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Investigation for a Suitable Screw of a Briquetting Machine

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ABSTRACT

Briquetting is a well-established technology. But its crucial part is the screw wear, which has a great influence on the cost of production. The aim of this study is to look .for the suitable parameters of screw, which can make this technology attractive to the people. With this objective, the study on existing Bangladeshi screw and few newly designed screws has been done. Four different types of new screw have been constructed, the design and idea of which are taken from the experience of Institute of Energy in Vietnam. The remarkable features of the screw are that it is short in length and the thread is not made as an integral part of the base of screw. Different types of pitch and height of screw have been used for this study.

1. INTRODUCTION

In our country, about eighty percent of total populations live in rural areas. The energy consumption of almost all rural people lies in cooking and house lighting. The biomass wastes like rice husk, rice straw, wheat straw, saw dust, bagasse, coconut coir, ground nut shell etc. have high energy content and low bulk density. So these biomass have low heat release per unit volume and the transportation and storage costs are high when these are used as received condition. Unfortunately, the rural people use these wastes in an unplanned, uneconomical and inefficient manner. Therefore, people have been gaining very little from those vast sources of energy [1] .

The term briquetting refers to the process of compaction of residues between roller and cavities into a product of higher bulk density than the original raw materials and regular shape. Briquetting of biomass in the form of solid fuel in an economically viable solution to the problem of low bulk density biomass that creates many problems in its collection, handling, transportation and storage [2].

In the screw press technology, which is used for briquetting of biomass, has a screw to compress the raw material through a taper die. This technology has been using for so many years in part of Asia and in European countries for briquetting some easily available materials. There are four types of Bangladeshi screws that have been installed and tested. There are differences between the above screws in terms of shape, dimension, and profile of screw, rotation speed of the screw and number of screw pitches. These differences together with location and number of screw threads located in the die make differences in production rate, amount of metal lost of screw due to wear and also specific energy consumption. It is observed that in all areas of Bangladesh, the main problem of running a

machine is the screw wear. It was observed that the screw made of mild steel lasts for 2-3 hours. A rigorous study shows that all the screw wear takes place at the tip. Professor S. K. Mishra of IIT, Delhi in his publication described in details about the base material suitable for screw. Based on his study, 13 samples of low carbon steel having carbon percentage ranging from 0.409-0.498 were tested in Biomass Briquetting Laboratory of BIT, Khulna. During briquetting the sliding of biomass takes place on the screw surface. The sliding action combined with high speed of the screw causes wear. The wear is more with more abrasive material because the coefficient of friction between the material and screw surface increases.

Several conditions should be taken before running screw in briquetting machine. These include the selection of base materials in making the screw, hard facing of screw portion exposed to wear. For the purpose of resurfacing Ferro speed hard craft. Chrom Curb N6006, electrode 700. XHD 2222 are used [3].

The aim of this study is to look for the suitable parameters of screw, which can make the biomass briquetting technology attractive to the people. With this objective, the study on existing Bangladeshi screw and few newly designed screws has been done. Four different types of new screw have been constructed, the design and idea of which are taken from the experience of Institute of Energy in Vietnam. The remarkable features of the screw are that it is short in length and the thread is not made as an integral part of the base of screw. Different types of pitch and height of screw have been used for this study.

2. DESIGN AND CONSTRUCTION OF MODIFIED SCREW

The design of the modified screw was done by Institute of Energy (IOE), Vietnam Construction work has been done here in the Biomass Briquetting Laboratory, BIT, Khulna. However, specification of the existing Bangladeshi screws and die are given by Table 1 and 2 respectively. In addition, Figures 1, 2, 3, 4 show the schematic diagram of the existing screws in Bangladesh and Figure 5 shows the schematic diagram of IOE screw. An existing die and its cross sectional view are also shown by Figure 6.

