Hydrothermal Treatment of Municipal Solid Waste and Sewage Sludge to Produce Solid Fuel and Liquid Fertilizer

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1. Introduction

Until now, the commercial means of waste treatment are mass land-filling and mass burning. In Japan, most of combustible wastes are incinerated. Land-filling is still the most popular way of waste treatment all over the world. The worldwide goal is to prevent or limit land filling of wastes. Therefore, a third option for waste treatment has to be found, where waste-to-energy (WTE) technologies should be the main focus.

Based on this background, Tokyo Institute of Technology is focusing on development and commercialization of small to medium scale WTE facilities for the utilization of mixed wastes, such as municipal solid waste (MSW), and high water content biomass, such as sewage sludge and animal manure as unutilized resources. In general, the economical feasibility of unutilized resources are not so good, but in the case of wastes, we can get revenue first by treating wastes and second by selling the product (electricity, steam, hot water, fuel, fertilizer, etc.). This Poster presentation introduces an innovative hydrothermal treatment technology, which can produce pulverized coal-like dry and uniform solid fuels from MSW and sewage sludge, as well as produce pathogen and heavy metal free organic liquid fertilizer from sewage sludge.

2. Key Features

Figure 1 shows the operating principle of the hydrothermal treatment, and Figure 2 shows a commercial plant applying this technology. Solid wastes (any combustible wastes such as MSW, plastics, food residue, animal manure, sewage sludge, etc.) are fed into the reactor. Saturated steam at 200-230ºC and 2-3 MPa is injected into the reactor for approximately 40 minutes. The reactor blades rotate for approximately 10 to 30 minutes to achieve uniform mixing. The product is discharged after extracting steam. The extracted steam is condensed, and the condensed water is discharged or recycled as boiler feed water after appropriate water treatment.

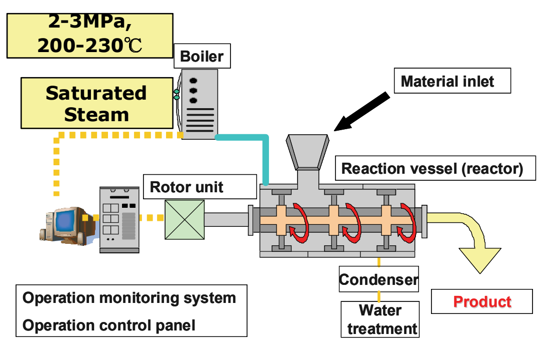

Figure 1. Operating principle of the hydrothermal treatment.

Figure 2. Commercial plant of the hydrothermal treatment.

In the case of MSW as shown in Figure 3, the raw wastes of various sizes become powdery material. The water content however remains about the same as that of the raw material. The powdery product is subsequently dried by ambient air or by air blowing. Drying carried out using natural energy results in low energy consumption. The product is almost odorless and with heating value of about two thirds that of coal. These can be used for co-firing with coal for power generation or as part-substitute for coal for cement manufacture. On the other hand, in the case of sewage sludge whose typical water content is around 80% after the mechanical dehydration, it becomes slurry-like material whose water content is higher than the raw sludge as shown in Figure 4. But this slurry-like product shows significantly improved dehydration performance compared with the raw sludge, and the mechanical dehydration of the product will produce separated water and solid residue with the water content less than 60%. The solid residue shows good drying performance as in the case of MSW product, and we can obtain dried powdery product easily whose heating value is about two thirds that of coal. About 20 to 30 % of the solid component is dissolved in the separated water, and the separated water contains much nutrient such as N, P and K. The heavy metal content in the raw sludge is left in the solid residue, so the separated water can be utilized as pathogen and heavy metal free organic liquid fertilizer after diluting with 30-50 times large amount of water.

In the Poster presentation, following experimental results will be shown employing the commercial plant shown in Figure 2.

