CHAPTER 4

Densified Fuels from Mixed Plastic Wastes and Corn Stover

4.1 Introduction

This chapter studied the pelletization of mixed plastic wastes and corn stover, and corn stover at the condition of various moisture content, type of material and preheating temperatures on the fuel properties. All samples are conducted at the compression pressure of 150MPa.

4.2 Experimental methodology

4.2.1 Materials

Plastic wastes were collected from Chiangrai Rajabhat University's dumpsite. The age of dumpsite is 5 years old. All plastic waste samples were shredded into small pieces, less than 3 mm in overall size. Corn stover was obtained from a local corn field after harvested and sun-dried for 3 weeks. The biomass sample was shredded to about 1.5 mm in size using an agricultural shredding machine. Both materials were sent for analysis of their properties.

4.2.2 Pelletization

Pelletization was carried out using a hydraulic compactor, shown in Figure 4.1. Shredded plastic wastes and corn stover (total 1.4 g) were mixed at ratio of 55:45 w/w, 1.4 g in total weight. The pelletized fuel was 8 mm in diameter and 20 mm in length. The die wall was heated by hot water. Various pelletizing conditions were investigated. The moisture content was varied between 5, 10, 15 and 20%. The die wall temperature was varied between 75 and 100°C.

The applied compression pressure was fixed at 150 MPa. All pellet products were kept in the zip lock plastic bag and stored in controlled room.

4.2.3 Physico-chemical analysis

The raw materials and the pelletized fuel were analyzed for their properties as guided by ASTM and EN standards as listed in chapter 3 (Table 3.1).

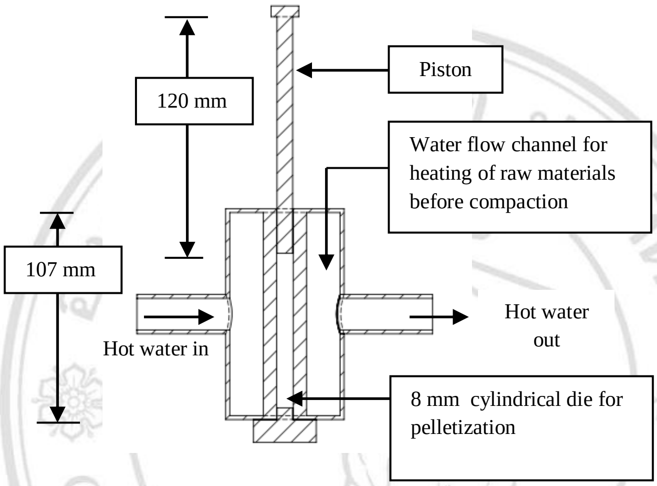

Figure 4.1: Compaction apparatus.

4.3 Results and discussion

Samples of pellets from corn stover and mixture between plastic wastes and corn stover are shown in Figs. 4.2 and 4.3, respectively. Under the same applied pressure, pellets from sole biomass can be made in more compact form than those from mixture of plastic waste and corn stover. Analysis results of chemical characteristics of plastic wastes and corn stover are shown in Table 4.1. Plastic wastes appeared to have lower moisture and ash content than corn stover, but, significantly higher calorific value than the biomass. Tables 4.2 and 4.3 show the characteristics of the pelletized fuels from corn stover only, and from a mixture between plastic wastes and corn stover. It was found that calorific value of corn stover pellet was between 15.64 – 16.60 MJ/kg. Carbon content was contained 52.17 – 53.72%. Ash content was 8 – 9%. Moisture content of corn stover pellet was found to increase with the moisture content of feed materials, as expected. The calorific value of plastic waste and corn stover pellets (26.38 – 29.56 MJ/Kg) were much higher than corn stover pellet, because of higher carbon content. Sulfur content and chlorine content were 0.12 – 0.13% and 0.07 – 0.19%, respectively.

Figure 4.2: Examples of corn stover pellets.

Figure 4.3: Examples of plastic waste and corn stover pellets.

Table 4.1: Characteristics of plastic waste and corn stover.

