ISSN: 2348-4098
Volume 3 Issue 2, 2015

COMPARATIVE STUDY OF BIOMASS-COAL BLENDS OF WHEAT PADDY AND MUSTARD HUSK USING WATER BOILING TEST

[1]DEEPAK SHARMA, [2]ABHISHEK SINGH JATAV

Department of mechanical engineering, Suresh Gyan Vihar University, Jaipur, India-302017

ABSTRACT

The major part of world's economy depends upon energy from fossil fuels (Petroleum, diesel, natural gas, coal, etc.) in order to produce different forms of energy. The limitation of fossil fuels on the earth and recent price hikes of these fuels in last two decades is kind of a concern for the energy sector across the world. Biomass being an alternative for the fossil fuels (mainly coal) for the generation of the energy looks a solution to the problem. The mustard husk and wheat paddy are common biomass found in the north India, which can be used as an alternative to the coal or can be blended with coal as the combustion fuel in various industrial purposes. The study deals with the investigation of variation in parameters(ignition time, water boiling time, specific fuel consumption, and burning rate) of mustard husk-coal blend and wheat paddy-coal blend with variation in proportions(100:0, 80:20, 60:40, 40:60, 20:80, 0:100) of coal-biomass blends respectively, using water boiling test simulation as the platform for the test. The results from the test indicate that, the mustard husk blends performed better than that of the wheat paddy blends. The variation of all parameters were also observed and the investigation was concluded with the fact that, 100% biomass is not as suitable fuel as the coal-biomass blend is, for the combustion process.

KEYWORDS: *Mustard husk, wheat paddy, coal, water boiling test.*

NOTATIONS

B = Biomass

C = Coal

K.cals/Kg = Kilo calorie Per kilogram

NOx = Oxides of nitrogen

SOx = Oxides of sulphur

MH = mustard husk

WP = wheat paddy

1. INTRODUCTION

The recent increase in fossil fuel prices and their limited stock is a big concern to the energy sector across the globe. This scenario have shifted the interest of energy sector toward the non-renewable sources of energy like, wind energy, solar energy, energy from biomass, geothermal energy etc. focusing on biomass, the average biomass potential in India is 625 million ton per year. Out of which the agriculture residue accounts for nearly 385 million ton per year. The main agriculture residue found in India are rice husk, mustard husk, wheat paddy etc. biomass being abundant and eco-friendly is a good alternative for the coal (in combustion processes). The biomass cam be fed to the furnace or boiler directly or in the form of briquettes. The briquette shape is the better idea because it will produce uniform combustion.

The biomass as a fuel is considered as eco – friendly in many respects , first, upon burning it does not shows net increase in carbon dioxide , as these fuels releases same amount of carbon dioxide as they consumes from the atmosphere during growth. Therefore biomass – coal blend tends to lower the net carbon dioxide emissions. And biomass contains a very negligible amount of sulfur or no sulfur, therefore net SO2 content also decreases. Also biomass have very little amount of nitrogen in them which upon burning forms NH radicals (mainly ammonia). The ammonia easily reduces into molecular nitrogen. Hence, biomass blending improves NOx level also

2. BIOMASS-COAL BLEND

The biomass coal blend is the fuel in which the biomass and coal are blended with the help of a suitable binder. The blends can be used as a fuel for the combustion as an alternative to the coal. The biomass coal blend technology have got expertise in recent years , the technology will led to socio-economic development of country and as a supplementary fuel for the country. It tends to improve air quality, is environment friendly and also cost-effective and also forest can be saved at the same time.

3. OBJECTIVE

ISSN: 2348-4098
Volume 3 Issue 2, 2015

The biomass-coal blends will show variation in properties when their proportion is changed from 0 to 100. The aim of the study is to find out the variation in parameters of burning of fuel, when the blend proportion is changed. With the help of this we will find out the nearly optimum blending ratio of biomass and coal. The biomass taken for the test are mustard husk and wheat paddy. Both the fuels are blended with coal in the ratio 100:0, 80:20, 60:40, 40:60, 20:80, 0:100 of coal-biomass respectively. The parameter to be studied is ignition time, water boiling time, burning rate and specific fuel consumption and the fuel cost.

4. METHODOLOGY

4.1 MATERIAL

The biomass (mustard husk and wheat paddy) and coal(lignite) and binder(wheat flour) have been chosen for the study. We have the ultimate and proximate analysis of the biomass materials and coal below in the table.

