Journal of Manufacturing Engineering, December, 2013, Vol. 8, Issue. 4, pp 244-248

PRODUCTIVITY IMPROVEMENT IN SCREW TYPE BIOMASS BRIQUETTING MACHINE BY IMPROVING MOULD LIFE

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ABSTRACT

In this paper the details of the actual experiments done on a screw briquetting machine to improve the life of the mould by various process and the improvements obtained are discussed. The main difficulty faced by the users of screw briquetting technology is the frequent wear of the screw and the die (mould). The screw on normal conditions of operation has worn out in just 4 hrs in a 400 kg/hr capacity machine. On experimental conditions using various hard facing techniques up to 18 hrs of production for screw has been achieved. Many researchers are concentrating mainly on improving screw life. But the die also has severe wear problem but it is not given much priority. But actually the wear of die induces the faster wearing out of screw as the raw material flows back through the gap formed between the mould and screw and stops the production. There is a very high probability of improving the life of screw and the productivity by designing a better mould. From the experiments it was found that the usage of W2C coating on EN8 by the method of furnace bracing improves the life of the mould from 4 tons to more than 40 tons which is a 10 times improvement in productivity as for as the mould is concerned.

Keywords: *Briquetting, Wear Protection, Mould Life and Biomass.*

1. Introduction

The rough estimate of biomass availability in India is estimated at 500 million metric tons per year and in it the surplus amount, after all kinds of ineffective uses, is around 30% with a potential to generate 16,000MW. India has more than sufficient availability of biomass fuels like bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, coffee waste, de-oiled cakes, jute wastes, groundnut shells and saw dust. In spite of the potential the actuality is constrained by issues like food security, non availability of commercially viable technologies, infrastructural bottlenecks in feedstock supply chain and seasonality and distributed nature of harvesting. On the policy front lack of uniform and fair Tariff regime and insufficient financing mechanisms are hindering the growth of India’s biomass power market. A biomass based power project relies heavily upon the availability of biomass at a sustained level and affordable cost over a long period of time as projects generally recover money over 10-15 years. Though biomass in the form of agro residues is available in most part of the country without regional limitations there are quantity and seasonal fluctuations and long lean periods. Proper inventory storage models are needed to make the plant loading stable [1]. By proper collection and storage strategies plant load factor can go up to 85% which is 3 times higher than wind and solar based power projects. To ensure that a TIFAC report has suggested anchor suppliers of biomass like sugar mills and rice mills and the set up of cooperatives or local bodies which follow the method of milk societies and ensure fixed amount of residues for a sustainable period [2].

Even if a big network of biomass collection is set up their operational profitability is doubtful. Most of the agricultural residues have very low bulk density and which makes it difficult to handle, transport and store. Further they are of varying varieties and of different sizes and shapes, it is very difficult to sort, process and load before transporting. This problem can be reduced by biomass densification with a ratio of approximately 7:1 to form briquettes [3]. At all the major collection centers briquetting plants should be set up and the collected materials should be made into briquettes before storage and transport. The briquetting process has the following advantages: 1. the net calorific value/unit volume increases, 2. the briquettes are easy to transport and store, 3. most of the briquettes will be of standard size which can be fixed as per the requirement. Most of the various biomass densification processes come under the types 1. High pressure compaction, 2.Medium pressure compaction with heating, 3.Low pressure compaction with binder. No binders are required if the

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The content of this manuscript has been presented in 3rd International Conference on Recent Advances in Material Processing Technology (RAMPT’13)

particles deform under high pressure and they are joined together by van der Walls' forces and interlocking. But still some materials need binders to become briquettes. Most of the agricultural residues need no binders as the lignin composition in them act as a binder under heat and pressure.

