Journal of Sciences and Multidisciplinary Research
Volume 11, No. 3, 2019

DEVELOPMENT AND TESTING OFEXPERIMENTAL RIG FOR UNIVERSAL TESTING MACHINE (UTM)FOR COMPRESSION OF AGRICULTURAL RESIDUES

[1]Kudabo E.A, [2]Olaoye J.O and Gbadamosi, L
[1]Department of Food and Bio-Processing Engineering
University of Ilorin
[2]Department of Agricultural and Bio-Environmental Engineering Technology,
Kwara State Polytechnic, Ilorin
Email:ekudabo@gmail.com

ABSTRACT
Rig was developed for Universal testing machine of model SF 300-2041 installed at department of Agricultural and Bio-System Engineering, University of Ilorin to compressed and eject Sorghum Stover and Moringa shell grinds. The Rig consists of Pistons, Cylinder, Ejection unit and Base Plate. The Rig was tested using Sorghum stover grind and Moringa shell grinds on the UTM. The results of the test obtained from using the developed Rig on the universal Testing Machine are as follows: Modulus of Elasticity of 175.558n/mm^2 and 97.510N/mm^2 for Sorghum Stover and Moringa shell grinds respectively. The maximum Force at break for ejection was obtained to be 15.50N and 476.33 for Sorghum Stover and Moringa shell grind respectively.

INTRODUCTION
Numerous Agricultural waste materials can be used to form briquettes which are alternate source of energy, namely Sorghum Stover, Saw Dust Rice husk, Coconut shell,Tobacco stem and Maize stalk e.t.c. The process of production of briquettes involves the application of compressive force to the agricultural waste to enhance densification and makes the material combustive. There is therefore the need to study the rheological/ mechanical behaviours of different agricultural materials and model their parameter to enable prediction to be made on their suitability for briquettes. The appropriate instrument for determination of all these properties is Universal Testing Machine (UTM). However there is the need to have devices that will match the UTM. The objective of this paper is to develop a rig that will be fitted with the UTM for further experimentation.

Sorghum is one of the Cereals(Agricultural products) in Nigeria. It is grown nearly in all the states of Nigeria and have high waste that could be used to produce briquette as renewable energy. Moringa shell grind could be used as pellet for animal feed or for energy depending on the farmer choice. It grows now in many places and is of high nutrient content for feed. For utilization of all this plants waste as renewable biomass materials in various applications, densification is one of the essential pre-processing steps to be considered in the Biomass conversion Process.

LITERATURE REVIEW

Densification characteristics of several biomass residues such as alfalfa, Wheat straw, barley straw, rice husk and saw dust have been studied in the past(Mani *et al.,* 2003). Both densification machine variables (Pressure) and biomass variables (particle size, Moisture content and Pre heating temperature) have been reported to influence the density and strength of dandified products made from the biomass material (Mani *etal.,* 2003; Kaliyan and Morey, 2009).During the initial stage of Compression, particles rearrange themselves under low Pressure to close packing and inter-particle air is removed from the bulk material. During this phase the original particles retain most of their properties. Energy is dissipated due to inter particle and particle towall friction. At high pressures the particles are forced against each other even more and undergo elastic and plastic deformation, thereby increasing inter-particle contact. Because the particles approach each other closely enough, short range bonding forces like electrostatic forces and sorption layers become effective. Under yield Stress brittle particles may fracture leading to mechanical interlocking of particles. At higher pressures reduction in volume continues until density of the compacted material approaches the true density of the particles. If the pressure applied is high enough to generate heat, some of the component of the particle will melt locally. Once cooled the molten particle would form very strong solid bridges. After removal from the die, the compacted material will relax (elastic spring back) due to residual stresses and released of compressed air (Kaliyan and Morey, 2009).

Shakya*et al.,* (2006) finding shows that agricultural residues like ground nut shells, straws, tree leaves, grass, rice and maize husks, banana leaves and sawdust can be used for briquette making. Although some materials burn better than others, the selection of raw material is usually most dependent in what is easily available in the surrounding area of where the briquettes are made. The briquettes can consist of a blend between several different raw materials. However to use agricultural residues efficiently for energy production, a detailed knowledge of its physical and chemical properties are required.