Table 1: Proximate and ultimate analysis of the fuels

Sample	Ash content (%)	Volatile Matter (%)	Fixed carbon (%)	Moisture content (%)	Sulphur content (%)	Gross calorific value (K.cals/kg)
Coal	33.57	24.95	28.33	13.15	0.65	5960
Mustard Husk	6.04	74.48	19.15	0.33	0.26	4239
Wheat Paddy	8.49	65.19	17.81	8.51	0.21	3880

4.2 PREPARATION OF BIOMASS AND COAL SAMPLES

The samples of the biomass and coal were sun dried for 5 days, if there is any moisture in the samples. The samples were weighed separately according to the requirement in the particular proportion.

Table 2: Fuel prices

S. No.	Fuel	Cost (in rupees)
1	Coal (lignite)	10
2	Mustard husk	2
3	Wheat paddy	3

Figure.1: blend and binder mixing

4.3 PREPARATION OF BIOMASS-COAL BLENDS

The **samples** of coal and biomass were weighed and then mixed according to the proportions. 5% of the wheat flour was added to each sample as a binder. Then blends were made with the help of water added into them. The proportion of sample in which they were mixed was as follows:

ISSN: 2348-4098
Volume 3 Issue 2, 2015

Table.3: Ratio of biomass and coal in the blend

S. No.	Coal : biomass (%age)	Coal + Mustard Husk	Coal + Wheat Paddy
1	100% C + 0% B	100 g. C + 0 g. MH	100 g. C + 0 g. WP
2	80% C + 20% B	80 g. C + 20 g. MH	80 g. C + 20 g. WP
3	60% C + 40% B	60 g. C + 40 g. MH	60 g. C + 40 g. WP
4	40% C + 60% B	40 g. C + 60 g. MH	40 g. C + 60 g. WP
5	20% C + 80% B	20 g. C + 80 g. MH	20 g. C + 80 g. WP
6	0% C + 100% B	0 g. C + 100 g. MH	0 g. C + 100 g. WP

Figure 2: prepared blends of different proportions

ISSN: 2348-4098
Volume 3 Issue 2, 2015

4.4 TEST PHASE

4.4.1 Water boiling test: Preparation phase

Apparatus required:

Cooking stove, A pot(1 liter), Metal plate for burnt biomass, A tong, A thermocouple (accurate to 1 degree), A digital weighing machine(with capacity of 5 kg, with accuracy of ±1 gram), Measuring cylinder (up to 1 liter), A Bunsen burner, A tripod stand, Wire gauge, LPG gas cylinder, A stopwatch, Dust pan, A manual spreadsheet for data handling

4. 4.2 Water boiling test: test phase

The water boiling test is the simplified simulation, which is generally used for the simulation of cooking process. Mainly water boiling test is used to compare the cooking efficiency of different stoves of different designs and the amount of emission produced during cooking, but the test can also be used for comparing different fuels using a single stove. In water boiling test many parameters of fuels like water boiling time, burning rate, ignition time, specific fuel consumption, etc. are measured and compared with that of other fuels. For this test sample of identical weight of different fuels are taken then burnt on the stove and constant water is boiled every time and the parameters are taken.

Figure 3: Water boiling test

4.5 FOCUSED PARAMETERS

1. Ignition Time: Ignition time here is the time required for the blend to catch the fire completely. For this each of the briquettes sample was ignited from the base.

2. Water boiling time: The water boiling time is the time taken by the water to reach the local boiling temperature. This is measured directly using a stop watch.

3. Burning rate: Burning rate is defined as the mass of biomass blend (fuel) burnt to the total time taken.

$$\text{Burning rate} = \frac{\text{mass of fuel consumed (g)}}{\text{Total time taken(in min.)}}$$

4. Specific fuel consumption: the specific fuel consumption is defined as the mass of fuel burnt to the total mass of remaining water.

$$\text{Specific fuel consumption} = \frac{\text{mass of fuel consumed (kg)}}{\text{Total mass of water remaining (ml)}}$$

4.6 ATMOSPHERIC CONDITIONS

Atmospheric Pressure –1 Atm. approx.

