظ علي البيئة والزراعة بالتعامل مع هذة المخلفات بطريقة آمنة.

٣- إنتاج وقود حيوي صلب ، قابل للتخزين بسهولة، وسليم بيئيا في المناطق الريفية المصرية.

* أستاذ هندسة المنشآت الزراعية والتحكم البيئي – كلية الهندسة الزراعية – جامعة الأزهر- القاهرة.

** أستاذ مساعد هندسة المنشآت الزراعية والتحكم البيئي – كلية الهندسة الزراعية – جامعة الأزهر- القاهرة.

*** معيد بقسم هندسة المنشآت الزراعية والتحكم البيئي- كلية الهندسة الزراعية - جامعة الأزهر- القاهرة.

لتحقيق الأهداف السابقة تم إجراء الخطوات التالية:

١- ضغط حطب الذرة على ثلاثة مستويات للرطوبة (٧,٣٣، ٨,٧٢ و ١٠,٥٢٪) باستخدام المكبس الهيدروليكي.
٢- إستخدام أربعة مستويات لضغط التشكيل (١٥، ٣٢، ٤٩ و٦٠ ميجا باسكال)، ثلاثة مستويات من درجات الحرارة (درجة حرارة الغرفة (٣٥°م)، ٧٥ °م و ١٠٠ °م)، وثلاث أزمنة لبقاء العينات تحت الضغط (١٠، ٢٠ و ٣٠ دقيقة).
٣- دراسة تأثير عوامل الدراسة على خصائص الجودة لقوالب حطب الذرة مثل [الكثافة الظاهرية (كجرام/م٣)، رجوعية القوالب (٪)، مقاومة القوالب للماء (دقيقة) ومتانة القوالب (٪)].
٤- تقييم جودة المنتج النهائي لاستخدامة كوقود حيوي صلب بقياس انبعاثات غازات (أول اكسيد الكربون، ثاني اكسيد الكربون، وأكاسيد النيتروجين)، كفاءة عملية الاحتراق للقوالب الناتجة ومقارنة النتائج مع نتائج حطب الذرة المفروم.

كانت أهم النتائج التى تم الحصول عليها كالتالى:

١- بزيادة ضغط التشكيل تزداد كلا من الكثافة الظاهرية ، ونسبة الانضغاط ، ومقاومة القوالب للماء و المتانة للقوالب الناتجة. بينما تقل الرجوعية بزيادة ضغط التشكيل.
٢- بزيادة المحتوي الرطوبي تقل كلا من الكثافة الظاهرية ، ونسبة الانضغاط ، مقاومة الماء و المتانة للقوالب الناتجة. بينما تزداد الرجوعية بزيادة المحتوي الرطوبي.
٣- بزيادة درجة الحرارة تزداد كلا من الكثافة الظاهرية ، ونسبة الانضغاط ، ومقاومة القوالب للماء و المتانة للقوالب الناتجة. بينما تقل الرجوعية بزيادة درجة الحراة.
٤- بزيادة زمن بقاء العينة تحت الضغط تزداد كلا من الكثافة الظاهرية ، ونسبة الانضغاط ، ومقاومة القوالب للماء و المتانة للقوالب الناتجة. بينما تقل الرجوعية بزيادة زمن بقاء العينة تحت الضغط.
٥- أن الانبعاث الناتجة من حرق قوالب حطب الذرة الناتجة كانت أقل من الانبعاثات الناتجة من حرق المخلف حطب الذرة المفروم. حيث كانت انبعاثات أول أكسيد الكربون لقوالب حطب الذرة ٩٥٪. أيضا الشيء نفسه بالنسبة لانبعاثات ثاني اكسيد الكربون، وأكاسيد النيتروجين. كما أن مدة بقاء القوالب مشتعلة كانت أكبر بالمقارنة بعينات حطب الذرة المفروم.
٦- وكانت أفضل الخصائص للقوالب الناتجة عند ضغط تشكيل ٦٠ ميجا باسكال ، محتوي رطوبي ٧,٣٣٪ ، درجة الحرارة ١٠٠ °م وزمن بقاء العينة تحت الضغط ٣٠ دقيقة.
٧- كانت أكبر قيمة للكثافة، نسبة الضغط، مقاومة القوالب للماء والمتانة هي ١٤٧٢ كجم/م٣، ٢٧، ٩٨٪ و ٨٨ دقيقة على التوالي. في حين، كان الحد الأدنى للمرونة التي تم الحصول عليها ٤,٨٨٪ وكانت أقل نسبة للغازات المنبعثة (أول وثانى أكسيد الكربون واكاسيد النتيتروجين) كانت للقوالب الناتجة بالمقارنة مع حطب الذرة المفروم لذلك توصى الدراسة بإستخدام قوالب حطب الذرة كوقود صديق للبيئة.