MATERIALS AND METHODS

Development of Experimental Rigs

Rig for this research, is a cylindrical mild steel rod of inner diameter 20 mm and outer diameter 32mm and of height 350mm. It was machined to this size. It also has a spindle that presses the material down the cylinder. Figure 1 and Plate 1 shows the piston and the cylinder of the compression unit while Figure 2 shows the sectional view of the rig with the ejection apparatus for ease removal of the briquettes after compression. Plate 2 shows the briquette Ejection apparatus while Plate 3 shows the bottom of compression support.

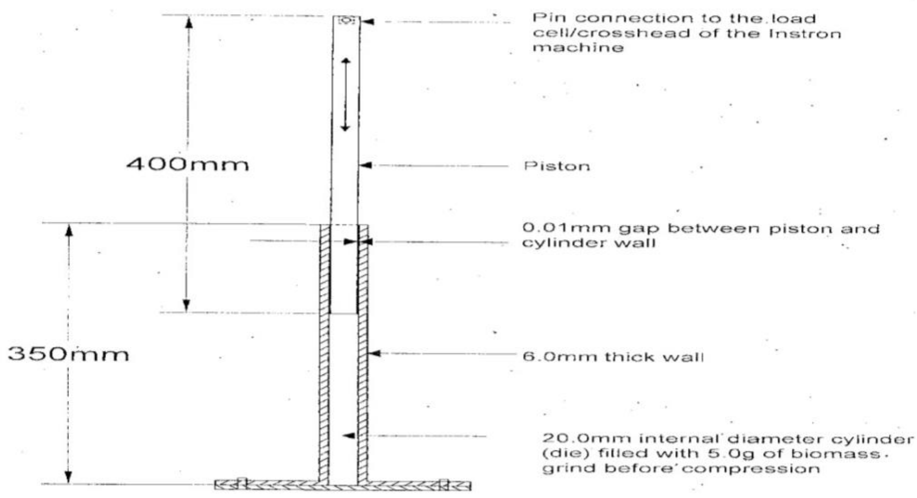

Figure 1: Sectional View of the Rig

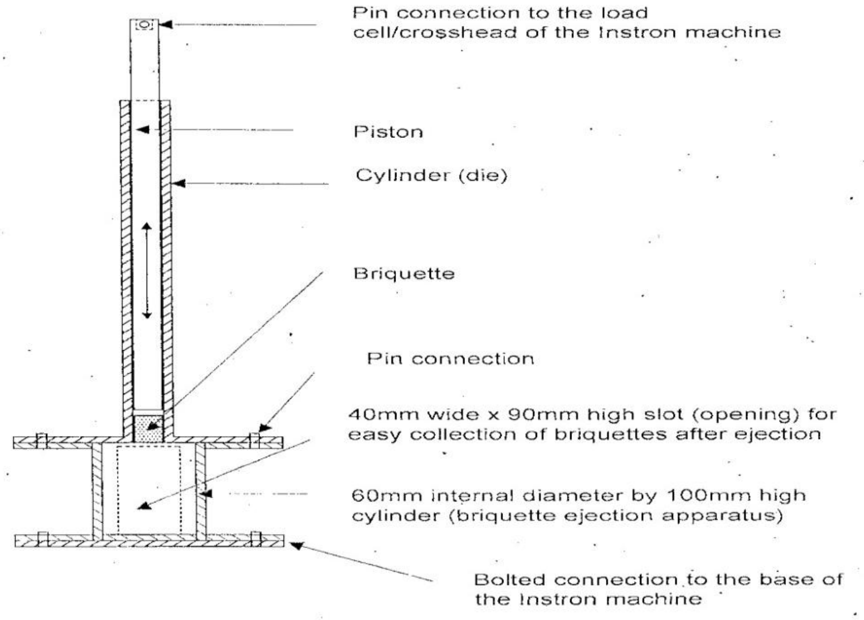

Figure 2: Sectional view of the Rig with the briquette ejection apparatus.

