Design of Compact Briquette Machine

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Abstract: The paper presents the design of the compact briquette machine. This working model basically utilizes the dry coconut waste as raw material which is the abundant source as biomass obtained from the religious places, farming sectors and local areas. Molasses is the binding agent which is the by-product of sugar industry which is also the solid industrial waste. This paper involves the design of motor, cutter, compaction mechanism and belt and pulley use as its primary components. The main purpose of designing this compact unit is to integrate the processes involved in the briquetting and reduce the cycle time required for the biomass production. The machine uses the shaft of 38mm diameter and the outer diameter of the screw is 55mm. This model works on the 2Hp motor to drive the unit.

***Index Terms*–Briquettes, molasses.**

I. INTRODUCTION

A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire. The term comes from the French language and is related to brick. Utilization of agricultural residues is often difficult due to their uneven and troublesome characteristics. The process of compaction of residues into a product of higher density than the original raw material is known as densification or briquetting. The briquette machine can be used in producing high quality wood shaft with low cost sawdust, corn cob and peanut shell, cotton stalk, tree branch, etc. The final stick is with high density for the fuel. It is one of the newest energy recycle machine, which has important use for the energy Industry. This machine is used for making the briquette from the sawdust, straw, hulls, coconut waste etc. It is best fuel and the feedstuff of animal. The briquette can be used as the burning material for the boiler or fire place for house warming. Briquettes can be produced with a density of 1200 kg/m^3 from loose biomass of bulk density 100 to 200 kg $/m^3$ these can be burnt clean and therefore are eco-friendly. Due to their heterogeneous nature, biomass materials possess inherently low bulk densities, and uneven and troublesome characteristics thus, it is difficult to efficiently handle large quantities of most feed stocks. The process of compaction of residues into a product of higher density than the original raw material is known as densification or briquetting.

Justina et al.[2] stated that the beginning of19th century, sawdust briquettes were made with tar or resins as the binders, but could not gain importance at that time due to relatively higher costs compared to wood and charcoal. But re-emerged in the 1950s when millions of tons of briquettes were produced and consumed . M.U. ajieh et al.[1] stated that here occur several materials indicating machine designs or squeezes for wood briquetting especially in the developed countries of the world. Uniformly, remarkable research from Authors across Asia shows that there is appreciable proof of wood briquetting as well as the use of wood as fuel wood in the backwoods areas for cooking in an open fire or stove. In Sub-Saharan West Africa and the rest of Africa, wood logging is predominantly used for direct combustion and building infrastructures. The subject of wood briquetting is very common, however there exists a considerable number of literature on the use of solid waste and agricultural residues for briquettes.Briquettes are largely combustible materials made from loose or low density wastes but compressed together into a solid. The compression leads to a product of higher bulk density, '-uniform size and shape. Developing countries are facing huge problem with waste management and agro residues such as coir pitch, dry leaves, rice husk, coffee husk etc., are contributing majorly to this problem. We usually see these agro residues and saw mill residues are usually burnt on roadside or dump yards, which again results in pollution.

Majid Ali et al [4] suggesdted that there are two types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibres are commercial available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used. According to official website of International Year for Natural Fibres 2009, approximately, 500000 tonnes of coconut fibres are produced annually worldwide, mainly in India and Sri Lanka. Its total value is estimated at $100 million. India and Sri Lanka are also the main exporters, followed by Thailand, Vietnam, Philippines and Indonesia. Around half of the coconut fibres produced is exported in the form of raw fibre. Muhammad SN et al [5] investigated that most of the biomass materials are, however, not suitable for direct utilization, because they are fluffy, uneven in size and shape and have very low density.These differences not only make difficult to handle, transport and store the biomass material in raw form. There are numerous ways to resolve these problems, of which briquetting is the most commonly utilized technologies. Kiran Kumar et al [3] studied the end use of briquettes is mainly for replacing coal in industry for heat applications (steam generation, melting metals, space heating, brick kilns, tea curing, etc) and power generation through gasification of biomass briquettes and for domestic uses.

II. METHODOLOGY

A briquette is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire. The term comes from the French language and is related to brick. Utilization of agricultural residues is often difficult due to their uneven and troublesome characteristics. The process of compaction of residues into a product of higher density than the original raw material is known as densification or briquetting. Fig.1shows the isometric view of the proposed machine.

