Journal of Applied Fluid Mechanics, Vol. 11, Special Issue, pp. 75-78, 2018.
Selected papers from *International Conference on Newer Techniques and Innovations in Mechanical Engineering (ICONTIME 2K18), 2018*
Available online at www.jafmonline.net, ISSN 1735-3572, EISSN 1735-3645.
DOI: 10.36884/jafm.11.SI.29420

Co-Combustion Analysis of Lignite Coal and Groundnut Shell using TGA

C. Sakthivel [1†], P. Gopal [2], C. Rameshkumar [3] and B. Suresh Kumar [1]

[1]*Department of Mechanical Engineering, K. Ramakrishnan College of Technology, Trichy-621112, Tamil Nadu, India*
[2]*Department of Automobile Engineering, Anna University, BIT campus, Trichy -620024, Tamil Nadu, India*
[3] *SMEC, VIT University, Vellore – 632014, Tamil Nadu, India*

†*Corresponding Author Email: sakthikrct@gmail.com*

(Received May 15, 2018; accepted July 18, 2018)

ABSTRACT

The technology of co-firing was used to study the combustion of groundnut shell and coal at three different ratio of biomass (10%, 20%, and 30% in weight) and combustion of miscanthus and coal at three different ratio of biomass(10%,20%,30%) using thermo gravimetric analysis (TGA). When compared to firing of coal, the co-firing of coal and biomass (groundnut shell, miscanthus) has shown a good combustion result. The ignition temperature (Ti) burnout temperature (Tf) is reduced in the co-combustion when compared to the combustion of coal alone. The best blend ratio of coal/groundnut shell is 80%/20%. The best blend ratio of coal/miscanthus is 70%/30%.

Keywords: Groundnut shell; Coal; Thermo gravimetric analysis; Co-combustion study.

1. INTRODUCTION

Vamuvaka (2009) suggested that to meet increasing energy demands we should cultivate biomass crops for bioenergy. Coal is acting as a major source to generate electricity as stated by Vekemans (2016). 40% of the world's electricity need is satisfied by coal. Due to high sulfur content in coal the combustion of coal results in SO_2 emission in large scale and it causes harm to the environment. Baxter (2005) and Hu (2015) studied and identified the co-combustion of coal and biomass has many advantages like low cost and renewable and also it has less amount of SO_x, NO_x, CO_2 emission. India places fourth in energy consumption in the world after United States, China and Russia. The moisture content of the biomass will be always high so it has to be dried before combustion .There are two types of dryer are there in the market for drying of biomass mechanical dryer and thermal dryer . Fluidized bed dryer can be used for drying of biomass as it has many advantages over other dryers was listed by Hajidawallo (2000). Demirabs (2004) defined the rate of co-firing as amount of biomass co-fired with coal. The availability of the coal has reduced and the usage of coal results in several emission problems. There is a need for replacement of coal with some non-fossil fuel alternate. Biomass can be the preferable energy and it is renewable. As for as India is an agriculture country the waste generated from agriculture can be utilized as an alternate. The usage of coal can be reduced by utilizing the agriculture waste along with the coal and it is called as co-firing of coal and biomass. The combustion characteristics of coal and biomass can be investigated in TGA and the best alternate can be found out. Srinivasan (2017) studied and analysed about the missile with grid fins and the effect on flow drag using ANSYS. Godwin (2017) and Lakshmanan (2017) investigated about the optimum parameters for obtaining the best performance using alternate fuels of IC engines working under the current cooling system using Nanofluids.

2. EXPERIMENTAL PROCEDURE

2.1 Methods

The fine particles of coal and groundnut shell sample and the fine particles of coal and miscanthus sample are investigated in this work. Both the samples were shredded into fine particles with small molecules and dried at 60ºC for 24 hours. Four samples were prepared with four different proportions. Sample 1 = 100% coal, Sample2 = 90% coal and 10% miscanthus, Sample3 = 80% coal and 20% miscanthus, Sample4 = 70% coal and 30 % miscanthus, Sample 5 = 90% coal and 10%

groundnut shell fine particles, Sample 6 = 80% coal and 20% groundnut shell fine particles, Sample 7 = 70% coal and 30% groundnut shell fine particles..

