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Original Article

Low Cost Technology for Solid Recovered Fuel Production from Municipal Solid Waste

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Abstract

The main objective of this study is to develop a low cost technology for Solid Recovered Fuel (SRF) production from Municipal Solid Waste (MSW) which consists of Paper + Card+ Wood+ Plastic+ Textile (Energy Rich Fraction), (No metal, glass or food waste) using solar heater. To fulfill these objectives a prototype is designed to bio dry the MSW so can reach less water content and higher calorific value. The results of this research have indicated that the solar heater reduced the moisture content from 11.73 % to 2.21 % in 3 to 5 days per batch with average of 6 working hours per day, and have increased the calorific value of the waste from 6174.3cal/g to 7337cal/g.

Keyword: Municipal, Recovered Fuel, Low cost, Solid Waste

Introduction:

Cairo, being one of the largest cities in the world, is home to more than 15 million inhabitants. Like other mega-cities, solid waste management is a huge challenge for Cairo municipality and other stakeholders. The city produces more than 15,000 tons of solid waste every day which is putting tremendous strain on city's infrastructure. Waste collection services in Cairo are provided by formal as well as informal sectors. While local authorities, such as the Cairo Cleanliness and Beautification Authority (CCBA), form the formal public sector, the informal public sector is comprised of traditional garbage-collectors (the Zabbaleen). Around 60 percent of the solid waste is managed by formal as well as informal waste collection, disposal or recycling operations while the rest is thrown on city streets or at illegal dumpsites. The present waste management is causing serious ecological and public health problems in Cairo and adjoining areas. In fact, disposal of solid waste in water bodies has led to contamination of water supplies is several parts of the city. Waste collection in Cairo is subcontracted to 'zabbaleen', local private companies, multinational companies or NGOs. The average collection rate ranges from 0 percent in slums to 90% in affluent residential areas.

MSW has been inadequately managed for many years in Egypt. Waste collection systems have left large areas of towns and cities (in some cases more than 50%) without service or under-serviced, and the majority of collected waste is dumped in facilities that lack any effective management.

The amount of solid waste produced annually in Egypt is growing at an estimated 3.4% per year (Country Report on the Solid Waste Management in Egypt, 2010). The waste generation is projected to exceed 30 MT yearly by 2025.

SRF is the solid fuel prepared (processed, homogenized and upgraded to a quality that can be traded amongst producers and users) from non-hazardous waste to be utilized for energy recovery in incineration or co-incineration plants and meeting the classification and specification requirements laid down in CEN/TS 15,359

Burning fossil fuels is a serious problem caused by human activity that demands strong remedial action as soon as possible. Fossil fuels (oil and natural gas) are the most important energy sources for Egypt. Egypt is currently the world's 25th largest oil producer, produce 4.5 billion barrels, by 2030 will produce 1.5 billion barrels (BP., 2009). Within approximately 20 years, Egypt's natural gas production will face the same fate as domestic oil production.

So, Renewable Energy (RE) has become a driving force in the effort to sustain the earth's natural resources and to improve the users' quality of life. RE can be defined as a free source of sustainable energy, such as wind or solar energy that produces no negative impacts during conversion process like the emission of hazardous substances. Several RE resources have been developed and successfully implemented. A secondary process that converts RE into other energy resources is required to fully utilize RE in a variety of applications.

Due to rising of energy cost and decreasing of the energy remaining reserves in Egypt in the same time increasing of energy demand, will solve this

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problem by using the MSW in production solid recovered fuel by low cost technology.

Mechanical Biological Treatment (MBT) partially processes mixed household waste by mechanically removing some parts of the waste and by biologically treating others, so the residual fraction is smaller, more stable and more suitable for many possible uses.

Bio-drying is a variation of aerobic decomposition, used within mechanical–biological treatment (MBT) plants to dry and partially stabilize residual municipal waste. Bio-drying MBT plants can produce a high quality (SRF), high in biomass content. Bio-drying (biological drying) is an option for the bioconversion reactor in mechanical–biological treatment (MBT) plants, a significant alternative for treating residual municipal solid waste (MSW). Waste treatment plants defined as MBT integrate mechanical processing, such as size reduction and air classification, with bioconversion reactors, such as composting or anaerobic digestion.

