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RESEARCH ARTICLE

DESIGN OF EXPELLING MACHINE FOR BRIQUETTES MADE OF OBTAINED BIO-CHARS FROM CASHEW NUT SHELLS' PYROLYSIS

Thierry Godjo[1, 2], Léandre Vissoh[1], Clotilde Guidi[1], Alain Adomou[1] and Sanya Emile[2].

1. Department of Mechanical Engineering, University Institute of Technology of Lokossa, B.P. 133 LOKOSSA, Benin.
2. Laboratory for Applied Energy and Mechanics (LEMA), EPAC, Abomey-Calavi, Benin.

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Abstract

In the context of densification of biochar made from cashew nut shells' pyrolysis, the University Institute of Technology of Lokossa has successively developed two small scale equipments: a manual lever press and a hydraulic press. Although both the developed equipments had significant densification rates (81% and 85% respectively for manual lever press and hydraulic press), it remains to enhance the throughput (10 kg/hr and 90 kg/hr respectively for manual lever press and hydraulic press).This paper presents the design of an efficient Expelling Machine for Briquettes made from cashew nut shells pyrolysis biochars. The machine has been designed to a capacity of 500 kg/hr and can expel briquettes at the rate of 1,000 briquettes/hr. The machine is powered using electric motor of 7 kW to be operated for 8 working hours. This machine improves the performances of existing briquetting technologies and it will enhance the environmental footprint.

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Introduction:-

World energy consumption is dominated by fossil energy that unfortunately causes gradual depletion of world petroleum reserves and the increasing exhaust emissions on environment and global warming(Höök and Tang, 2013). Due to this there is a need for suitable alternative fuels for use in diesel engines. Indeed, previous researches (Chou, Lin, and Lu 2009; Hassan, Kee, and Al-Kayiem 2013; Rattanongphisat and Chindaruksa 2011)have shown that fuel obtained from the biomass is a safe alternative as fuel.Cashew Nut Shell is one of important sources of energy(Das and Ganesh 2003; Das, Sreelatha, and Ganesh 2004; Tippayawong et al. 2011).

In Benin,the cashew world is known for quality of itsraw product. Benin's cashew nut is very well priced on the international marketfor its quality. In agriculture sector, cashew constitutes Benin's second largest source of revenue after cotton. It is produced in the central and northern regions of country. Collines, Zou, Borgu, Donga, Atacora are the major cashew producing areas in Benin.Since 2001, the area and production of cashew nut in Benin has increased at an annual growth rate of 3.39 and 6.58 per cent respectively(Mensah et al. 2012). The cashew value chain represents an enormous economic, social and environmental opportunityfor Benin.The cashewindustry is a rapidly growing sector in Benin.The cashew processing sector comprises many industrial processing units with a capacity of1,000 to 100,000 tons/year, whose output is exported to the European market (Afonkantan Benin Cashew factory of Parakou, Kake-5 of Savalou, Nad& Co of Tchaourou, Tolaro Global Benin of Tourou, La lumiere of

Corresponding Author: -Thierry Godjo.
Address: -Department of Mechanical Engineering, University Institute of Technology of Lokossa, B.P. 133 LOKOSSA, Benin.

Tchetti, etc.), and small units with a lower capacity of150 tons/year, whose output is sold on local and regional markets (GK5, AFETRACA, ZANCLAN, SONGHAI Centre, GNICOBOU units, etc.).

