

DISPOSABLE DIAPER RECYCLING TRIAL IN FURANO, HOKKAIDO, JAPAN

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Abstract

The population in Japan peaked around 2010;; however, the population has since begun to shrink. The average lifetimes of males and females in Japan are 81 and 87 years, respectively. Long lifetimes and low birth rates have transformed Japan into a "super--aging society". The amount of discarded disposable diapers is increasing globally as well as in Japan, and the final processing stage in majority of these cases is incineration or landfill. However, there are two recycling systems in Japan, including material recycling and thermal recycling. In material recycling, the high--quality pulp recycled from waste diapers is converted into material for newly reproduced diaper (in trial) or wall board, the low--quality pulp and sludge are converted into a soil enhancement additive, and the plastic is converted into refuse--derived plastic fuel (RPF) using a water--based system. In thermal recycling, recycled fuel is used for heating source for public bath. This increasing trend of waste diaper is also observed on a local level, such as in the city of Furano, Hokkaido, Japan, where they are sent to an incinerator. Furano has attempted to thermally recycle hygiene waste, including disposable diaper and pet litter, for a year. This thermal recycle is analyzed, and this recycle can save CO₂ emission in comparison with the conventional processing (incineration and landfill). A combination of thermal recycling and refuse--derived fuel (RDF), which is conducting there, is considered to be viable for handling disposable diapers in Furano.

Keywords: Aging Society, Material Recycle, Thermal Recycle, Disposable Diaper

1.0 INTRODUCTION

The population in Japan has reached the peak around 2010, and started to shrink (Cabinet office of Japan). The average lifetimes of male and female in Japan are 81 and 87 years old, respectively (Ministry of Health). Longer lifetime and fewer birth rate make Japan go into "Super Aging Society"(Muramatsu and Akiyama, 2011). This tendency occurs at a local city in Japan, Furano with population 22 thousand, Hokkaido, Japan, for example (see Figure 1). Recently the amount of garbage itself in Furano decreases gradually because of population shrinking. On the contrary, the amount of hygiene waste including waste diaper gradually increases (Furano) (see Table 1). This waste is processed in incineration in Furano now, but waste diaper with high moisture causes heavy stress to incinerator.



Figure 1: Location map in Japan

Table 1: Population, total garbage amount, hygiene waste, estimated amount of fuel recycled from hygiene waste, estimated calorific value from the recycled fuel, and CO2 amount emitted during processing the hygiene waste

year	Population	Total Garbage Amount [ton]	Hygiene waste[ton]	Estimated recycled fuel amount from hygiene [ton]	Estimated Calorific value [GJ]	Estimated Emitted CO2 during recycling[ton]
2008	24330	7508.7	514.4	227.8	3909.4	209.2
2009	24143	7504.9	522.7	231.5	3972.5	212.6
2010	23977	7527.9	514.7	227.9	3911.7	209.3
2011	23681	7381.0	540.3	239.3	4106.2	219.7
2012	23515	7434.2	552.2	244.5	4196.7	224.6
2013	23283	7517.1	553.2	245.0	4204.3	225.0
2014	22956	7380.1	551.5	244.2	4191.3	224.3
2015	22661	7247.1	546.7	242.1	4154.9	222.4
2016	22249	7209.4	640.9	283.8	4870.8	260.7
2017	21910	7190.2	634.8	281.1	4824.4	258.2

Diaper for adult is producing about 300 thousand tons per year in Japan (Itsubo et al., 2016). The amount of wasted diaper will also increase (Itsubo et al., 2016;; Fujiyama et al., 2012). In South Korea(Kim and Cho, 2017), Mexico (Espinosa--Valdemar et al., 2014), Europe and Turkey (Cordella et al, 2015), and Africa (Remigios, 2014), many disposable diapers for adult and baby are producing, too. The end of life of used diaper is almost incineration in Japan (Itsubo et al., 2016), and incineration or landfill in Europe and USA (Mirabella, 2013;; Weisbrod and Hoof, 2012).

Under the conditions mentioned above in Japan, Hokkaido Prefecture Government, Japan, established a working group on 2013 under council for recycling resource usage promotion (working group for producing fuel from waste diaper). During 3 years activity, site visit on waste diaper processing factory at Furano, and workshops were conducted. Hokkaido Government conducted questionnaire survey this issue to all 179 municipalities in Hokkaido on December 2014. Only 17 (ca. 10%) employed to sort waste diaper. Almost 80 % (144) employed incineration, and the rest (20%) employed landfill. There appeared the following problems;; as the processing amount increases, incineration efficiency decreases;; smell;; expensive processing cost;; not correctly sorting;; solid sewage is not removed;; and costs of time and money when sorting. And the final workshop was conducted at Sapporo, Hokkaido, Japan on March 24th, 2016 (Hokkaido Government).

Some recycling systems are in operation in Japan;; one is material recycle and the other is thermal one. In Omuta, Fukuoka, Japan, materials recycle system is running (Fig. 1). From waste diaper, they recycle high quality pulp, which is converted into wall board, low quality pulp and sludge converted into soil improvement material, and plastic converted into refused derived plastic fuel (RPF) through water--based system (Total Care Company). We call this "Omuta method" hereafter. The other material recycling system (Itsubo et al., 2016) is now on trial at Shibushi, Kagoshima, Japan (Figure 1). This system is similar to "Omuta method", but this can recycle high quality pulp, which is re--used as material of diaper (Itsubo et al., 2016). We call this system "Shibushi" method hereafter.