Previous Studies:

▪ Adani et al., (2002)

Studied influence of biomass temperature on biostabilization–biodrying of MSW. Three trials were carried out at three different biomass temperatures (A=70, B=60 and C=450C), obtained by airflow rate control. Biodegradation and biodrying processes are inversely related: fast biodrying determines low biological stability and vice versa. Process C showed the highest water elimination and lowest degradation rate was optimal for SRF production having the highest energy content.

▪ Sugni et al., (2005)

Pointed out how biomass temperature affects biodrying processes. Used the one way air-flow approach that is commonly used in full scale plants. They found that unidirectional flow causes lack of homogeneity in the final product, in relation to the parameters of moisture, calorific power and energy content.

▪ Ming Shao et al., (2012) Studied three ventilation modes: intermittent negative ventilation (IN), continuous negative ventilation (CN) and intermittent positive ventilation (IP) to provide the same amount of total air during biodrying of municipal solid waste (MSW). From the aspect of biodrying efficiency, continuous negative ventilation was the most preferable ventilation mode for

▪ Tambone et al., (2011) After 14 d of biodrying MSW, the water content was reduced allowing the production of biodried waste with a net heating value (NHV) of 16,779 kJ/kg wet weight. The low moisture content of the biodried material reduced also the potential impacts of the waste.

▪ Frei et al., (2004) A novel biodrying process was investigated whose goal was to increase the calorific value of pulp and paper wastewater sludge for efficient combustion in wood waste furnaces.

Our objective is to develop low cost technology for SRF production from MSW using solar heater.

Methodology:

The prototype consists of the following components: solar panel, air inlet, main waste drums equipped with inlet and outlet loading and out loading ports, air outlet, and gear box.Waste goes inside barrels from a plastic door, and goes out from another plastic door after drying inside rotating barrels. Hot air from solar heater goes through the pipe and pipe will distribute air inside barrels by inclined holes and air go through rectangular opening at the end of the pipe and go outside. Electric motor with small gear is mounted on steel frame and pipe with barrels assembly set on this steel frame.

In the right end of the pipe straight T- pipe will be assembling with closed end. Solar heater is responsible for heating air by capture and focus solar power.

Results and Discussions:

The MSW sample which consists of:

Paper + Card+ Wood+ Plastic+ Textile (Energy Rich Fraction) from Mansheyet Naser, (No metal, glass or food waste) with size less than 50 mm in four batches, two of them in the winter (December 2014) and the other two in summer (April and May 2015).

Homogeneous MSW sample of variable weight ranging from 50Kg to 150 Kg will be loaded into the main waste drum for various time period ranges from 2 to 8 hours. During this waste loading time the following variables were measured by data logger (Passport Interface): Air flow, ambient temp, air flow temperature in and out air moisture content.

Batch 1 (December 2014)

Day 1 from 8 am to 3 pm
Day 2 from 10 am to 4 pm
Day 3 from 10:30 am to 3:30 pm.

Batch 2 (December 2014)

Day 1 from 11:30 am to 4:30 pm
Day 2 from 9:30 am to 4:30 pm
Day 3 from 9 am to 3 pm.

Batch 3 (April 2015)

Day 1 from 9:30 am to 4:30 pm
Day 2 from 10 am to 4 pm
Day 3 from 9:30 am to 5 pm
Day 4 from 10 am to 5:30 pm
Day 5 from 10 am to 5:30 pm.

Batch 4 (May 2015)

Day 1 from 10:30 am to 4:30 pm
Day 2 from 8:30 am to 5:30 pm
Day 3 from 10:30 am to 6 pm
Day 4 from 10 am to 6 pm.

- Parameters in each batch are: Net Calorific Value, Moisture Content and Ash.

Waste analysis was conducted at Science & Technology Center of Excellence.