Faced to difficulties to energy access and managementof waste from the processing of cashew nutsin Benin, the shells stored in cashew nuts processingplants are directly used as fuel. They are thereforeburned in kilns to provide the energy required to produceheat for embrittlement of nuts, steaming anddrying almonds. This non controlled combustion generates significant pollution because Cashew Nut Shell Liquid (CNSL), substancecontained in cashew nutshells, produces abundant and acridsmoke irritating to eyes(Tagutchou and Naquin, 2012).To overcome the problem of access to energy in Benin, some researches have been carried out on the energy production from cashew shells(Godjo et al., 2015). Thus, two pyrolysis plants have been constructed in Benin, on basis of a reactor designed by CEFREPADE and RONGEAD. Those reactors have been used in Benin for energy recovery from cashew nut shells.Although the pyrolysis products reduce the waste deposit and provide the energy needed for combustion, the exploitation ofbiochars remains incomplete: they are bulky and difficult to transport, because of their low density(Godjo, 2016). In order to help operators tobetter manage and facilitate the transport of biocharbons,the University Institute of Technology of Lokossa has successively developed two small scale equipments: a manual lever press and a hydraulic press. The analysis of physical and mechanical properties of the manuallever pressshowedthat degree of densification, impact resistance of briquettes and resistance to water penetration, were respectively 81%, 90%and 0.94(Godjo, 2017).Although both the developed equipments had significant densification rates (81% and 85%, respectively for manual lever press and hydraulic press), it remains to enhance the throughput (10 kg/hr and 90 kg/hr, respectively for manual lever press and hydraulic press). This paper presents the design of an efficient Expelling Machine for Briquettes made of biocharsfrom pyrolysis of cashew nut shells.

Materials and Methods:-

The Expelling Machine, for Briquettes made of biochars from pyrolysis of cashew nut shells, is designed to have the following components: hopper, screw conveyor, cylinder, power transmission, electric motor, elements (bearings, belts and pulleys). Materials selection for the various components of the machine was based on calculations.
The fully assembled machine is shown in Figure 1

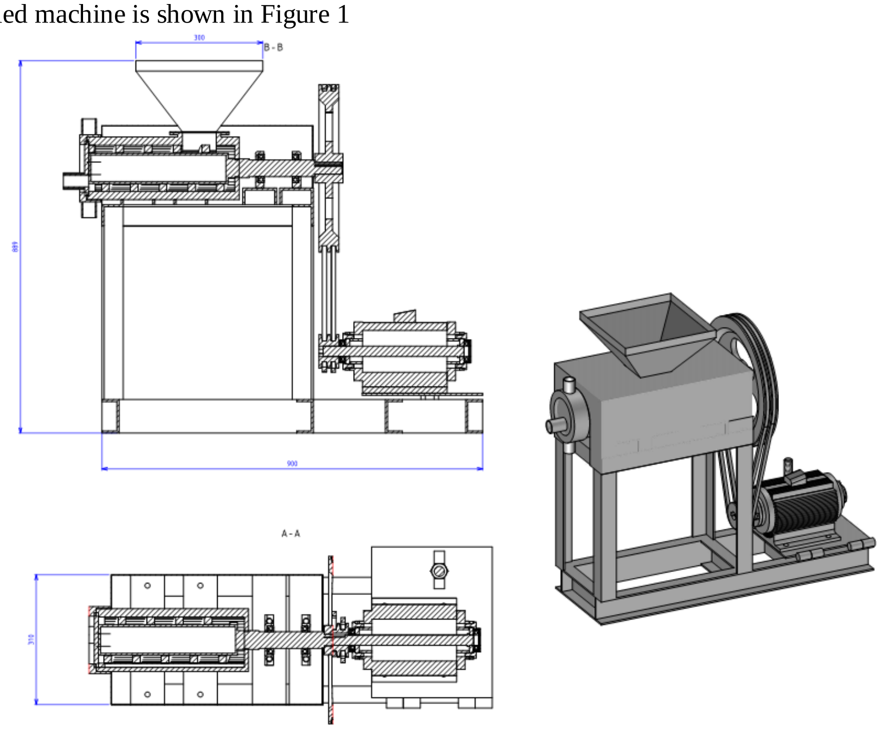

Figure 1:- Assembly drawing of theExpelling Machine for Briquettes made of biochars from pyrolysis of cashew nut shells.