The above fig.6 shows the isometric view of the proposed model having part details are as follows:

1. Hopper	9. Coupler
2. Pillow block bearing	10. Allen Bolt
3. Larger pulley	11. Mixer
4. Belt	12.Compaction barrel
5. Small pulley	13. Die
6. Motor	14. Frame
7. Speed reducer	15. Casing
8. Cutter shaft	

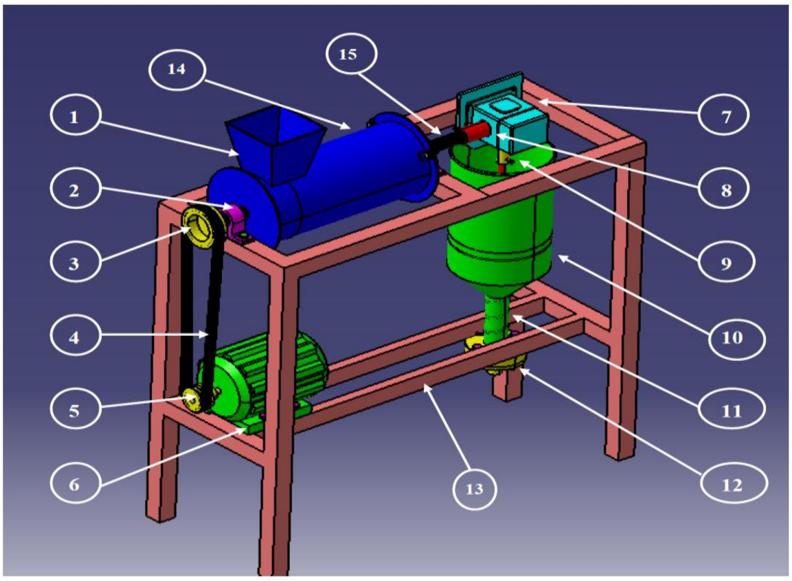

Fig.1: Isometric View of proposed model

The main function of the frame and base is to give the support to the whole unit. In supports the cutter and casing unit, pedestal bearings, extrusion and mixing unit, motor and die. For manufacturing of the frame the MS angles are used. The whole structure is joined together by means of the welded joint. As shown in fig.2. the frame support structure. The design of frame is done by using the Rankine's formula in which W_{cr} is the crippling load, 'a' is the Rankine's constant for MS material and K is radius of gyration.[6]

Rankine's Formula, $Wcr = \frac{f \ x \ A}{1+a(\frac{Le}{K})^2}$

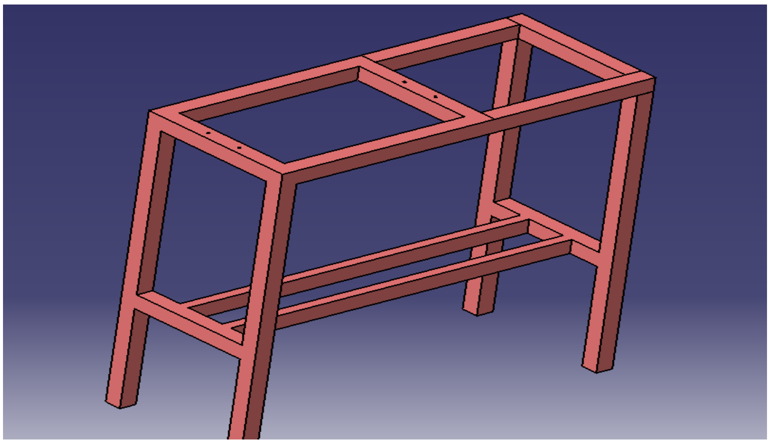

Fig.2: Design of support structure in CATIA

Prime mover is the basic part of this unit which is used to convert the electrical energy into useful motion. The drive units such as the belts and pulleys are used to transmit the motion from prime mover to the driven units. The briquette machine utilizes the electric motor as its prime mover to transmit the rotary motion to the cutter. The system requires electric motor to achieve the rotary motion of the cutter. It converts the electrical energy into rotary motion. It not only give the power to cutter but also give the power to the extrusion unit. In the above equation N is the rpm of cutter and T is the torque acted on it.

Power required to rotor, $Pout = \frac{2\,x\,\pi\,x\,N\,x\,T}{60000}$, kw [6]

As we are using the coconut biomass as our raw material which is having the maximum strength among all the other biomass. The strength of the raw coconut husk fibre is 130N/mm.^{2}. The maximum torque obtained at the rotor shaft is given by Tc = Fc x R. where R is the radius of the rotor, Fc is the force acting on the rotor. The fig.3 shows the design of the cutters which are mounted on the rotor.