- Input Variables are: Humidity, Airflow and Air Temperature.
- Measured: Air Temperature, Waste Temperature, Humidity (absolute and relative), Dew Point, Differentiation Pressure, Air flow and Venturi Water in each batch by Data Logger.
- Energy Input = 250 Watt.

<u>Batch 1:</u>

- After 3 days with 18 working hours, reached high calorific value (almost 7337),
- And low moisture content (almost 3.64 %).
- Bio-drying municipal solid waste increase Ash content to 3.78 %.
- Increased waste temperature till it reach max. 43.6 When max. Air temperature 25.4.
- When the air flow increases the waste temperature decreases.
- When the moisture content increases the calorific value decreases.

<u>Batch 2:</u>

- After 3 days with 18 working hours, reached high calorific value (almost 6930.2),
- And low moisture content (almost 3.57%).
- Bio-drying municipal solid waste increase Ash content to 3.78 %.
- Increased waste temperature till it reach max. 39.1 When max. Air temperature 32.8.
- When the air flow increases the waste temperature decreases.
- When the moisture content increases the calorific value decreases.

<u>Batch 3:</u>

- After 5 days with 35.5 working hours, reached high calorific value (almost 6472.5),
- And low moisture content (almost 2.34%).
- Bio-drying municipal solid waste increase Ash content to 5.9 %.
- Increased waste temperature till it reach max.73.1When max. Air temperature 42.8.
- When the air flow increases the waste temperature decreases.
- When the moisture content increases the calorific value decreases.

<u>Batch 4:</u>

- After 4 days with 31.5 working hours, reached high calorific value (almost 6489.8),
- And low moisture content (almost 2.06 %).
- Bio-drying municipal solid waste increase Ash content to 8.01 %.
- Increased waste temperature till it reach max. 62.1 When max. Air temperature 38.3.
- When the air flow increases the waste temperature decreases.
- When the moisture content increases the calorific value decreases.

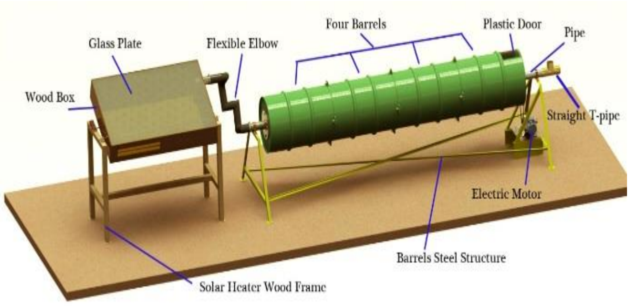

Fig. 1: Bio Dryer Construct

<u>Batch 1:</u>

Day 1:

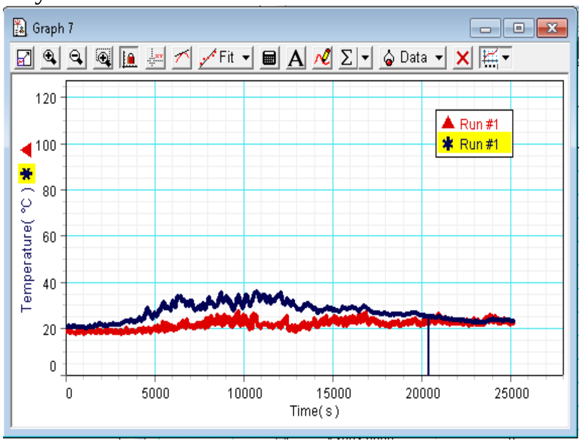

Fig. 2: Temp.of Air (C)&Temp. of Waste (C) &Time (S)

Day 2:

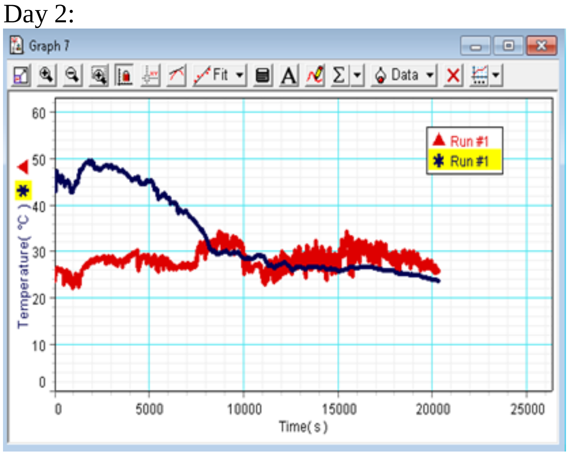

Fig. 3: Temp.of Air (C)&Temp. of Waste (C) &Time

Day 3:

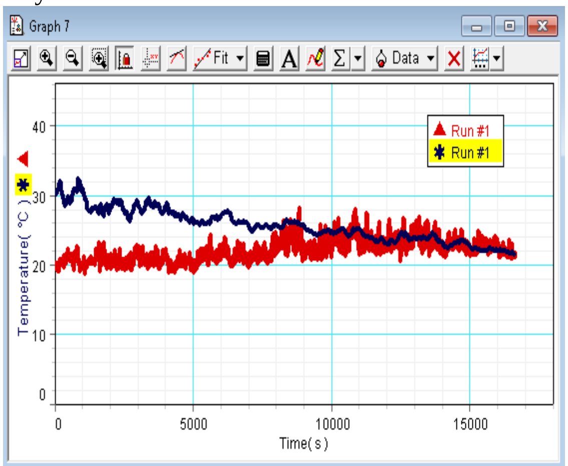

Fig. 4: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 3:

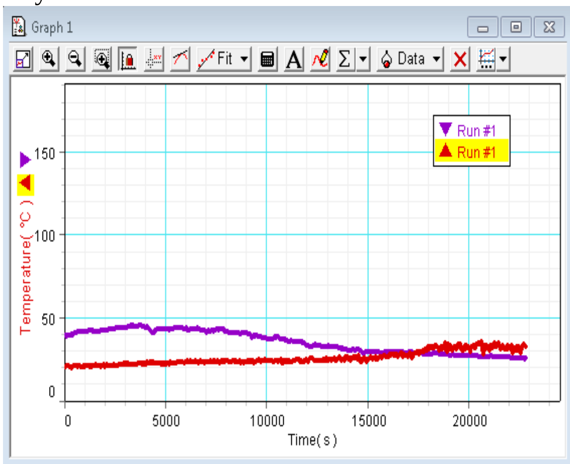

Fig. 7: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

<u>Batch 2:</u>

Day 1:

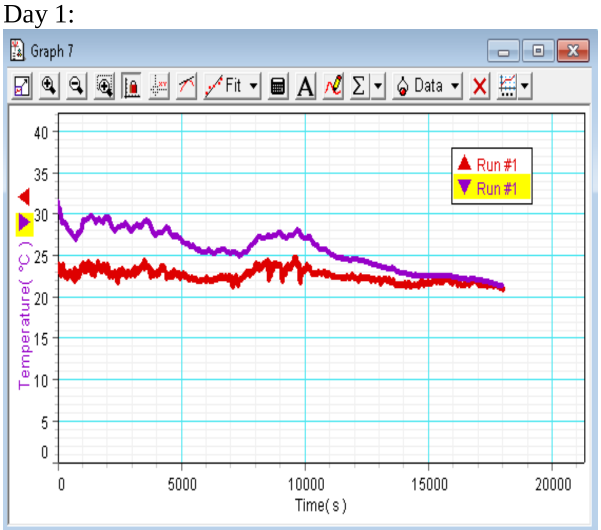

Fig. 5: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

<u>Batch 3:</u>

Day 1:

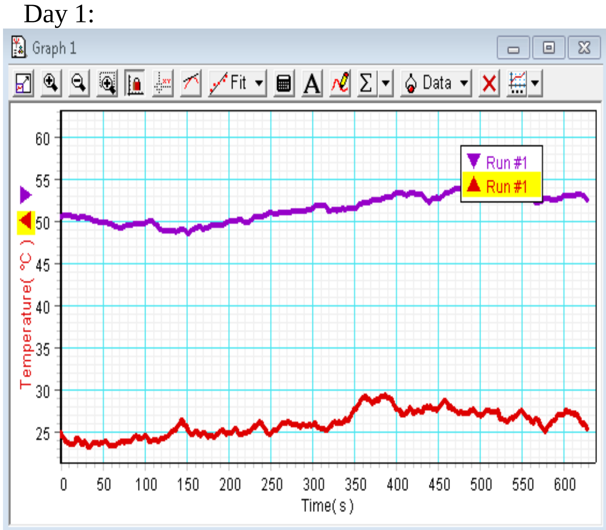

Fig. 8: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 2:

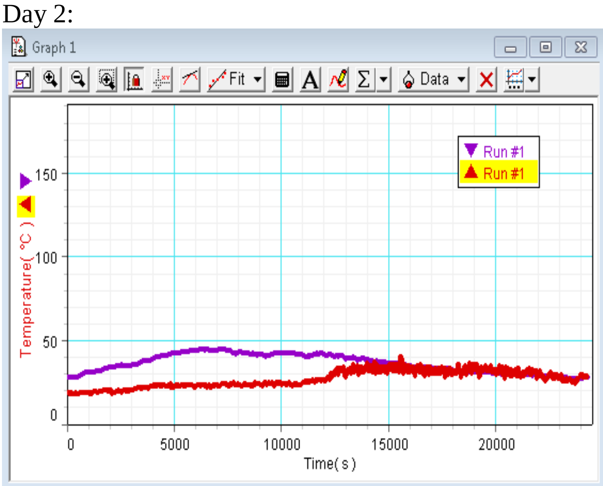

Fig. 6: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 2:

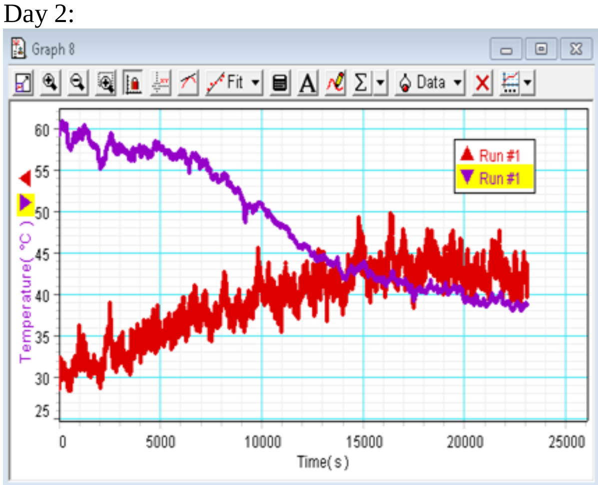

Fig. 9: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 3:

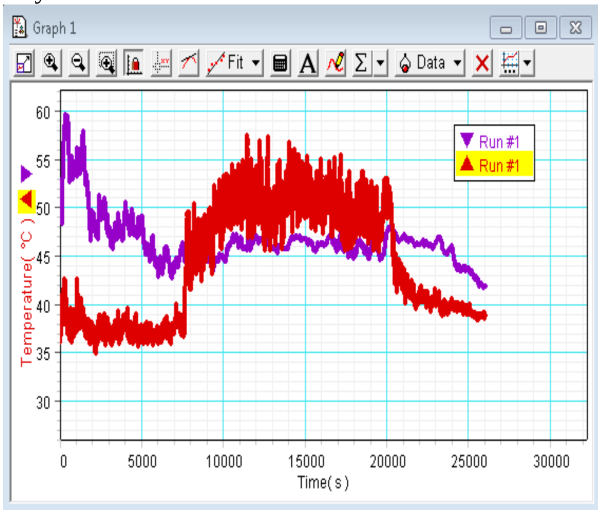

Fig. 10: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 4:

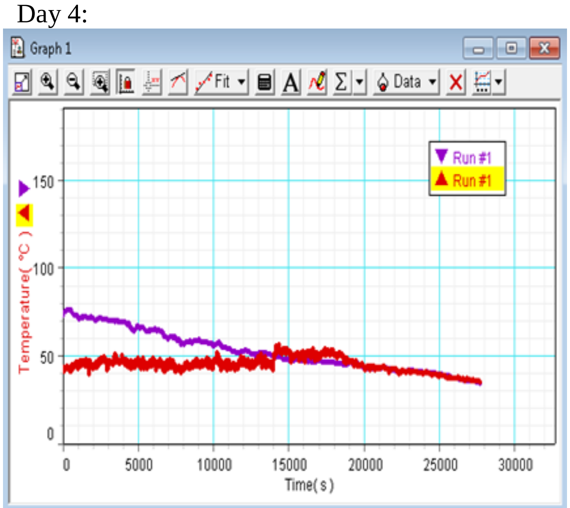

Fig. 11: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 5:

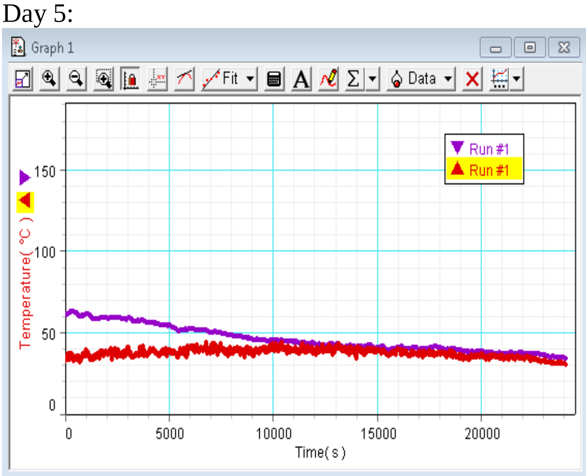

Fig. 12: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Batch 4:

Day 1:

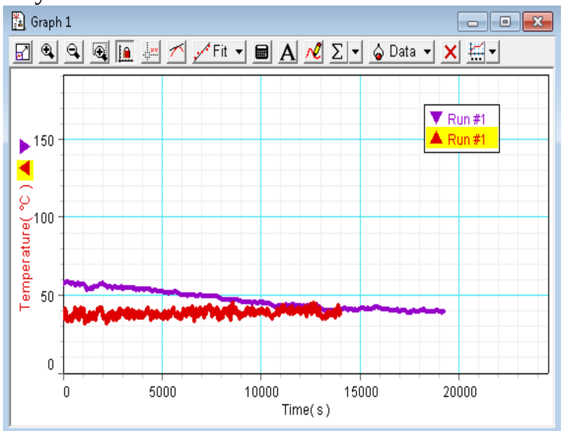

Fig. 13: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 2:

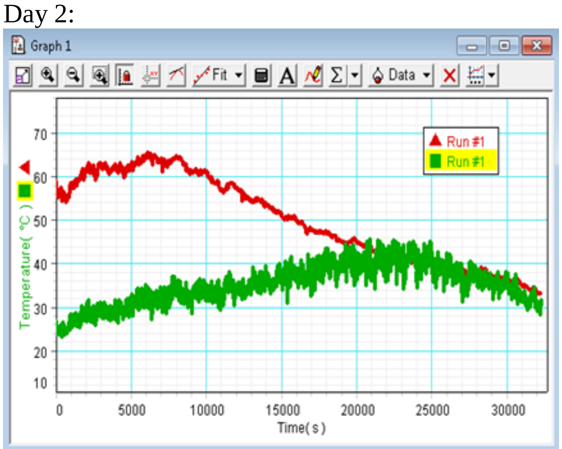

Fig. 14: Temp.of Air (C) & Temp. of Waste (C) &Time

Day 3:

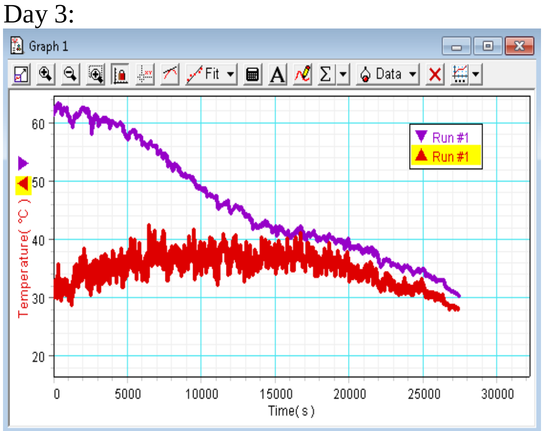

Fig. 15: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Day 4:

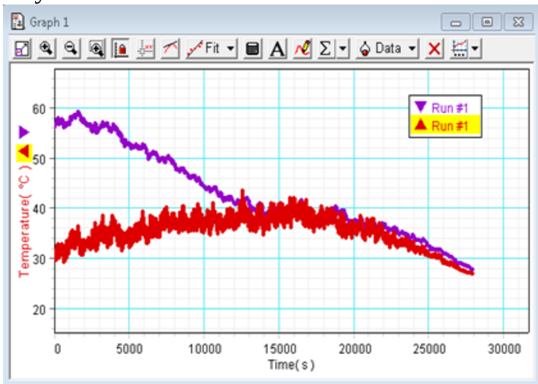

Fig. 16: Temp.of Air (C) & Temp. of Waste (C) &Time (S)

Batch 3&4:

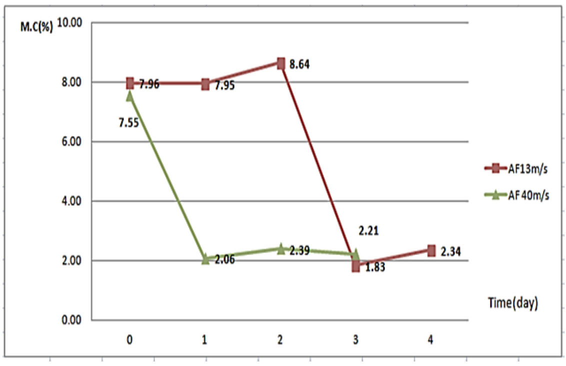

Fig. 20: M.C (%) & Time (day)

Batch 1&2:

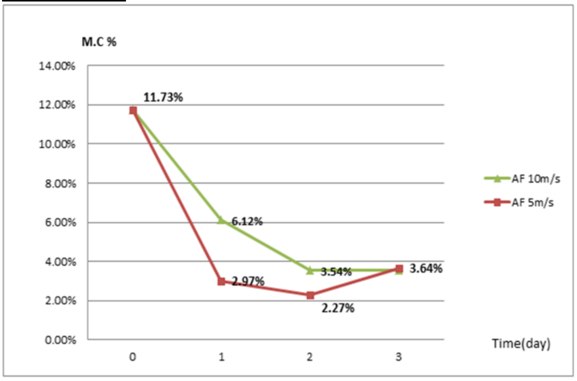

Fig. 17: M.C (%) & Time (day)

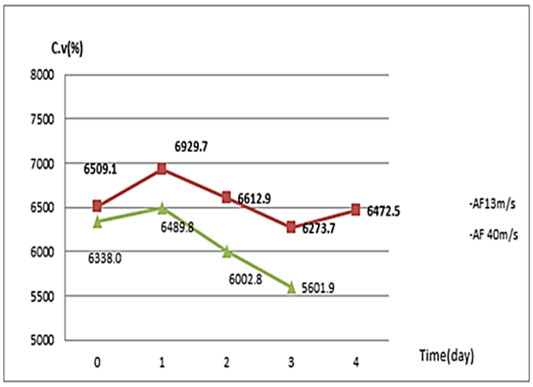

Fig. 21 : C.V (cal/ g) & Time (day)

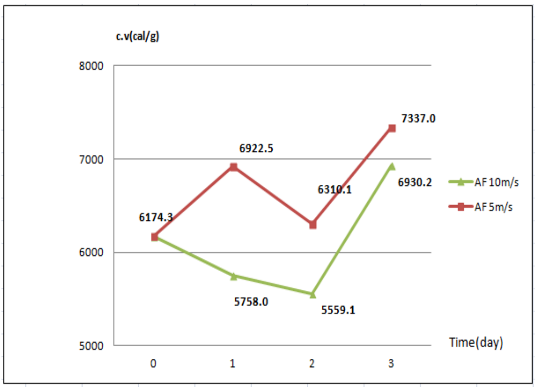

Fig. 18 : C.V (cal/ g) & Time (day)