	Moisture (%)	Ash (%)	Sulfur (%)	Chlorine (%)	Calorific value (MJ/kg)
Plastic wastes	0.35	0.22	0.17	0.15	58.0
Corn stover	8.47	8.62	0.08	0.11	15.4

Table 4.2: Characteristics of pellet from corn stover.

Preheating temperature (°C)	Moisture content of material (%)	Pellet characteristics						
		Moisture content (%)	Ash (%)	Sulfur (%)	Chlorine (%)	Carbon (%)	Oxygen (%)	Calorific value (MJ/kg)
25	5	2.17	8.92	0.08	0.11	53.19	43.79	15.8
25	10	3.62	8.26	0.09	0.13	52.17	44.81	17.9
25	15	5.36	9.36	0.08	0.11	53.04	43.94	16.2
25	20	7.30	8.49	0.08	0.12	53.77	43.21	16.1
75	5	3.95	8.39	0.08	0.11	53.19	43.79	16.3
75	10	4.43	8.63	0.09	0.13	52.17	44.81	15.6
75	15	6.53	8.41	0.08	0.11	53.04	43.94	16.6
75	20	7.26	8.11	0.08	0.12	53.77	43.21	16.4
100	5	0.96	9.12	0.08	0.11	53.19	43.79	16.1
100	10	1.05	8.02	0.08	0.13	52.17	44.81	16.3
100	15	2.37	8.52	0.08	0.11	53.04	43.94	16.4
100	20	5.50	8.65	0.08	0.12	53.77	43.21	16.3

Moisture content affected to calorific value and durability index of the densified fuel. At 75°C and 100°C, increasing moisture content from 5% to 10% led to increased durability of corn stover pellet from 85 – 87%, but decreased calorific value. From Figs. 4.4 and 4.5, moisture content was not found to significantly affect the pellet density, but it direct impacted on durability. For the mixture of plastic and biomass, preheating temperature did not affect change in density or durability, but, for biomass only, higher preheating temperature (100°C) seemed to result in higher pellet density and durability index. Material type had important effect on ash, sulfur, carbon and chlorine content as well as calorific value. Calorific value of corn stover was increased when it was mixed with plastic waste. While plastic waste has high sulfur and chlorine content, they can be reduced by mixing with corn stover, similar to that reported in Chen and Tsai (2011). Li and Zhang (2001) and Yaman (2000) found that mixed paper briquette had low HHV because of high ash content. When the briquette made from mixed paper and plastics, their properties were improved. Preheating temperature can affect mechanical strength in terms of durability index and pellet density and moisture content of pellet. The pellet density with 100°C of preheating temperature was higher than 75°C. Furthermore, there was some moisture loss during compression process which reduced moisture content of pellet. Increasing preheating temperature from 75 to 100°C was found to increase durability index from 97 – 99% and 89 – 99% for mixed plastic waste and corn stover pellet and corn stover pellet, respectively.

Table 4.3: Characteristics of pellet from mixed plastic waste and corn stover.

Preheating temperature (°C)	Moisture content of material (%)	Pellet characteristics						
		Moisture content (%)	Ash (%)	Sulfur (%)	Chlorine (%)	Carbon (%)	Oxygen (%)	Calorific value (MJ/kg)
25	5	2.42	6.76	0.13	0.12	82.83	15.12	26.4
25	10	3.37	6.10	0.12	0.12	86.65	12.03	27.2
25	15	4.19	6.34	0.12	0.07	86.13	12.69	28.4
25	20	6.30	6.00	0.12	0.12	84.33	12.52	28.1
75	5	1.36	6.40	0.13	0.12	82.83	15.12	26.4
75	10	2.62	6.12	0.12	0.12	86.65	12.03	27.2
75	15	3.02	7.02	0.12	0.07	86.13	12.69	28.4
75	20	3.98	6.26	0.12	0.12	84.33	12.52	28.1
100	5	1.02	6.83	0.13	0.12	82.83	15.12	26.4
100	10	1.88	6.76	0.12	0.12	86.65	12.03	27.2
100	15	2.12	6.10	0.12	0.07	86.13	12.69	28.4
100	20	2.42	6.30	0.12	0.12	84.33	12.52	28.1