Plate 1 Briquette Compression Cylinder and the Piston (Fabricated)

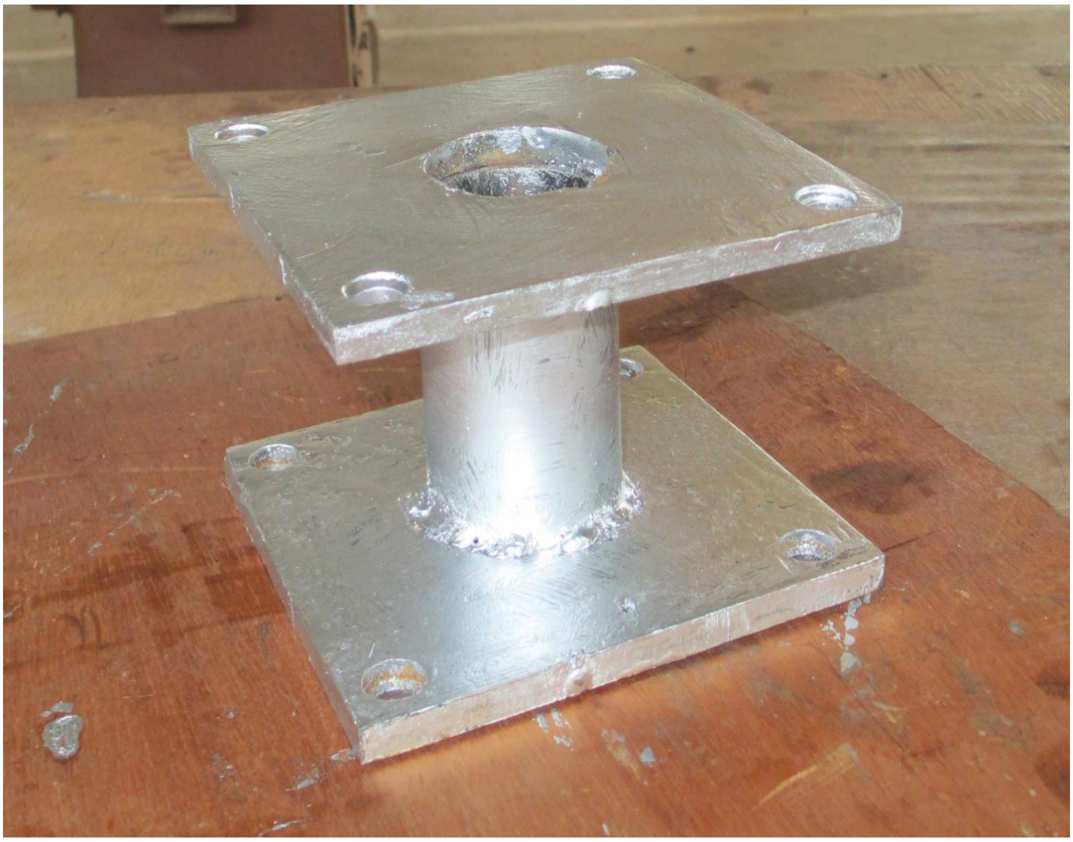

Plate 2 Briquette Ejection Apparatus (Fabricated)

Plate 3Bottom of the compression support

Universal Testing Machine

Universal testing machine of model SF 300-2041 at department of Agricultural and Bio-System Engineering, University of Ilorin was used in this experiment. The Universal Testing Machine is as presented in plate 4

Materials for the Research Work

The materials and equipment that were used in the research work are as follows: Sorghum Stover grind, Moringa grind, Hammer mill with Shredder, Rig, Universal Testing machine, and Weighing machine.

Plate 4 Universal Testing Machine.

Plate 5 Dry Sorghum Stem and Leaves **Plate 7 Castor Oil Stover.**

Biomass samples

The sorghum Stover (***Sorghum bicolor***) that was used in this research was harvested and stored inside open shed in the department of Agricultural and Bio- Environmental Engineering Technology, research farm, Kwara State polytechnic, Ilorin. Moringa shell was obtained from residence at No 30 Muhammed Raji street Tanke Iledu, Ilorin, Kwara State, Nigeria. A 10 Hp hammer mill with sieve 3mm was used to grind the Sorghum Stover and Moringa shell. After hammer milling the grinds had (10 %) moisture content wet basis. Bulk densities of the grinds, were calculated from the mass of grinds that occupied a 250ml glass container (Kaliyan and Moore 2006). While measuring the bulk density of the grinds, the glass container was manually filled by slowly discharging the samples to the container from a height of about 100mm, and the container with the sample was tapped gently about 4 -6 times on a laboratory bench to remove large voids inside the sample as well as to reduce the sample filling error.

Briquetting procedure

All the experimental units were conducted using universal testing machine FS 300-02041. The machine was controlled by a computer loaded with software.10.0g of biomass grind was added to the die with a funnel. A steel rod was used to stir the grind for ease flow from the funnel.