MSW treatment

Compared with coal, the solid fuel produced from MSW contains much less sulfur but more chlorine originating from PVC (organic chlorine) and salt (inorganic chlorine). Our target chlorine content in the solid fuel product is less than 3000 ppm for safety usage in cement kilns as co-firing fuel with coal. In the case of Japanese MSW, the drying process will produce solid fuel with a chlorine content around 10,000 ppm. By raising the temperature and holding time of the hydrothermal reaction, the organic chlorine content in PVC can be effectively pyrolized into hydrogen chloride, part of which will be discharged from the reactor together with steam, which results in the solid fuel product with less chlorine content compared with that produced from conventional drying processes. This dechlorination performance of the hydrothermal treatment will be presented.

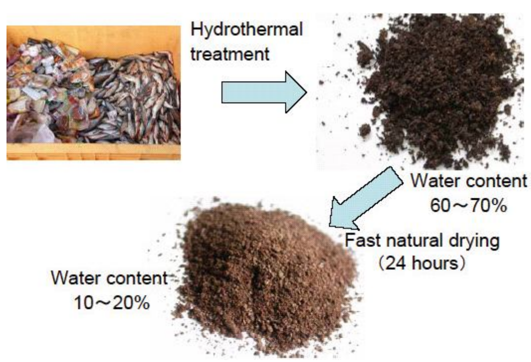

Figure 3. MSW treatment.

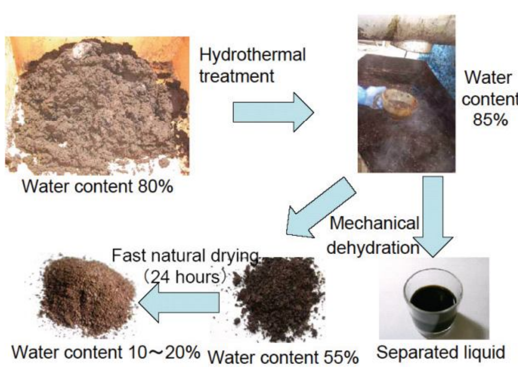

Figure 4. Sewage sludge treatment.

Then the co-combustion performance of the solid fuel product with high ash Indian coal is investigated by the thermogravimetric analysis. The results confirm that up to 20% of the MSW product blend, the ignition and carbon burnout performance have improved and help in achieve a homogeneous combustion. For 30% to 50% blends, the constituents burn independently without any interaction, results in two different region of burning and the coal is ignited only when it achieved its own ignition temperature.

Sewage sludge treatment

The solubilization rate of N, P and K contents in the raw sludge is investigated by changing the temperature of the hydrothermal reaction. The results show higher solubilization rates for these nutrient elements by raising the temperature.

Then the fertilizing effects of the separated water are investigated by the germination and planting tests. The test results show that the separated water can be utilized as liquid fertilizer by appropriately diluting with water.

3. Conclusions

The hydrothermal treatment can effectively convert mixed solid wastes such as MSW into pulverized coal-like dried fuel which is suitable for co-firing with coal in boilers or cement kilns. This is one of most effective means to reduce CO_2 emission associated with coal firing. The hydrothermal treatment can also produce solid fuel suitable for co-firing with coal together with pathogen and heavy metal free organic liquid fertilizer from sewage sludge.

Author Biography

Dr. Kunio Yoshikawa is a Professor of Frontier Research Center, Tokyo Institute of Technology, Japan. He graduated from Tokyo Institute of Technology and obtained Ph.D. in 1986. After his graduation, Prof. Yoshikawa worked for Mitsubishi Heavy Industries for one year, and returned to his home university as a Research Associate, then became Associate Professor and Professor. His major research areas are energy conversion, thermal engineering, combustion, waste treatment technologies and atmospheric environmental engineering. He has authored more than 200 papers. His main awards are the AIAA (American Institute of Aeronautics and Astronautics) Best Paper Award in 1999, the ASME (American Society of Mechanical Engineers) James Harry Potter Gold Medal in 2001, and the JSME (Japanese Society of Mechanical Engineers) Environmental Technology Achievement Award in 2006.