2. Literature Survey

Due to various technical constraints and the lack of research skills to simplify the technology briquetting technology is yet to develop fully in emerging economies. Ensuring the availability of raw materials and its quality without destroying the ecosystem beyond repair are the crucial factors for its success [4]. As per Regional wood energy development programme in Asia (RWEDP) briquetting of biomass residues for fuel is an important option but the option should not be advocated indiscriminately. The viability of this option depends on site- specific conditions like local resource bases, environmental conditions, fuel markets and infrastructure [5]. Based on those insights regular research is going on in finding the real potential, designing the efficient equipments, modeling sustainable systems and analyzing the cost. On international level there is more than sufficient interest in developing the biomass briquetting as an alternate fuel. By the European Commission it is commonly agreed, that one promising option to reach their energy targets is the use of biomass as a renewable energy carrier. As biomass is carbon neutral, during growth process as much CO2 is captured via photosynthesis as is released during thermal utilization and consequently net carbon emissions equal zero [6]. On Nov. 3,2012 the world's first biomass exchange was launched from Rotterdam, Netherlands, by Energy Exchange APX-ENDEX (Amsterdam Power Exchange-European Energy Derivatives Exchange), The trade platform is, besides standardize and certify products, indispensible to make energy generation more sustainable. Even in emerging economies biomass is considered as the engine of growth. Biomass accounts for 92% of final energy consumption in Tanzania and the total biomass resources for is about 27 million tons of oil equivalent (TOE) from the natural forests and other major industrial biomass energy sources include saw mill industry, sugarcane plantations, sugar industry by-products, cashew nut industry, coffee industry and sisal industry. The major uses of biomass are wood fuel for domestic purpose, tobacco production, brick making, tea drying and fish smoking [7].

Efforts are being put in various fronts in designing various equipments to utilize biomass not only as briquettes for fuel. An extruder capable of converting crop residues and low-cost industrial by-products into briquettes of about 25mm diameter which can be used as cattle feed has also been designed. Further the extruder can be driven by the power take-off of category II agricultural tractors already available [8]. Still one of the major applications of biomass pertains to its use as a fuel in power plants. Dry biomass provides considerable benefits for combustion, such as increased boiler efficiency, lower flue gas emissions and improved boiler operations, compared to fuels with high moisture. Though there is need and demand a lot of inefficiencies in the path make it uneconomical. Various research efforts failed to overcome the blockades of high collection and transportation costs that result from the wide distribution and low density of biomass resources. Furthermore, the process efficiency is low, the unit price of plant construction is high and it is more disadvantageous than the fossil resource. It is important to construct a socio-technological system that can consider, collectively, a combined utilization system of biomass wastes and unused biomass resources. An optimization model for a Demand-driven biomass processing network using genetic algorithms (GAs) in solving the problem is proposed [9]. Not only GA but also the development of a simulation model with an easy- to use graphical user interface for the bio fuel supply chain management, including selection of the optimal bio fuel facility location, logistics design, inventory management, and information exchange is in the development[10]. Research is going on in addressing the separate issues in improving the productivity and on a trial basis waste heat from a process industry plant (100MWoutput) is being used as the heat source for drying the biomass before feeding into the extruder. The biomass, pine chips at 60wt% moisture, is being dried and then be provided as the input fuel for a subsequent 40 MW power plant [11].

3. Existing Technologies

It is now established that any power plant running on coal can be replaced with briquettes and many small scale power plants are actually practicing it. But there is a big lag in the technologies of producing quality briquettes on a commercially profitable scale. The piston press technology and screw press technology are the commonly used methods in India, both of them does not use any binders and called as binder less technology. Currently most of the units in operation belong to the piston press called as the reciprocating ram type. In this technology the biomass is put in die and high pressure is applied by a reciprocating ram. And the product comes out as compacted discs for each stroke. In a screw extruder the biomass is compacted by passing through a die with the force of a screw press under high pressure and temperature. Due to high temperature the lignin in the biomass melts and each and every particle fuses with each other to form a continuous mass. The out coming continuous briquette should be cut at appropriate length of requirement. There will be a hole inside the screw briquette formed during the forming process and it is supportive for good combustion. The picture of a typical screw briquetting machine and the output, the briquettes with a hole are shown in Figure 1.Comparing both the processes the briquettes made of screw type are extremely good. These briquettes are comparatively better in strength and homogeneity. The outer surface is carbonized to a level which aids in easy ignition and it defends against ambient moisture.