Room temperature –32.1º C

Altitude – 431 meter

Local boiling temperature – 98.57ºC

5. RESULTS AND DISCUSSIONS

We come to certain discussions and parameters about the fuel properties. After going through the test with every fuel sample we observed the following things:

Table 4: effect of variation in biomass composition different parameters

		Composition					
Parameters		**100% C + 0% B**	**80% C + 20% B**	**60% C + 40% B**	**40% C + 60% B**	**20% C + 80% B**	**0% C + 100% B**
Ignition time	Mustard husk	182	102	60	42	30	**12**
	Wheat paddy	182	125	85	58	42	**17**
Water boiling time	Mustard husk	20.21	15.33	10.76	8.36	7.76	**6.93**
	Wheat paddy	20.21	17.63	11.2	10.03	8.65	**7.88**
Burning rate	Mustard husk	4.96	6.57	9.56	12.16	13.4	**15.24**
	Wheat paddy	4.96	5.75	8.99	9.8	11.91	**13.28**

ISSN: 2348-4098
Volume 3 Issue 2, 2015

Specific fuel consumption	Mustard husk	1.63	1.29	1.09	**0.88**	1.2	2.38
	Wheat paddy	1.63	1.47	1.28	**1.02**	1.49	3.22
Ash content	Mustard husk	11.3	12.5	11.2	9.5	7.6	**6.4**
	Wheat paddy	11.3	12.2	11.8	10.7	8.9	**8.4**
Sample cost	Mustard husk	100	84	68	52	36	**20**
	Wheat paddy	100	86	72	58	44	**30**
Cost of blend for evaporating same amount of water(113 ml)	Mustard husk	185.2	123.2	84.4	52	**43.7**	54.1
	Wheat paddy	185.2	142.9	104.1	**70.47**	74.2	109.33

5.1 IGNITION TIME

With increase in biomass content the ignition time decreases, this is because of high volatile content of biomass as compared to that of coal.

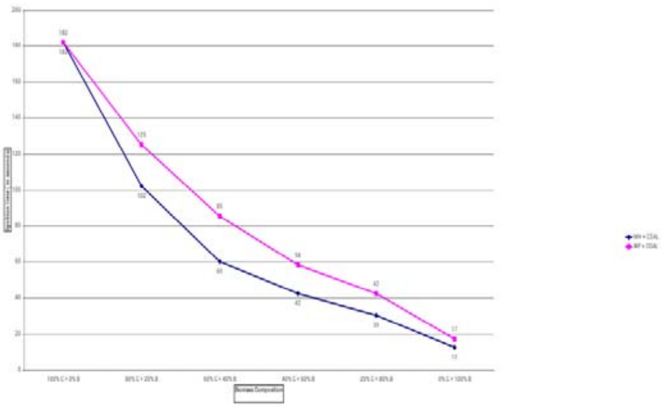

Figure 4: Effect of biomass concentration on ignition time

5.2 WATER BOILING TIME

The water boiling time is the time taken by water to reach to its local boiling point (98.57ºC for Jaipur). For every 100grams sample of blend, the water boiling time decreases with increase in the biomass proportion, it was 6.53 min and 7.23 seconds for mustard husk and wheat paddy 100% composition blends respectively and was 20.21 min for 100% coal.

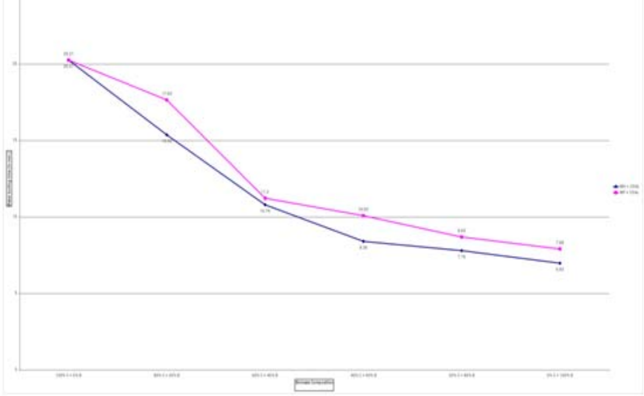

Figure 5: Effect of biomass concentration on the water boiling time

5.3 BURNING RATE

The burning rate also increases with increase in the biomass composition, the burning rate for 100% composition of mustard husk and wheat paddy was 15.24 and 13.28 respectively and for 100% coal it is 4.96. here we can see the role of biomass in increasing the burning rate.