Subsequently the bottom of the piston was inserted into the die, and the top of the piston was connected to the cross head of the testing machine load cell by a pin connection. Computer software was run, which actuated the crosshead piston to compress the grind from zero pressure to a set maximum pressure at a constant speed of 25.4mm min^{-1} (Kaliyan and Moore 2006).

The compression step involved loading (i.e application of pressure) and unloading (i.e removal of pressure) processes. During loading, the piston went down and compressed the grind. During unloading the piston went up and the briquette formed inside the die relaxed. After the completion of the compression stage, the piston was taken out of the die and the die was removed from the base of the machine and the ejection apparatus was then place on the Universal Testing machine and the die placed on top of the ejection apparatus.

A separate program (setting) was used to operate the crosshead – piston to push (i.e eject the briquette out of the die. A constant crosshead speed of 25.4mm min^{-1} was used to eject the briquette

Plate 8 Sorghum Stover grind.

Plate 9Moringa Shell grind.

RESULTS AND DISCUSSIONS

Plate 9 and 10 shows the briquette obtained from the test conducted this revealed that the rig developed produce briquette adequately. Table 1 shows the result obtained from the experiment conducted and it reveals many mechanical properties of the briquettes produced during

Compression and ejection process from Universal Testing Machine (UTM.

Sorghum Stover grind has means EN 826.compression Modulus of Elasticity of 175.558N/mm^2 while Moringa Shell grind has 97.510N/mm^2 under compression force using a load cell of 300kgf. The ejection stage have means value of 22.738 N/mmm2 and 38.422N/mm2 EN 826.compression Modulus of Elasticity forSorghum Stover andMoringa Shell grind respectively. This shows thatSorghum Stovergrind has highEN 826.compression Modulus of Elasticity toMoringa Shellgrind; henceSorghum Stovergrind is more durable thanMoringa Shell grind. At similar condition Sorghum Stovergrindproduced better quality briquettes thanMoringa Shellgrind. This could be due to the differences in the cell structure compositions and Mechanical properties (Kaliyan and Morey 2007).

Figure 1 shows the relationship between the applied force and deflection, it revealed that Sorghum Stover behave to a greater degree elastics characteristics. There was progressive Change in deflection of Sorghum Stover till about 500N force. Figure 2 shows that the ejecting force for Sorghum Stover grind ranges from 280N to 400N. The stress- strain behaviour of the Sorghum Stover and Moringa Shell revealed that Sorghum Sover has Stress of 42.473N/mm2 and Strain of 112.831% while Moringa Shell grind has Stress of 42.511N/mm2 and Strain of 109.75%. This implies that the two has a closed value of Stress

Moringa has the higher Energy to brake of 237.55N-m to that of Sorghum Stover of 139.239N-m. This may be as a result of high bonding in Moringa to that of Sorghum Stover. Physical observation of the briquette produced shows that Moringa Shell grind has a fine Structure.

Figure 3 shows that the Moringa Shell grind deflection increased as the applied load increases but more pronounced to force 1000N with corresponding deflection of value between 60-136N

Plate 10 Sorghum Stover Briquette obtained from UTM

Plate 11 Moringa Shell Briquette obtained from UTM

Table 1 Mechanical Properties of Briquettes produce from Sorghum Stover and Moringa Shell.

Mechanical Properties from UTM	Compression Process		Ejection Process	
	Sorghum Stover grind (n=3)	Moringa Shell grind (n=3)	Sorghum Stover grind (n=3)	Moringa Shell grind (n=3)
EN 826 Comp. Modulus of Elasticity (N/mm)	175.558	97.510	22.738	38.422
Energy to Break (N-m)	139.239	237.553	3.095	61.906
Energy to Peak (N-m)	139.239	237.553	1.385	47.326
Energy to Upper Yield (N-m)	139.239	237.553	1.385	1.640
Force@ to Break (N)	3072.000	30049.00	15.50	476.333
Force @ Peak (N)	30022.500	30049.00	376.250	1288.75
Force @ Upper Yield (N)	30022.500	30049.00	376.250	945.250
Strain @ Break (%)	112.831	109.751	108.789	90.747
Strain @ Peak (%)	112.831	109.751	74.440	56.053
Strain @ Upper Yield (%)	112.831	109.751	74.440	25.929
Stress @ Break (N/mm^2)	42.473	42.511	0.022	0.674
Stress @Peak (N/mm^2)	42.473	42.511	0.532	1.823
Stress @Upper Yield (N/mm^2)	42.473	42.511	0.532	1.337
Time to Failure (sec)	67.710	65.848	65.276	54.455
Young Modulus (N/mm^2)	175.558	97.510	22.738	38.422