Design considerations:-

Electric Motor Selection:-

The electric motor, for the designed machine is selected based on the load characteristics of machine. It is a three-phase 50Hz motor, for industrial purpose. The power of electric motor is the selected power allowing biomass conveying and rotating of screw shaft. An electric motor, with a power rating of 7 kW, was selected and the speed at shaft-end, 1450 tr/min.

Design power:-

Design Power (P_D) is obtained by multiplying power tobe transmitted by service factor. For screw conveyors, it's known that the service factor is from 0.96 to 0.99 (Wood and Wollenberg 1996).A service factor of 0.96is selected.

$$P_D = Pe * \mu \quad (1)$$

P_D = 7*0.69 = 6.72 kW

The torque developed can be obtained using equation(Lemm et al. 2011).

$$T = \frac{60}{2\pi N} * P_D \quad (2)$$

Where N is the Speed of the shaft

$$T = \frac{60}{2\pi * 1450} * 6.72 = 42.27 \text{ (N.m/rad)}$$

Design of Screw Shaft:-

The helical flight on the shaft is made from 2.5 mm thick steel. The helical flight ensures adequate transportation of cashew biomass without bending and at the same time exerts pressure on cashew biomass.

The length of screw is 329 mm with outside diameter of 111 mm andconstant throughout the length. The total length of shaft is 599 mm.

The dimensions ofscrew-shaft are shown in Figure 1.

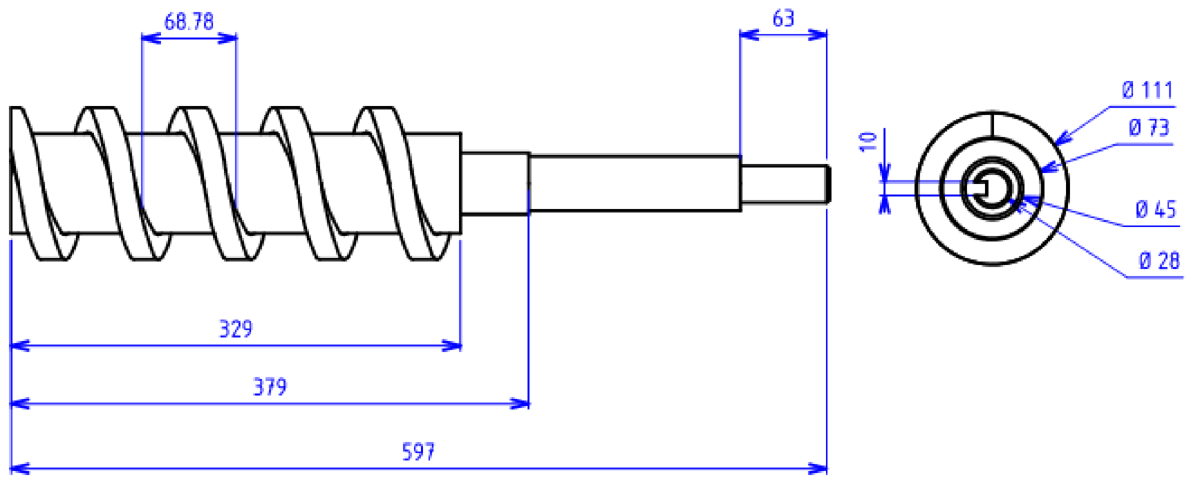

Figure 2:- Screw Shaft Definition Drawing

Design of Cylinder:-

The screw conveyor press is surrounded by a barrel which is cylindrical. The clearance between the barrel and screw conveyor is taken to be 2.5 mm. Galvanized steel (GS) pipe was used. The length, internal diameter and thickness were 400 mm, 150 mm and 5 mm, respectively. The opening for mounting of hopper was machined from 39 mm distance at the beginning of barrel. The Cylinder Definition Drawing is presented in Figure 2.