2.2 Apparatus and Procedure

Thermo-gravimetric analyzer is used to carry out the experiment and the specification is TGA 4000, PYRIS 6 TGA small samples of 5mg were heated up from 35ºC to 900ºC at 10ºC/min by supplying nitrogen at 20 ml/min.

3. RESULTS AND DISCUSSION

3.1 Lignite Coal Sample Properties

The table 1 depicts the various property values of coal sample taken for research.

Table 1 Property of Lignite coal

Parameters	Values
Total ash	52.13%
Moisture	2.41%
Volatile matter	24.96%
Fixed carbon	20.50%
Carbon	82.87%
Sulphur content	0.0006%
Lignite content	23.11%
Calorific value	4816.78 kCal/kg

3.1 CB1

The 100% of coal was first investigated for combustion and the percentage of weight loss of the sample is shown in the figure 1. The weight loss is about 43% in the above operating condition. The maximum weight loss rate is at 150ºC and 350ºC T_i= 100ºC and T_f=870ºC.

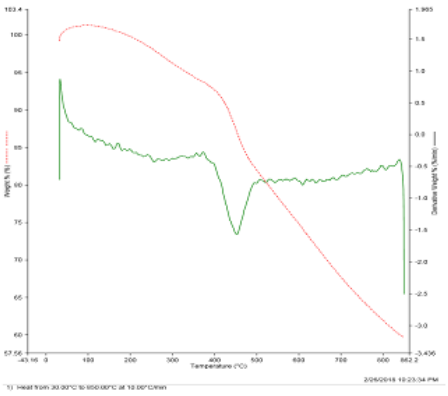

Fig. 1. TGA of Sample CB1

3.2 CB2

The 90% coal and 10% miscanthus was investigated for combustion and the percentage of weight loss of the sample is shown in fig 2. The weight loss is about 30% in the above mentioned operating condition .The maximum weight loss is at 120ºC and 400ºC , T_i= 80ºC and T_f=860ºC

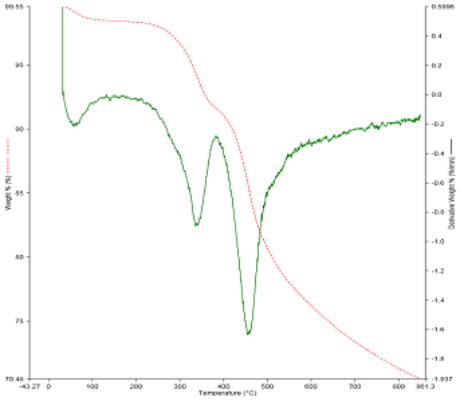

Fig. 2. TGA of Sample CB2

3.3 CB3

The 80% coal and 20% miscanthus was investigated for combustion and the percentage of weight loss of the sample is shown in fig 3. The weight loss is about 34% in the above mentioned operating condition .The maximum weight loss is at 150ºC and 380ºC , T_i= 90ºC and T_f=860ºC

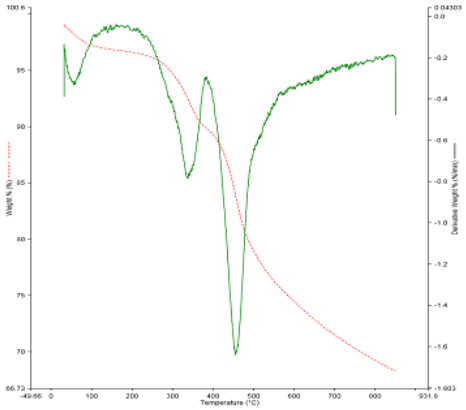

Fig. 3. TGA of Sample CB3

3.4 CB4

The 70% coal and 30% miscanthus was investigated for combustion and the percentage of weight loss of the sample is shown in fig 4. The weight loss is about 38% in the above mentioned operating condition .The maximum weight loss is at 150ºC and 550ºC , T_i= 70ºC and T_f=850ºC