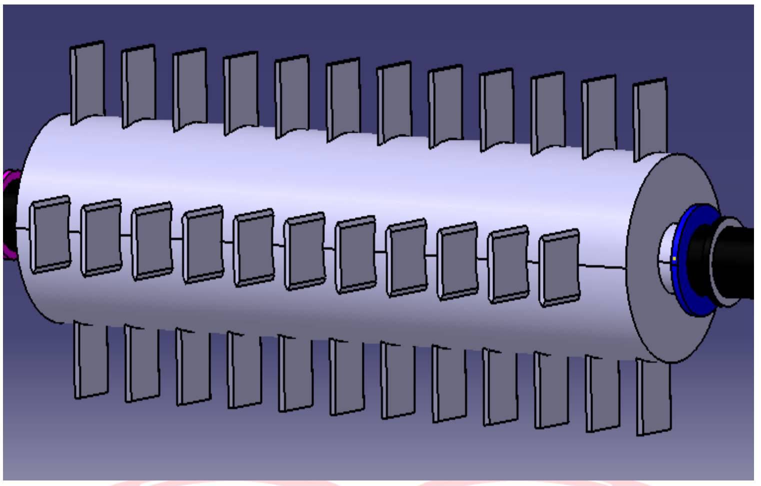

Fig.3: Design of cutter in CATIA

The power required to overcome frictional losses can be computed assuming 10% losses due to frictional forces. Essentially, the shaft is designed on the basis of strength, rigidity and stiffness. The shaft is the main component of the cutter section. The rotor is also mounted on the rotating shaft. The rotor consists of the different small cutters are mounted on it. The above equation will give the value of diameter of shaft in which the 'd' indicates the diameter of shaft, τperindicates the permissible shear stress, 'T' indicates the torque, 'm' indicates the maximum bending moment.[6]

$$\frac{\pi}{16} * d^3 * \tau per = \sqrt{(Kb * m)^2 + (Kt * T)^2}$$

The main function of the pulley and belt drive is used to transmit the power and torque from motor shaft to the cutter rotor which is mounted on the shaft. The pulleys are used. As the large sized pulley is use at the cutter shaft while the small size pulley is mounted on the motor output shaft. The available data is input power, P_{in}= 2 Hp=1.5 kw, input speed, N_1=1440 rpm, approximate central distance, C=584 mm. As the system is motor driven and medium duty application (<10hrs/day duty) So, service factor can be selected as F_a= 1.1.

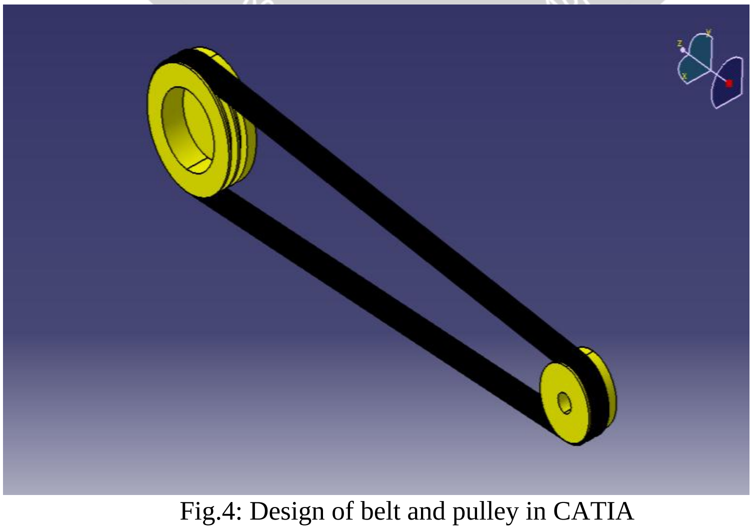

Fig.4: Design of belt and pulley in CATIA

Fig.4 shows the design of belt and pulley in CATIA. As per the design power calculations and the speed of faster pulley we've to select "A-grade" v-belt by using graph relation. Speed ratio and pulley pair selection. i = $\frac{N1}{N2}$, where N indicates the speed.

Pitch length, L = $2c + \frac{\pi}{2}(D + d) + \frac{(d+D)^2}{4C}$

Exact central distance, C= A + $\sqrt{A^2 + B}$

Where, A= $\frac{1}{4}\left[L - \frac{\pi}{2}(D + d)\right]$ and B = $\frac{(D-d)^2}{8}$

Length of arc of contact for smaller pulley, ϴ = $180^0 - sin^{-1}\left[\frac{D-d}{L}\right]$

Belt speed, V = $\frac{\pi DN}{60000}$

Belt Rating, $kW_{rating} = \left[0.45v^{-0.09} - \frac{19.62}{de} - 0.765\ x\ 10^{-4}\ x\ v^2\right] v^2$

Number of belts required, Z= $\frac{Design\ power}{[kW]m} = \frac{1.65}{0.8585}$ = 1.92 = 2