For the construction of modified screw, at first a mild steel (MS) rod of total length 463.55-mm having diameter of 35 mm was taken. Then the rod was centered for facing operation. In Lathe machine, facing operation was done. Then taper angle of the base rod was calculated for taper turning. Taper turning operation was also done in Lathe machine. For the proper setting of the screw and the briquetting machine, shaper operation was done on the back end of the screw. The flights are made from mild steel of diameter 6.35 mm. Then the flights are welded on the shaft. Grinding was done for proper working condition.

Table 1: Specifications of the existing Bangladeshi Screw

Item	Dimension (mm) for Screw No. 1	Dimension (mm) for Screw No. 2	Dimension (mm) for Screw No. 3	Dimension (mm) for Screw No. 4
Total Length	463.55	444.5	438.5	457.2
Part of thread	304.8	273.05	304.8	279.4
No. of thread	8	10	7	6
Pitch of thread	38.5	28.62	37.2	49.53
Taper	2.45^0	2.45^0	2.45^0	2.45^0
Depth of thread	11.45	10.79	11.27	11.98
Front end diameter	22.14	25.32	21.73	22.12
Back end diameter	32.8	36.77	34.68	34.72

R.P.M.	477	480	480	478
Weight	3.75 (kg)	3.9 (kg)	3.5 (kg)	3.5 (kg)
Base Material	Mild Steel	Mild Steel	Mild Steel	Mild Steel

Table 2: Specifications of die used in briquetting machine

Item	Dimension
Length	310 mm
Inclination	2.45^0
Outside Diameter	90 mm
Inside diameter (Front)	61 mm
Inside diameter (Back)	73 mm

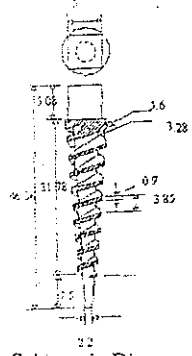

Figure 1: Schematic Diagram of Locally designed screw (No.1)

Figure 2:Schematic Diagram of locally designed screw (No.2)

Figure 3: Schematic Diagram of locally designed screw (N0.3)

Figure 4: Schematic Diagram of locally designed screw (N0.4)

3. EXPERIMENTATION

Nowadays, there are several processes available for briquetting of biomass residues Among them, one of the most popular type is screw press with heated die. In Bangladesh almost all the briquette manufacturers are using this type of machine. In this process, a screw through a die heated from outside, forces the materials. A number of ridges are provided inside the

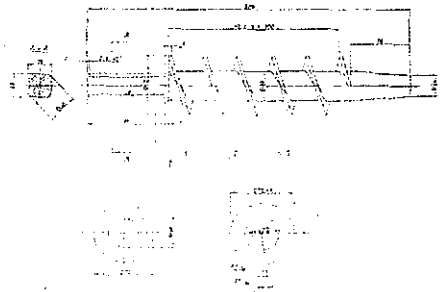

Figure 5: Schematic Diagram of IOE Screw

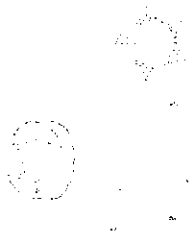

Figure 6: Die and its cross sectional view

die to prevent the free rotation of densified biomass with the screw. The briquette is usually 3-5 cm in diameter. Normally the die temperature is maintained at 300°C. The raw materials get heated up to 220°C in the process. The concept is to heat the biomass at a temperature, which is sufficient to soften the lignin which is one of the major component of all type of vegetation, as well as pushing through the die to get it compacted. In this process, the lignin itself is working as binding material. So there is no need to add any binding material [4]. The modified briquetting machine at the Biomass Briquetting Laboratory of BIT, Khulna was used for this study. Rice husk was mainly used as raw materials for the tests. The screw used for briquetting of biomass is of tapered shape and rotates at a speed of about 450-480 rpm. The temperature of the heated die ranges from 250^0 C to 300^0 C. From experimental observation, it is found that good quality of briquette can be obtained with an output of 90 to 110 kg/hr if the temperature is set at 250°C.