Thermal recycling system is running at Houki Town, Tottori, Japan (Figure 1). We call this "Houki method" hereafter. After two years preparation, Houki town started to produce fuel recycled from waste diaper, and this fuel is used for public hot bath heating. By using new fuel, they expect to reduce 20 % gas consumption, and 31ton CO₂ (Houki town). The same systems are working at some places in Japan (Super Faith Company). This method was tested out in Furano City, Hokkaido, Japan. Tsuji et al. (n.d.) have evaluated this thermal recycle used by "Energy Profit Ratio" (EPR), where EPR (Amano, 2008) is defined by

$$\text{EPR} = \text{output energy} / \text{input energy}$$

Trial Activity in Furano, Hokkaido, Japan

Furano is located at the center of Hokkaido, Japan. Furano is also "environmentally friendly town", because that recycling rate of this town is about 90 %, and this high recycling rate is supported by correctly garbage sorting (14 categories) conducted by citizen. One of the categories, non--recyclable plastic and paper, is recycled as fuel. Furano calls it refused derived fuel (RDF). In 14 categories, waste diaper is belonging to "Hygiene Waste", which includes pet litter, too. Furano does not want to increase the number of garbage categories more. Now, waste diaper and pet litter are processed at the same time, and this is sent to incinerator at near town. Neighboring five municipalities, Furano city, Kami--Furano town, Naka--Furano Town, Minami--Furano Town, and Simukappu Village made consortium for processing garbage. All kitchen waste generated in these regions is carried into the common composting factory. If Furano successes in recycle of waste diaper, recycle rate will increase to 95 %.

Furano City considered to introduce "Houki method" (see Figure 2). Furano city asked trial waste hygiene recycle to a private company in Furano city. This company had introduced "Houki method" machine, and processed hygiene waste temporarily during one year. We have analyzed the result (Tsuji et al.);; the EPR value of the hygiene waste is 1.14, we get 0.443 [ton] recycled fuel from 1 [ton] hygiene waste, and CO₂ emission is 48.2 [ton/year] during recycling.

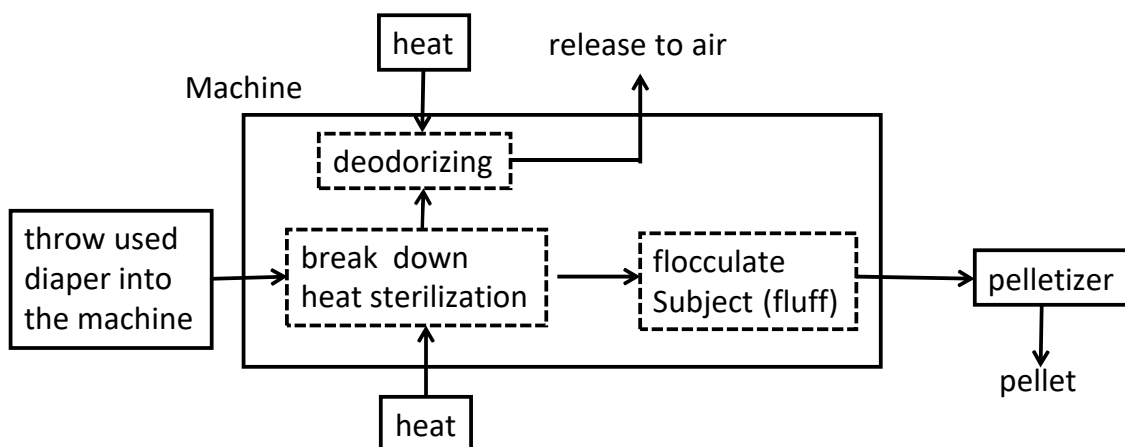


Figure 2: Processing flow of "Houki method"

2.0 RESULTS AND DISCUSSION

From the EPR view point, the hygiene waste is not bad because EPR is greater than 1. The author analyzed from the view point of CO₂ emission;; the thermal recycle of used diaper releases 0.406 [tCO₂/ton] (Tsuji et al.) when 1 ton of waste diaper is input to the system. Omuta method emits 0.290 [tCO₂/ton] and Shibushi emits 0.613 [tCO₂/ton] (Itsubo et al., 2016). While, the conventional processing of diaper (incineration and landfill) releases 0.868 [tCO₂/ton] (Fujiyama et al., 2012) or 0.578[tCO₂/ton] (Itsubo et al., 2016). Then, the thermal recycling system can save CO₂ emission. Table 1 shows the virtual (estimated) amount of CO₂ emission if Furano conducts the thermal recycling.

Furano is producing RDF from non--recyclable plastic and fiber as mentioned above. EPR of RDF is 7.8 (Amano and Tsuchiya, 2010), but this includes the consuming energy for transporting RDF to the boilers at the outside of Furano, where RDF is used. As Furano is now in trial to use this RDF at the inside of Furano, this transporting energy is neglected. Then, EPR will be 9.2. The combination of RDF and fluff recycled from diaper is good (Tsuji et al.). After recovering the fluff derived from hygiene waste, it can easily be incorporated into the RDF production line. When the fuel that is derived from hygiene waste is used, the much ash is observed after burning. In addition, the chlorine content in hygiene waste is less than RDF even though the waste diapers may contain polymer, while RDF has a higher chlorine content and produces less ash. Further, a pelletizer is not required to manufacture pellets from fluff.

"Houki method", the same as Furano, is very small machine. And operation is very simple, because that we just throw bag containing waste into machine, and we get flocculate subject after 15--16 hours later. In nursing house or small town, for example, thermal recycle like "Houki method" is good, because that operation is very simple, system is small, we need not water and waste water treatment equipment and EPR is not be less than 1 and less CO₂ emission than the conventional processing (incineration and landfill).

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