3.1 Difficulties in Screw Press Technology

The main difficulty faced by the users is the frequent wear of the screw and the die (mould). The screw on normal conditions of operations wears out in just 4 hrs in a 400 kg/hr and even less than that depending on the raw material. Widespread basic research is lacking and there is huge gap between entrepreneurs and the researchers. on experimental conditions using various hard facing techniques up to 18 hrs of production for screw has been achieved. Most researchers are concentrating on improving screw life but not much attention is given to the mould. The die also has severe wear problem but it last slightly better than screw just about 2 to 3 times as it doesn't revolve in the production process. The wear of die induces the faster wearing out of screw as the raw material flows back through the gap formed between the mould and screw and disturbs the process and stop in a very short time. There is a very high probability of improving the life of screw and the productivity by designing a better mould which does create a supportive environment for the screw.

4. Experimental Setup

For the study, screw briquette machine shown in Figure 1 with following specifications Shown in Table 1 is used: It was supplied by GONGYI HONGJI MACHINERY FACTORY, CHINA.

Table 1: Specifications of Experimental set up

Sl.No	Parameter	Value
1	Machine Capacity	300 kg/hr
2	Screw Speed	300 mm
3	Screw Diameter	92 mm
4	Pitch	40 mm
5	Mean thickness	08 mm
6	Depth	25 mm
7	Briquette Size	65 mm Square with chamfered corners
8	Central hole size	25 mm
9	Density	1400 kg/m^3
10	Bulk Density	1100 kg/m^3
11	Motor Specifications	22.5 kW, 1440 rpm, 415 V

Fig. 1 The Screw Briquetting Machine

4.1 Description of Machine Components

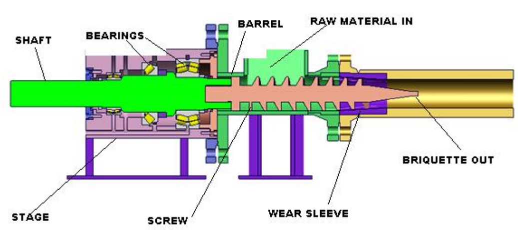

Fig. 2 Sectional View of the Shaft-Screw-Mould Assembly

Figure 2 shows the illustrative cross section of the shaft-screw-mould assembly. From the figure it can be seen that the machine shaft is supported by radial and thrust bearings. Radial bearings support the dead load on the shaft while thrust bearings support the axial load due to compression of saw dust by screw. One end of the shaft is connected to the gear drive. In the other end of the shaft screw is inserted. Starting section of screw placed inside barrel conveys the material into the mould. Mould is made in two sections, first in which the cross section gradually reduced to the final shape of briquette (called forming mould or wear sleeve) and the later with uniform cross section of the final briquette which exerts necessary back pressure for compression due to friction.

4.2 The Proposed Design

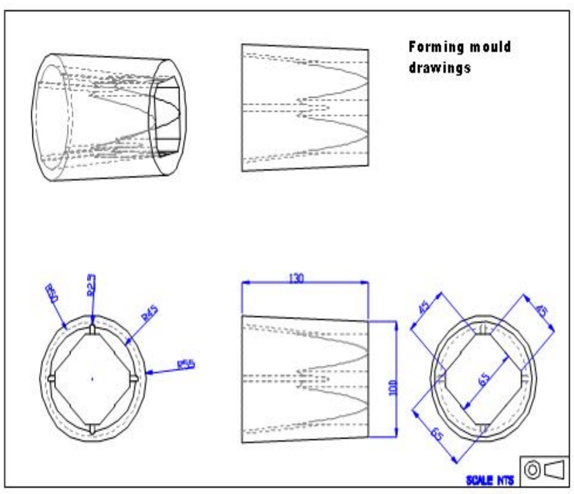

Fig. 3 The Forming Mould

Forming mould which is shown in its various views in Figure 3 is made into an insert piece of the main mould as this section tends to wear-out quickly in operation and requires frequent replacement. As the internal surface of the forming mould wears out, clearance between screw and mould surface increases causing backward leakage and reduction in capacity. At some point briquette formation ceases and the mould requires replacement. The sectional views of mould and screw assembly at initial stage and worn out stage are shown in Figure 4. Worn-out mould also exposes several unprotected screw parts causing early replacement of entire screw. As the compaction must occur in a very short span in a worn-out mould, compacting pressure required also increases (increased drive power, higher rate of wear in screw and mould). In this experiment different materials, hardening techniques and hard coatings are tested for mould.