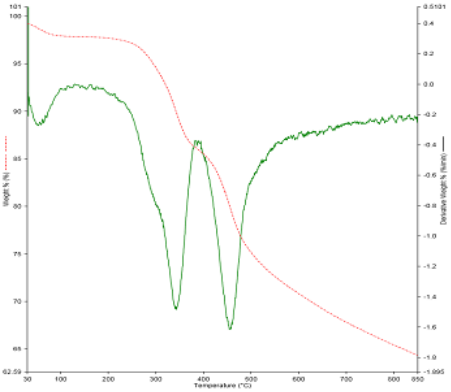

Fig 4. TGA of Sample CB4

3.5 CB5

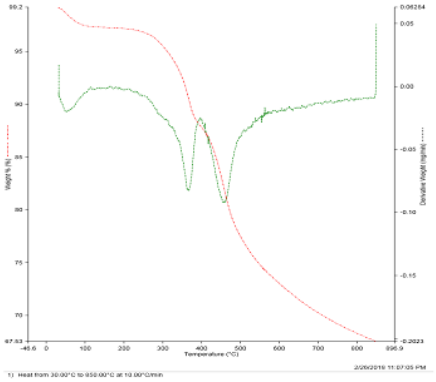

Fig. 5. TGA of Sample CB5

The 90% coal and 10% groundnut shell was investigated for combustion and the percentage of weight loss of the sample is shown in Fig 5. The weight loss is about 33% in the above operating condition. The maximum weight loss rate is at 128 ºC and 380ºC T_i= 85ºC and T_f=850ºC.

3.6 CB6

A 80% coal and 20% groundnut shell was investigated for combustion and the percentage of weight loss of the sample is shown in Fig. 6. The weight loss is about 65.55% in the above operating condition. The maximum weight loss rate is at 100ºC and 650ºC T_i= 75ºC and T_f=620ºC.

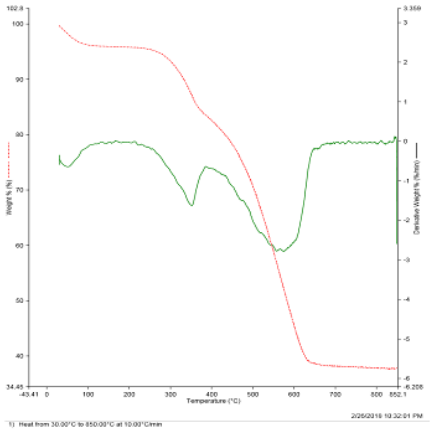

Fig. 6. TGA of Sample CB6

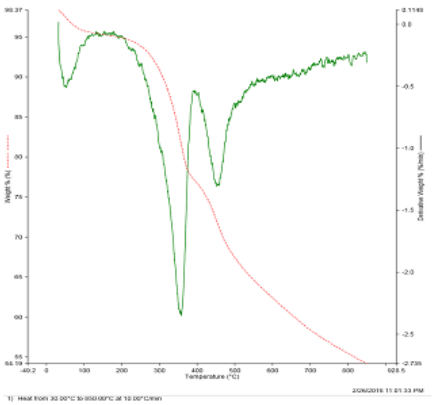

Fig. 7. TGA of Sample CB7

3.7 CB7

A 70% coal and 30% groundnut shell was investigated for combustion and the percentage of weight loss of the sample is shown in fig 4. The weight loss is about 56% in the above operating condition. The maximum weight loss rate is at 125 ºC and 450 ºC T_i= 80 ºC and T_f=850 ºC.

Table 2 TGA of Sample CB7

Sample Code	Ignition temperature T_i (□)	Burnout temperature T_f (□)	Weight loss percentage of sample in %
CB1	100	870	43%
CB2	80	860	30%
CB3	90	860	34%
CB4	70	850	38%
CB5	85	860	33%
CB6	75	620	65.55%
CB7	80	850	56%

Table 2 shows consolidated results for all the samples utilized in this work.