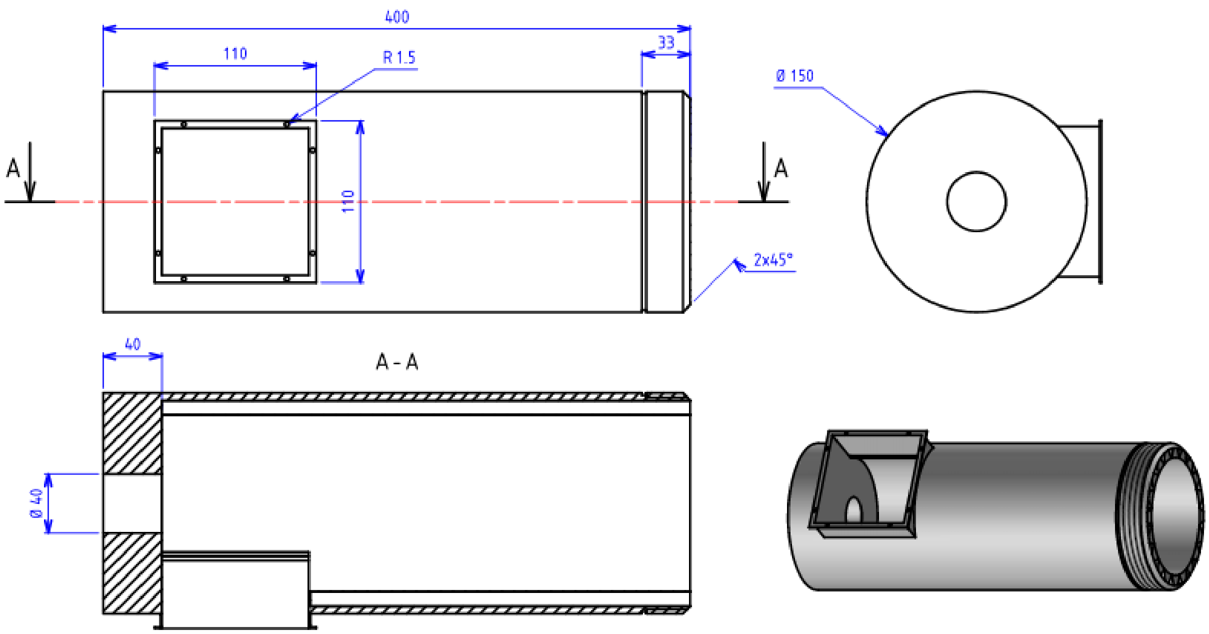

Figure 3:- Cylinder Definition Drawing.

Design of Hopper:-

A square frustum-shaped hopper (as in Figure 4) was constructed and mounted at the cylinder intake. It was constructed from 2 mm thick mild steel (MS) sheet.