Figure 6: Effect of biomass concentration on burning rate

5.4 SPECIFIC FUEL CONSUMPTION

The specific fuel consumption of the blends shown unexpected variation the minimum specific consumption was at 60% biomass and 40% coal composition for both wheat paddy as well as mustard husk blend. Which means that blend of coal and biomass perform better than both the fuels in particular.

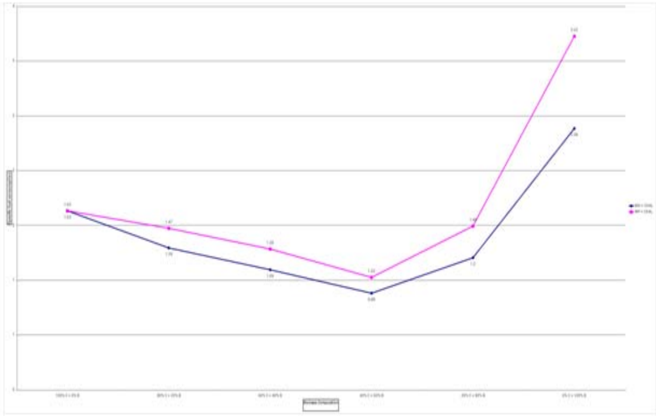

Figure 7: Effect of biomass concentration on specific fuel consumption

5.5 ASH CONTENT

The ash content also shown unexpected variation throughout the composition as the ash content of 80% coal and 20% biomass was greater than all of the other blends for both the biomasses.

Figure 8: Effect of biomass concentration on the ash content

5.6 COST OF EACH BLEND

The cost analysis graph shows that with increase in biomass composition the cost of the blend decreases, but it does not means to use 100% biomass sample, because 100% biomass sample have lower bulk density and burns quickly as compared to the other blends. That's why the specific fuel consumption of the 100% biomass is more than that of 60% biomass 40% coal sample. At this point we understands the benefit of the blending.

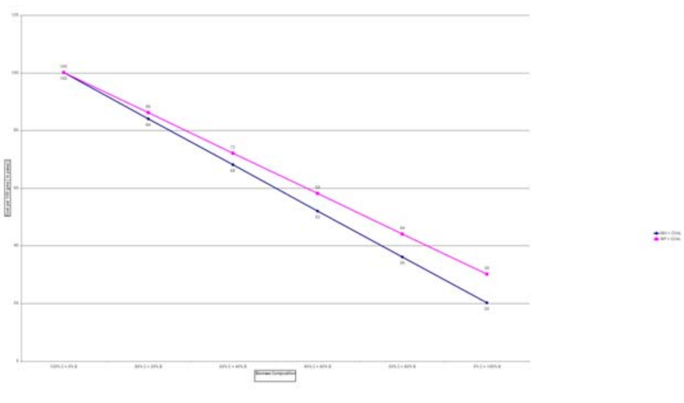

Figure 9: The cost of each 100 gram sample of coal-biomass blend

5.7 COST OF EACH FUEL BLEND FOR EVAPORATING SAME QUANTITY OF WATER

As from the specific fuel consumption concern, specific fuel consumption is different for all the samples of biomass, the cost for each sample of the blend is different and all blends evaporated different amount of water. The minimum specific fuel consumption occurs at 40% coal and 60% biomass blend, which boils maximum 113 ml. of water. So, now we have to calculate the amount of each blend required for evaporating same quantity of water. The blend which will evaporate the 113 ml. of water in minimum cost will be the suggested fuel for the combustion.

For this we will have to calculate cost required for boiling 113 gram of water (in paisa):

$$\text{Cost required for boiling 113 gram of water (in paisa)} = \frac{\text{Cost of 100 gram of blend} \times 113}{\text{Water evaporated by blend}}$$

By using the above mentioned formulae, we can calculate the cost of the required amount of fuel to boil 113 ml of water (i.e. the water evaporated by blend of minimum specific fuel consumption), the results of the calculation are mentioned in Table 4.