5. CONCLUSION

The combustion characteristics of coal and groundnut shell fine particles are studied in Nitrogen atmosphere. The main results are as follow:

- CB1- The maximum weight loss rate of a sample is at 150^0c and 350^0c, the Ignition temperature (T_i)=100^0c and Burnout temperature(T_f)= 870^0c.The weight loss is 43%.
- CB2- The maximum weight loss rate of a sample is at 120^0c and 400^0c, the Ignition temperature (T_i)=80^0c and Burnout temperature(T_f)= 860^0c.The weight loss is 30%.
- CB3- The maximum weight loss rate of a sample is at 150^0c and 380^0c, the Ignition temperature (T_i)=90^0c and Burnout temperature(T_f)= 860^0c.The weight loss is 34%.
- CB4- The maximum weight loss rate of a sample is at 150^0c and 550^0c, the Ignition temperature (T_i)=70^0c and Burnout temperature(T_f)= 850^0c.The weight loss is 38%.
- CB5- The maximum weight loss rate of a sample is at 128^0c and 380^0c, the Ignition temperature (T_i)=85^0c and Burnout temperature(T_f)= 850^0c.The weight loss is 33%.
- CB6- The maximum weight loss rate of a sample is at 100^0c and 650^0c, the Ignition temperature (T_i)=75^0c and Burnout

Table 3 TGA of Sample CB7

Sample Code	Ignition temperature T_i ºC	Burnout temperature T_f ºC	Weight loss percentage of sample in %
CB1	100 ºC	870 ºC	43%
CB2	80 ºC	860 ºC	30%
CB3	90 ºC	860 ºC	34%
CB4	70 ºC	850 ºC	38%
CB5	85 ºC	860 ºC	33%
CB6	75 ºC	620 ºC	65.55%
CB7	80 ºC	850 ºC	56%

temperature (T_f)= 620^0c.The weight loss is 65%.

- CB7- The maximum weight loss rate of a sample is at 125^0c and 450^0c, the Ignition temperature (T_i)=80^0c and Burnout temperature(T_f)= 850^0c. The weight loss is 56%.
- The best coal/Groundnut Shell blend percentage is 80% / 20% by the reason of the T_i& T_f and weight loss percentages. In the 20% groundnut shell fine particles, the temperature of T_i & T_f are reduced and have higher weight loss when compared to other percentages of 70%/30% and 90%/10%.
- The best coal/miscanthus blend percentage is 70%/30% by the reason of T_i& T_f and weight loss percentages. In the 30% miscanthus fine particles the temperature of T_i& T_f and weight loss percentages are same when compared to the combustion of coal alone. So instead of using coal in 100% we can use 70% coal and 30 % miscanthus as the results are same .By taking 70% coal and 30% miscanthus ratio we can reduce the amount of coal used and the emission problems created during the combustion of coal also reduced.
- These results provide a reference for further co-combustion study on groundnut shell and miscanthus.

REFERENCES

Baxter, L. (2005). Biomass-coal co-combustion: opportunity for affordable renewable energy. *Fuel* 84, 1295-1302.

Demirbas, A. (2004). Combustion characteristics OF different biomass fuel. *PROG ENERGY combust sci,* 30, 219-30.

Godwin Antony, A., S. Dinesh, K. Rajaguru, V. Vijayan (2017). Analysis and Optimization of Performance Parameters in Computerized I.C. Engine Using Diesel Blended with Linseed Oil and Leishmaan's Solution. *Mechanics and Mechanical Engineering*, 21(2), 193–205.

Hajidawallo, E. and Hamdullahpur, F. (2000). Thermal analysis of a fluidized bed drying process for crops PART-II: Experiment results and model verification. *Int J Energy Res*; 24:809-20.

Hu, S., X. Ma, Y. Lin and Z. Yu (2015). Thermo gravimetric analysis of the co-combustion of paper mill sludge and municipal solid waste, energy convers. *Manage* 99, 112-118.

Lakshmanan, P., P. Kaliyappan, M. Ranjithkumar, K. Aravinth, D. Vakkachan, C. Moorthy and S. Kumar, (2017). An Experimental Investigation to Study the Performance and Emission Characteristics of Chicken Fat Oil Fuelled DI Diesel Engine. *Journal of Applied Fluid Mechanics* 10, Special Issue, 85-91.

Srinivasan, R., V. Vijayan and K. Sridhar (2017). Computational Fluid Dynamic Analysis of Missile with Grid Fins. *Journal of Applied Fluid Mechanics* 10, Special Issue, 33-39.

Vamvuka D. (2009). Biomass, Bioenergy and the environment. *Tziolas Publications*, Salonica.

Vekemans, O., J. Laviolette, J. Chouki (2016). Co-combustion of coal and waste in pulverized coal boiler. *Energy* 949, 742-754.