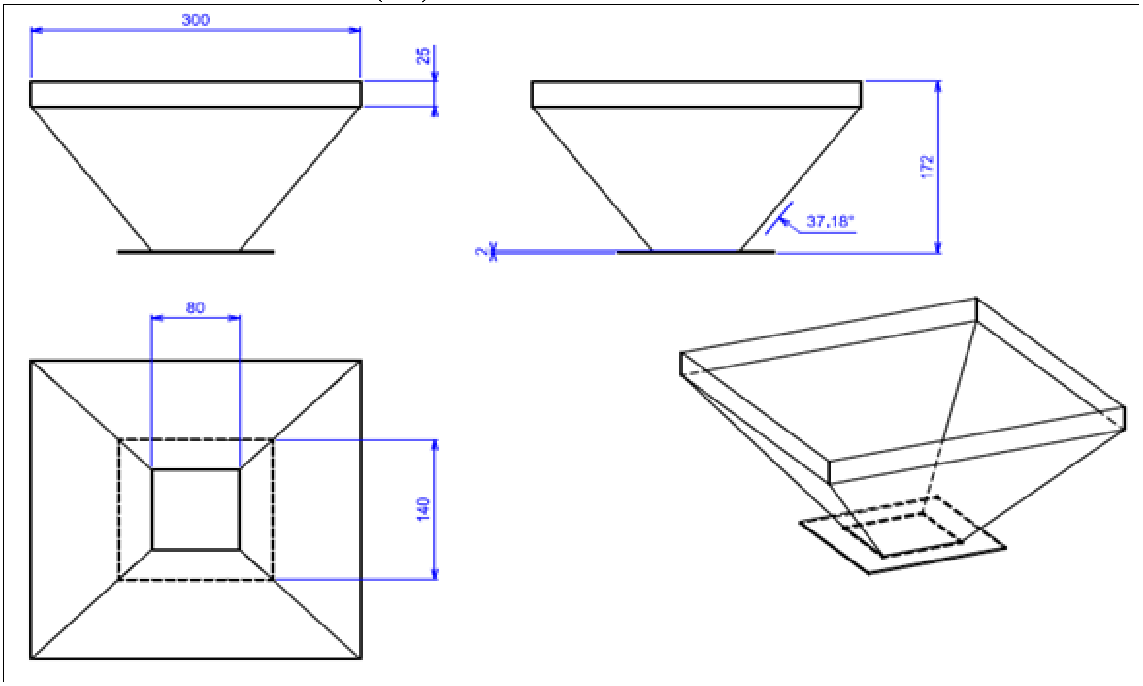

Figure 4:- Machine Hopper Definition Drawing

Design ofFrame:-

The dimensions of the frame is presented in Figure 5. It was constructed from 45 × 45 × 4 mm mild steel (MS) angle iron. The frame serves as the skeleton for other parts.

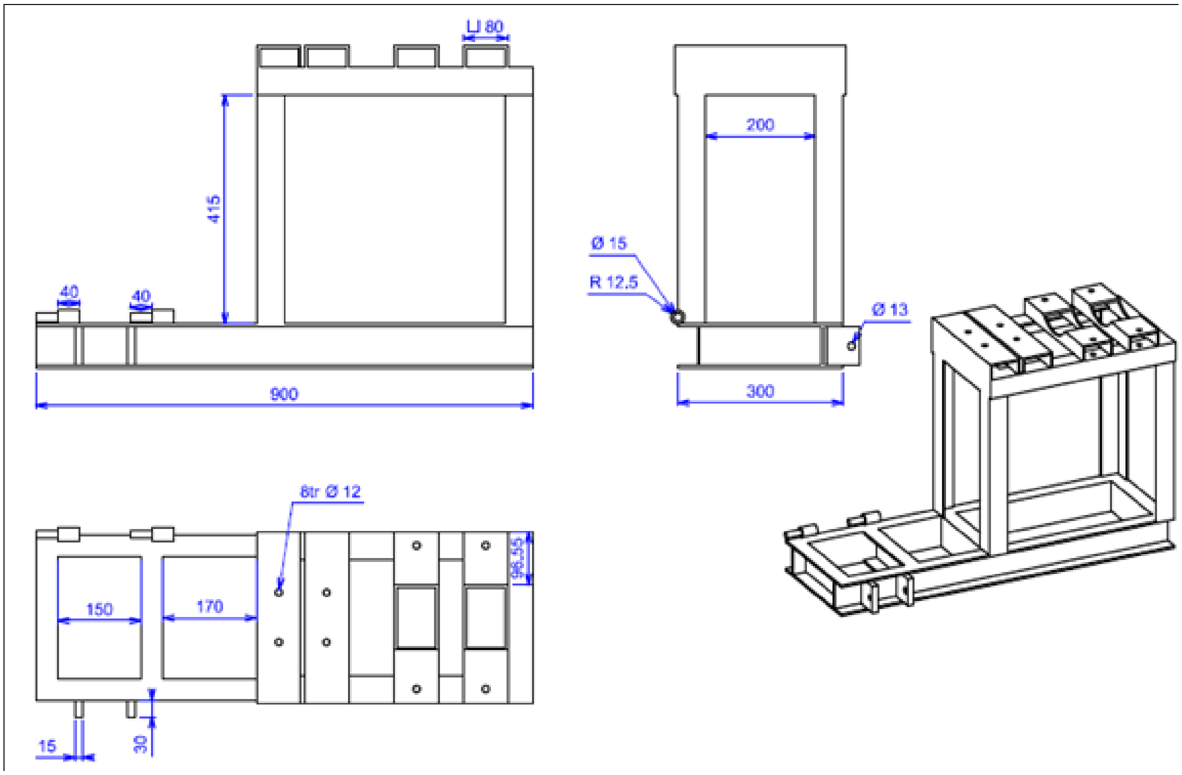

Figure 5:- Frame Definition Drawing.