The first section of the screw is used to convey the material, which becomes partially compressed at the tapering section. Finally the briquette is obtained after the biomass passed through the die and the pointed portion of the screw called the guide rod that helps in forming a hole at a center of the briquette. During briquetting, the sliding of biomass takes place on the screw surface. The sliding action combined with the high speed of screw causes wear, because the biomass gets rubbed against the surface of the screw continuously. The research was undertaken with an aim to protect the surface from severe wear so that the screw could be used for a longer period of time. Figure 7 shows the block diagram of a heated die screw press type briquetting machine.

The problems for modified screw are that sometimes the briquetting machine is overloaded and stopped and the screw faces rapid wear on it. During the testing of Vietnamese screw, it is difficult to get product for the lack of proper die clearance and as it is a 15 hp motor, it is not able to run the machine at loaded condition.

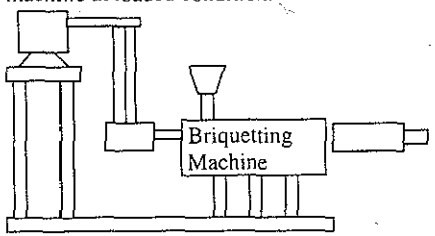

Figure 7: Block diagram of a heated die screw press type briquetting Machine

4. RESULT AND DISCUSSION

The study has been undertaken to investigate the performance of screw for the production of briquette. The variable parameters are pitch of screw, revolution of motor, die temperature, life of screw etc. Two main different types of screw have been considered, one of which is designed by BIT. Khulna and the other is designed by IOE, Vietnam. Four different pitches of Bangladeshi screw were tested and the data are shown in Table 3. The results are presented both in tabular and graphical form in Tables 4,5 and 6, and in Figures 8,9 and 10 respectively. The base material for screw was selected to be AISI 1035, a low carbon mild steel bar on the basis of easy availability and low cost.

Table 3: Data for modified (no.1) and existing (no.2, 3,4) Bangladeshi screws

Screw no.	No of obs	Time(min)	RPM	Production rate (kg/hr)	Power Consumption by driving motor (kw)	Amount of briquetting burnt in die heater (kg)	Die Temp (^{0}C)	Screw Life (hr)
1	1	15	477	90	2.7	2	250	1.25
	2	15	478	80	2.8	2	260	
	3	15	480	73	2.75	2	255	
	4	15	479	75	2.77	2	267	
2	1	15	479	76	2.8	2	252	1.11
	2	15	475	73	3.0	2	265	
	3	15	480	65	3.0	2	271	
	4	15	477	62	3.1	2	272	
3	1	15	477	81	3.0	2	250	1.23
	2	15	478	85	2.9	2	260	
	3	15	480	77	2.8	2	255	
	4	15	477	74	2.92	2	267	
4	1	15	475	84	2.85	2	252	1.06
	2	15	477	97	2.86	2	265	
	3	15	480	103	3.43	2	271	
	4	15	479	91	3.33	2	272	

Table 4: Experimental result for modified (No. 1) and existing (No. 2,3 4) Bangladeshi Screws

Screw no.	No of obs	RPM	Energy consumption rate for driving motor (kwh/kg of production)	Energy Consumption rate for die heater (kwh/kg of production)	Energy cost for driving motor (Tk/kg)	Energy cost for die heater(Tk/Kg)	Total cost for energy (Tk/kg of production)
1	1	477	0.163	0.022	0.60	0.044	0.644
	2	478	0.147	0.025	0.67	0.05	0.725
	3	480	0.135	0.027	0.735	0.057	0.790
	4	479	0.120	0.026	0.815	0.053	0.860
2	1	479	0.147	0.026	0.735	0.054	0.778

	2	475	0.164	0.027	0.820	0.061	0.740
	3	480	0.187	0.030	0.930	0.064	0.996
	4	477	0.228	0.032	1.14	0.049	1.20
3	1	477	0.148	0.024	0.74	0.040	0.789
	2	478	0.122	0.023	0.645	0.053	0.694
	3	480	0.155	0.025	0.775	0.054	0.827
	4	477	0.166	0.027	0.810	0.047	0.864
4	1	475	0.1904	0.023	0.952	0.041	0.999
	2	477	0.117	0.020	0.585	0.039	0.266
	3	480	0.129	0.019	0.65	0.043	0.686
	4	479	0.146	0.021	0.73	272	0.773