The speed reducer is the basically used to transmit the power from the input power of the cutter to the output screw which is used for the extrusion. The reducer transmits the power without losses. It transmits the power to the screw shaft which is in perpendicular direction with the cutter shaft. The speed which is required for the solid and liquid mixing of the molasses and the husk waste is ranges from the 60 to 120 rpm. So, we have selected worm gearbox as per the specifications of worm gearbox, $Zw/Zg/q$ / m where Zw is the number of teeth on worm, Zg is the number of teeth on gear, ‘q’ is the dimeteral quotient and ‘m’ is the module. Fig.5. shows the worm speed reducer. [6]

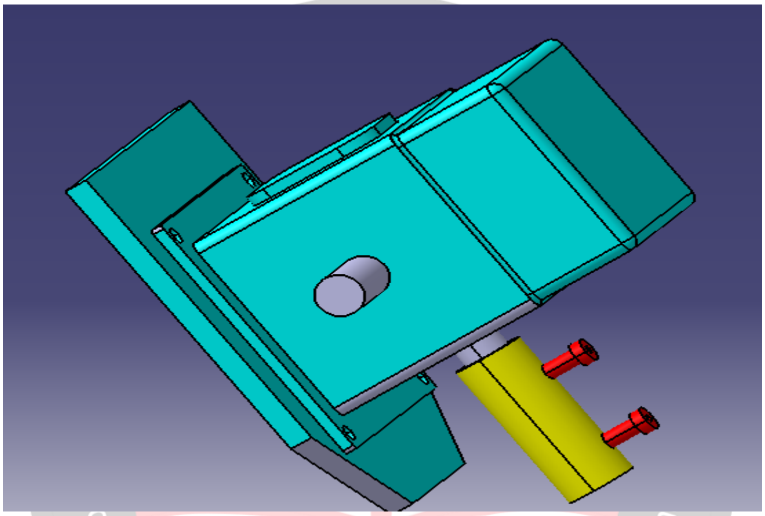

Fig.5: Speed reducer in CATIA

In a screw extruder, the rotating screw takes the material from the feed port, through the cone section of the mixer unit, and compact it against a die which assists the build-up of a pressure gradient along the screw. During this process the biomass is forced into intimate and substantially sliding contact with the barrel walls. This also causes frictional effects due to shearing and working of biomass.

The combined effects of the friction caused at the barrel wall, the heat due to internal friction in the material and high rotational speed of the screw cause an increase in temperature in the closed system which helps in heating the biomass. Then it is forced through the extrusion die, where the briquette with the required shape is formed. At this stage just before entering the die, the pressure exerted is maximum. If the die is tapered the biomass gets further compacted. Fig.6 shows the compaction screw made in CATIA. The tangential force acting on screw is given by $(Fw)t = \frac{Tw}{\frac{dw}{2}}$

The radial force is given by, $(Fw)r = (Fw)t * \frac{tan\varphi n}{sin\lambda}\left[\frac{tan\lambda}{tan\varphi v + tan\lambda}\right]$

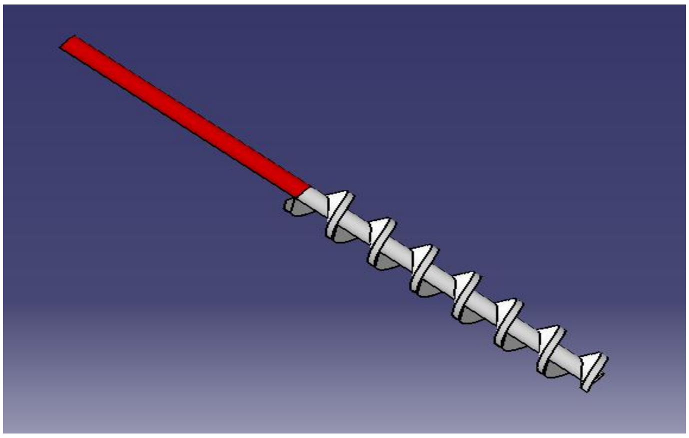

Fig.6: compaction screw made in CATIA

III. RESULTS AND DISCUSSION

Table. 01: Design Specification

Sr.	Parameter	Data
1	Electric Motor	2Hp
2	Belt Designation	A56
3	Large pulley diameter	127 mm
4	Small pulley diameter	50 mm
5	Centre distance	560 mm
6	Blade dimensions	38 x 2 mm
7	Cutter shaft diameter	38 mm
8	Screw Diameter	M56
9	Gear ratio	15
10	No. of belts required	2
11	Angle dimensions	35 x35x 2.5 mm
12	Kw rating	0.9825
13	Speed reducer designation	2/30/10/4
14	Force on screw	3189.03 N

CONCLUSION

This project produces the briquettes from the waste biomass sources such as coconut husks as well as the other biomass. As we have already seen the design of this compact machine. It is more compact than the existing machines with better product output. Apart from the existing machines this machine integrates the processes involved in it, so this will ultimately reduces the cycle time required for the briquettes production.

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