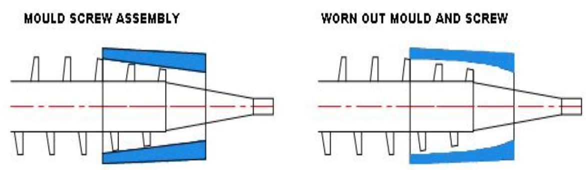

Fig. 4 Sectional Views Of Good And Worn Out Mould

5. Results and Discussions

The life of the mould made of MS supplied with the original equipment lasted only for 4 tons of raw material. The manufacturing cost of the mold similar to the one supplied with the original equipment costs around Rs 4500 and its cost per ton works out to 1125 Rs/ton. The next one was made by EN8 and it went through hardening to HRC level of 42 and it lasted for about 6 tons. The cost of making the mould is Rs 5000 and the cost per ton works out to 833 Rs/ton. Then a mould made of HIGH Cr is tried and it was carbonized to HRC 54 and it lasted for 7. The cost of making it was Rs 6000 and the cost is 857 Rs/ton.

All the previous moulds cannot be reused and when every mould wears out it needs to be scraped. Though the mould was eroded only in few places it becomes unusable. Then a mould was made from MS and it was coated with LT700 by arc welding and grinded to a thickness of 2 mm and its Hardness level was HRC 58.. In the first trial it lasted only for 4 tons and it was removed and again reconditioned with LT700 to its previous dimensions and reused for another 4 tons. The same mould was used 3 times and for 12 tons and after 3 trials the mould was damaged and reconditioning was impossible. The mould cost Rs 4500 and each conditioning cost 1000 each and the cost is 625 Rs/ton. Next the same process is done with GEECOR 404(WC) electrode for 2mm thickness and hardness up to HRC 62 and it gave a life of 6 tons per conditioning for 3 times, mould costs Rs 4500 and each conditioning about Rs 1500 and hence the cost is 500 Rs/ton. All the details of the experiments conducted and the observations are presented in the Table 2.

5.1 W2C Coating by Furnace Bracing

An emerging technology, infiltration based tungsten carbide wear protection called furnace bracing is tried for the hard coating in which W2C coated to a thickness of 1mm as a fine coating of very high accuracy. The process, a protected trade secret, bonds tungsten carbide to ferrous metal base material. This results in a hard, protective clad which is extremely wear resistant and durable. Actually the W2C particles are made to penetrate the base matrix in a fine layer making it unnecessary to grind the surface again for fine finishing to dimensions. The mould lasted for about 40 tons of raw material and still in working condition. It cannot be reconditioned but the base material can be made with low cast MS itself. The furnace brazing process costs Rs 6000 and the base mould Rs 4000working out the cost to 250 Rs/ton, which is just half of GEECOR 404(W2C) electrode coating. Brazed tungsten carbide protects the components four to eight times longer than those which are hard faced. This furnace bracing process of coating mould and even the screw (which is in experiment) is promising and both hard and soft cost can be reduced significantly on per ton basis. Hard cost represents the cost of replacing worn out parts and the soft cost represents inconsistent quality and productivity losses. The major advantage is actually undisturbed production process which is uncharacteristic of all the existing briquetting processes.

Table 2: The Experimental Data for all Trials with Various Hard Facing Processes

Sl. No	MATERIAL	HARDNESS HRC	PROCESS	LIFE IN Tons	COST Rs/Ton
1	MS		hardening	4	1125
2	EN8	42	hardening	6	833
3	HIGH Cr	54	Hardening	6.5	857
4	LT 700	58	arc welding	4	625
5	GEECOR 404(WC)	62	arc welding	6	500
6	W2C coating	Not known	furnace bracing	40	250

6. Conclusions

The improvements made in the life of mould improves the productivity of the briquetting process to a great extent by making it unnecessary to regularly remove and change the setup ,i.e., it reduces the setup cost. As the life is improved, the cost of tools per ton of production is reduced to ¼ of the normal cost and this price reduction goes to profitability. All the metallurgical improvements done in the life of the mould by the process of furnace bracing can be transferred to the screw with appropriate modifications and a viable solution for the profitable briquetting process can be developed.

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