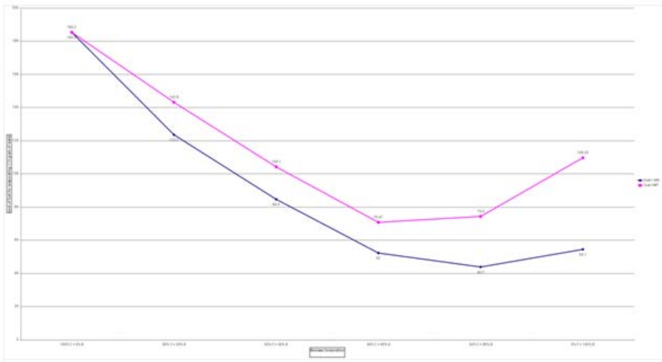

Figure 10: Analysis the variation in cost of blend for evaporating same quantity of water

6. CONCLUSION

The water boiling test simulation was carried out perfectly. And it was concluded that the blend of mustard husk and coal performed better than that of the wheat paddy and coal blend. As the volatile content and the calorific value of the mustard husk is greater than that of the wheat paddy, so it is proved to be a better biomass for blending.

But, next investigation was to find out, which composition of the mustard husk and coal performed better and is optimum to use as a combustion fuel. From all the parameters studied through the water boiling test, the specific fuel consumption was of main concern. In order to evaporate same quantity of water, the 20% coal and 80% biomass blend of mustard husk resulted in the lowest cost of 43.74 paisa. Which means the blend of 20% coal and 80% mustard husk is best according to economical as well as fuel consumption reasons.

ISSN: 2348-4098
Volume 3 Issue 2, 2015

REFERENCES

1. P.D Grover, S.K. Mishra.(1996). Regional Wood Development Program in Asia. Biomass Briquetting: Technology and Practice. PP- 167-195.
2. Rijul Dhingra, Abhinav Jain, Abhishek Pandey, and Srishti Mahajan.(2002). Assessment of Renewable Energy in India, Vol. 5, No. 5.
3. C. Devendra, D. Thomson.(2002). Alternative Fuels PP-27-40.
4. R. Jorapur, AK. Rajvanshi.(1995). Biomass Bioenergy PP- 91-8.
5. R. Benerjee.(2006). Energy Policy 34 (1) PP- 101-111
6. L. Barbieri, F. Andreola.(2013). Waste Management 33 PP – 2307-2315.
7. M.V Madurwar, R.V. Ralegaonkar, S.A. Mandavgane.(2013). Construction and Building Materials 38 PP- 872-878.
8. C. Fernandez- Pereia, J.A. la Casa.(2011). Fuels 90 PP-220-232
9. M. Hiloidhari, D. Dhiman.(2014). Renewable and Sustainable Energy Reviews 32 PP- 504-512
10. R.A. Saidur, A. Demirbas, M.S. Hussain, S. Mekhilef.(2011). Renewable and Sustainable Energy PP- 2262-2289.
11. T. U. Onuegbu, U.E.Ekpunobi.(2011) Comparative study of water boiling test and ignition time of coal-biomass blend .
12. Ilochi Nkechinyere Olivia.(2010) Comparative analysis of coal briquettes blend with maize cob and groundnut shell , vol-2 , PP 77-82.
13. R.M. Davies, D.S.(2013) abolude. Ignition time and Burning Rate of water hyacinth Briquettes, Vol- 2 , 111 – 120.
14. C.S.Rani, T. C. Kandpal, S.C. Mullick.(1992). Priliminary study of water boiling test for fuel wood stoves., Vol 33,PP 919 – 929.
15. P. McKendry.(2002) Bioresource Technology 83, PP 37–46.
16. N. Gholipour Zanjani, A. Zarringhalam Moghaddam, S. Dorosti.(2014).physical and chemical properties of coal briquettes from biomass-bituminous blends, Petroleum & Coal 56(2) 188-195.
17. A. I. Raju, K. Ramya Jyothi, M. Satya, U.Praveena.(2014). Studies on development of fuel briquettes for household and industrial purpose, ISSN: 2321-7308.
18. Mahidin, Yanna Syamsuddin, Samsul Rizal.(2013), Use of Biomass as Co-Fuel in Briquetting of Low-Rank Coal: Strengthen the Energy Supply and Save the Environment, Metallurgical and Materials Engineering Vol:7 No:12.
19. Beena Patel and Bharat Gami.(2011), Biomass Characterization and its Use as Solid Fuel for Combustion, Vol 3, PP 123-128.
20. Ramesh Man Singh1, Hee-Joon Kim2, Mitsushi Kamide3 and Toran Sharma.(2009). Bio-briquettes-an Alternative Fuel for Sustainable Development, Vol 10, PP 121-127.