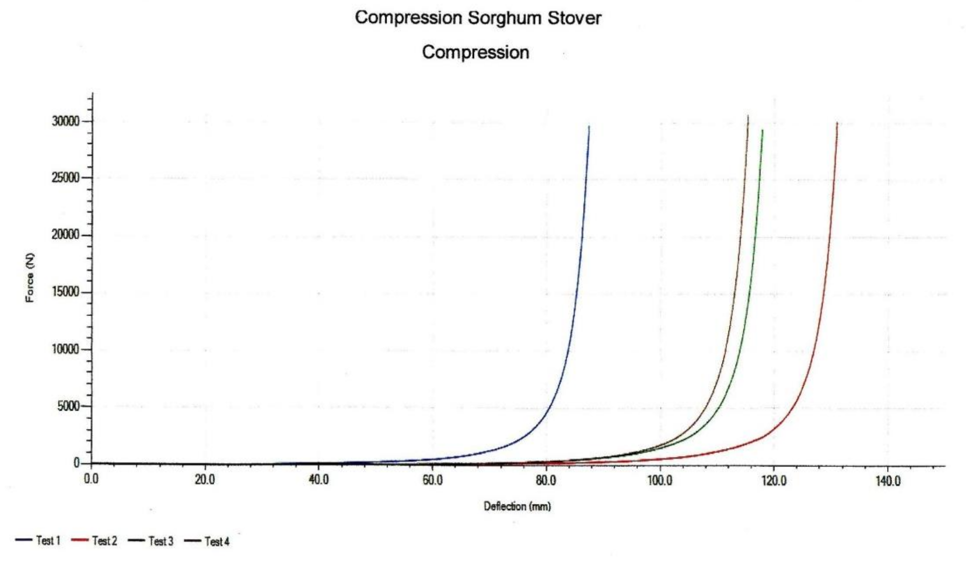

Figure 1 Effect of deflection on force require to compress grind Sorghum Stover

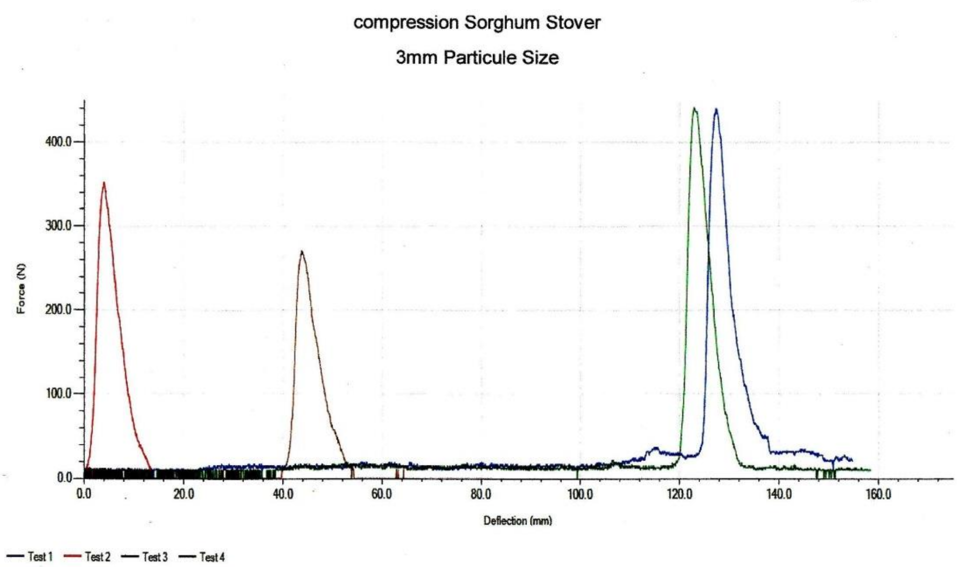

Figure 2 Effect of deflection on force require to eject the Briquettes

Reference to this paper should be made as follows: Kudabo E.A, Olaoye J.O and Gbadamosi, L (2019), Development and Testing of Experimental Rig for Universal Testing Machine (UTM) for Compression of Agricultural Residues. *J. of Sciences and Multidisciplinary Research,* Vol. 11, No. 3, Pp. 17-28