Operation of the Expelling Machine for Briquettes made from cashew nut shell pyrolysisbiochars:-

The principle of operation involves the rotation of the helically flighted shaft in the cylinder. The electric motor was used to power the machine. The raw material are fed from the hopper to the screw conveyor which rotates in the expeller housing. When the electric motor is switch on, the screw, which conveys raw materials, moves and packs the raw material being heated along the passage to the far side. The compression is achieved by decreasing pitch of the auger, designed to act as a screw press. Thus, the machine compacts and expels the briquettes.

Machine Performance Evaluation:-

The performance indicators evaluated are the throughput capacity and expelling rate.

Throughput capacity:-

It quantifies the machine's capability in terms of quantity of cashew nut shells' biochars it can process, per unit time. It can be quantified using(Harmanto et al. 2009) relationship, as stated in following equation.

$$Throughputcapacity\ (\frac{kg}{hr}) = \frac{\text{cashew nut shell pyrolysis biochars}}{Timetakenforexpelling} \quad (3)$$

Expelling rate:-

The expelling rate quantifiesthe number of expelling Briquettes that machine is capable of expelling per unit time.

$$Expellingrate = \frac{NumberofexpellingBriquettes}{Timetakenforexpelling} \quad (4)$$

Results and Discussion:-

The summary ofpreliminary results of performance evaluation of the developed Expelling Machine, for Briquettes made of biochars from pyrolysis of cashew nut shells, is presented in Table 1.

Table 1:- Preliminary results of the performance evaluation of the developed Expelling Machine for Briquettes made of biochars from pyrolysis of cashew nut shells

		Expelling Machine for Briquettes made of biochars from pyrolysis of cashew nut shells
Structural characteristics and energy	Overall dimensions	0.90 m x 0.31 m x0.89 m
	Loading height	0.89 m above ground
	Energy used	Electric Motor
Technical Performances	Throughput(kg/hr)	500.32 ± 1.266
	Expelling Rate (number/hr)	1000 ± 1.115
	Efficiency (%)	96.500 ± 0.182
Final Product Characteristics	Weight (g)	200
	Shape	Irregular
	Average dimensions (mm)	[150-250]

The results presented in Table 1 show that the throughput of machine is 500.32 kg/hr and expelling rate, 1000 briquettes/hours. It's a better performance compared to those of manual lever press (Godjo 2017)and hydraulic press which have respectively displayed10kg/hr and 90 kg/hr as throughput and 70briquettes/hours and 420 briquettes/hours as expelling rates. The increase in throughput of the developed machine may be attributed to the reached pressure. In fact, the attained pressure, for kinds of Expelling Machines, is from 610 to 1350 kN/m² (Orhevba et al. 2016 ; Okoye, Jiang, and Hui 2008 ;Bahadar, Khan, and Mehran 2013) against 180 kN/m² for manual lever press and 350 kN/m² for hydraulic press.

Conclusion:-

The Expelling Machine, for Briquettes made of biochars from pyrolysis of cashew nut shells, is designed. This machine is conceived as ideal for biomass briquetting. Its expected capacity is 500 kg/hr and it can expel briquettes at the rate of 1,000 briquettes/hr. This results are of interest from the point of view of technic,ergonomic and environmental. Indeed, the capacity and the overall dimensions of the machine are those allowing a better ease and improving the use. Finally, the designed machine contributes to enhance the environmental footprint.

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