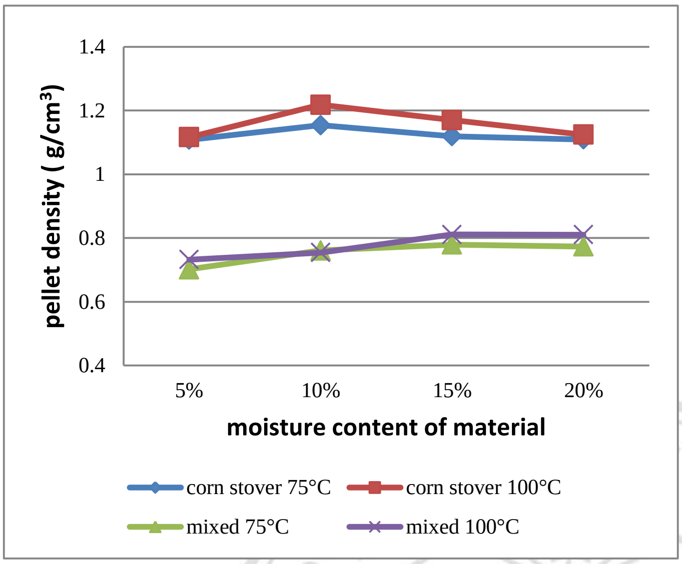

Figure 4.4: Relation of pellet density and moisture content of

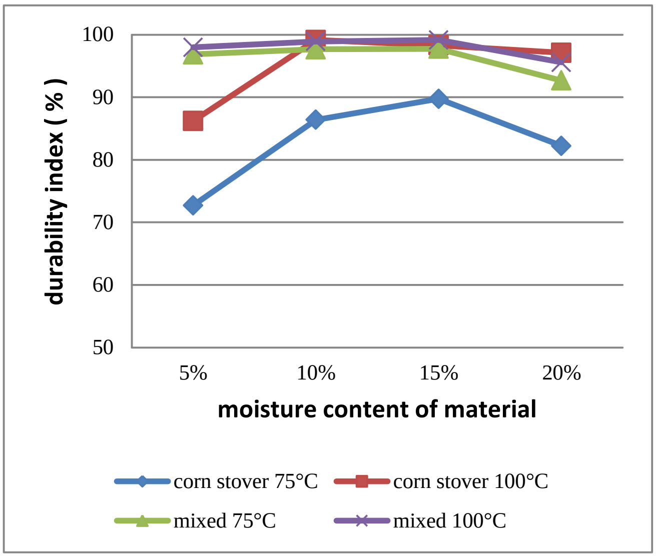

Figure 4.5: Relation of durability index and moisture content of material.

4.4 Conclusion

Plastic waste and agriculture waste can be upgraded to densified fuel. Properties and quality of the pelletized fuel depended on type of material, moisture content, and preheating temperature. Type of feed material affected quality of densified fuel in terms of density, durability index, calorific value, and sulfur and chlorine components. Mixing plastic waste with corn stover offered densified fuel with higher calorific value and lower ash content, hence improved quality. Furthermore, starting moisture content of the feed and preheating temperature before compaction were observed to have influence on density and durability index of the pellets. This research found that optimum moisture content was 5-15%, and higher preheating temperature can result in higher pellet density and durability index.

4.5 References

Chen, W. S., Chang, F. C., Shen, Y. H., & Tsai, M. S. (2011). The characteristics of organic sludge/sawdust derived fuel. *Bioresource Technology, 102*(9), 5406-5410. doi:10.1016/j.biortech.2010.11.007

Li, Y., Liu, H., & Zhang, O. (2001). High-pressure compaction of municipal solid waste to form densified fuel. *Fuel Processing Technology, 74*(2), 81-91. doi:10.1016/s0378-3820(01)00218-1

Yaman, S., Şahan, M., Haykiri-açma, H., Şeşen, K., & Küçükbayrak, S. (2000). Production of fuel briquettes from olive refuse and paper mill waste. *Fuel Processing Technology, 68*(1), 23-31. doi:10.1016/s0378-3820(00)00111-9