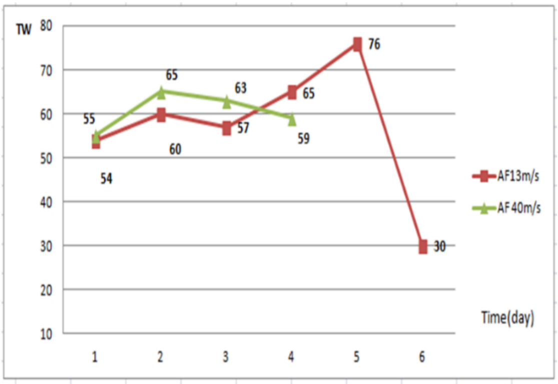

Fig. 22 : C.V (cal/ g) & Time (day)

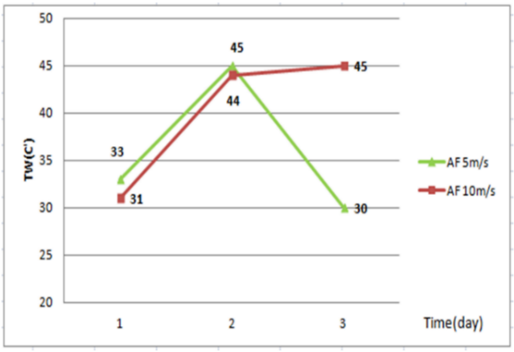

Fig. 19 : C.V (cal/ g) & Time (day)

Batch 1:

Day	Time	AT	WT	MC %	CV	Ash contet %
9-12-2014	8 am 3 pm	18.6 21.9	20.6 23.9	11.73% 2.97 %	6174.3 6922.5	2.61 %
10-12-2014	10 am 4 pm	24.3 25.4	43.6 23.5	2.27 %	6310.1	
11-12-2014	10:30 am 3:30 pm	19.4 21.4	30.5 21.4	3.64 %	7337	3.78 %

Batch 3:

Day	Time	AT	WT	MC %	CV	Ash content %
25-4-2015	9:30am 4:30pm	24.8 25.4	50.4 52.5	11.73 7.96	6174.3 6509.1	2.61
26-4-2015	10 am 4pm	28.9 42.8	59.2 39.1	7.95	6929.7	
27-4-2015	9 am 3 pm	36.9 41.2	49.3 46.8	8.64	6612.9	3.78 %
28-4-2015	10 am 5 pm	41 38.6	73.1 38.8	1.83	6273.7	
29-4-2015	10 am 5 pm	34.6 30.3	60.5 34	2.34	6472.5	5.9

Batch 4:

Day	Time	AT	WT	MC %	CV	Ash content %
2-5-2014	10:30 am 4:30 pm	38.3 36	57.1 39	11.73 % 7.55 %	6174.3 6338	2.61 %
3-5-2014	8:30 am 5:30 pm	26.2 31.5	58 33	2.06	6489.8	
4-5-2014	10:30 am 5:30 pm	31.6 30.2	62.1 30.3	2.39	2006.8	
5-5-2015	10 am 6 pm	30.4 26.7	56.1 27.7	2.21	5601.9	8.01

Conclusion:

The main objective of this study is to develop a low cost technology for Solid Recovered Fuel (SRF) production from Municipal Solid Waste (MSW) which consists of Paper + Card+ Wood+ Plastic+ Textile (Energy Rich Fraction), (No metal, glass or food waste) using solar heater. To fulfill this objectives a prototype is designed to bio dry the MSW so can reach less water content and higher calorific value.

- After working almost 8 hours per day for 3 to 5 days per batch, reached high calorific value(almost 7400),And low moisture content (almost 1.8 %) from bio-drying the municipal solid waste by solar energy.

- Bio-drying municipal solid waste increase Ash content increase waste temperature till it reach over 50c.

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