Table 5: Experimental result for modified (No.1) and existing (No.2, 3,4) Bangladeshi Screws

Parameters	Screw No.1	Screw No.2	Screw No.3	Screw No.4
Production Rate (kg/hr)	90	76	85	103
R.P.M.	477	480	480	478
Electricity cost for Production of 100 kg Briquette	60.00	73.68	64.70	64. 72
Fuel Cost for Production of 100 kg Briquette	4.44	5.26	4.70	3.88
Total Cost for Production of 100 kg Briquette	64.44	78.964	69.40	68.60
Power Consumption Rate (kwh/kg)	0.12	0.147	0.129	0.190

Table 6: Comparison of the cost of production of briquette (Electrical System)

Types of screw	Production rate (kg/hr)	R.P.M.	Electricity cost for Production of 100 kg Briquette	Fuel Cost for Production of 100 kg Briquette	Total Cost for Production of 100 kg Briquette
Screw no.1	90	477	60.00	4.44	64.44
Screw no.2	76	480	73.68	5.26	78.94
Screw no.3	85	480	64.70	4.70	69.40
Screw no.4	103	478	64. 72	3.88	68.60

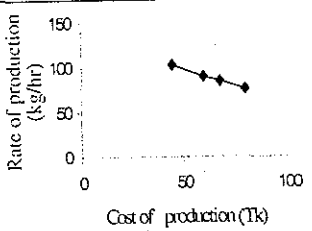

Figure 8: Variation of cost of production with production rate

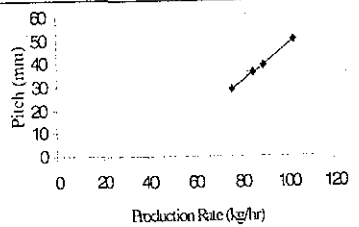

Figure 9: Variation of production rate with pitch of screw

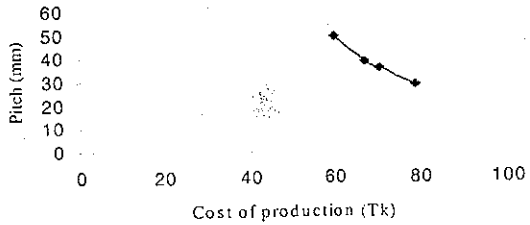

Figure 10: Variation of production cost with pitch of screw

5. CONCLUSIONS

The study on existing Bangladeshi screw and few newly designed screws has been done. Four different types of new screw have been constructed, the design and idea of which are taken from the experience of Institute of Energy (IOE) in Vietnam. From this study, it can be concluded as follows:

(1) Considering all the parameters, Bangladeshi modified screw having pitch 38.5 mm is the most suitable one for briquetting machine.
(2) Cost of product reduces with the increase of production rate.
(3) Production rate increases with the increase of pitch of the screw.

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REFERENCES

Ali, M. N., Islam, M. M., Rahman, A. N. M. M. and Gani, M. A., "Scope of Biomass Briquetting in Bangladesh", Proceedings of the National Seminar on Utilization of Renewable and Alternative Energy Sources for Sustainable Development (NSURAESD' 98), BIT, Khulna-9203, Bangladesh, March 1998, PP 51-65

Bhattacharya, S. C. and Shrestha, R. M., "Biocoal Technology and Economics", Regional Energy Resources Information Center, AIT, Bangkok, Thailand, 1990"

Ali, M. N., Final Report on Pilot Project on Briquetting of Biomass Fuels: Manufacturing and Marketing: Renewable Energy Technologies in Asia, A Regional Re~earch and dissemination Program. Submitted to AIT, Thailand, 1998

Ali, M. N, Final Report on Development and Dissemination of Improved Biomass Briquetting System and Briquetting Stoves: Renewable Energy Technologies in Asia: A Regional Research and Dissemination Program, Phase-II. Submitted to AIT. Thailand. December 2001.