CURRENT ISSUES OF OIL RECLAMATION SYSTEM FOR RECYCLING MUNICIPAL WASTE PLASTIC CONTAINING PVC AND PET IN JAPAN

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Abstract: The oil reclamation system for recycling municipal waste plastics in Sapppro plastic recycle Co. LTD. (SPR) has been operated commercially for near ten years by which more than 67,000 ton waste plastics had been recycled even though polyvinyl chloride (PVC) and polyethylene terephthalate (PET) are contained. As a result, SPR has achieved high recycling rate about 90% of recycled products. In addition, hydrocarbon oil has been produced as a by-product which can be used as the raw material for chemical industrial plant. Moreover, cascade recycle which chemical recycle (CR) will be done for selected waste plastics mixed with material recycle (MR) residues after material recycle has been studied since 2008. This paper reports the current issues of oil reclamation system for recycling municipal waste plastics in Japan.

1. Introduction

1.1 Waste plastic recycling in Japan

In 2007, the domestic plastic waste in Japan has reached total 9.94 million tons including 5.02 million tons of household waste and 4.92 million tons of industrial waste. Among those, about 7.22 million tons (73%) are reutilized as materials, fuels, electricity and thermal supply etc. However, 2.71 million tons (27%) were incinerated or land filled [1]. The quantity recycled from the plastic containers and wrapping among the household waste plastic, has reached to 380,000 tons. Under the Container and Packaging Recycling Raw in Japan, about 40% were processed by material recycling operation (called MR, that waste plastics are as the raw materials for plastic products.) and 60% were processed by chemical recycling operation (called CR, like liquefaction, gasification, coke oven, blast furnace etc.). [2]

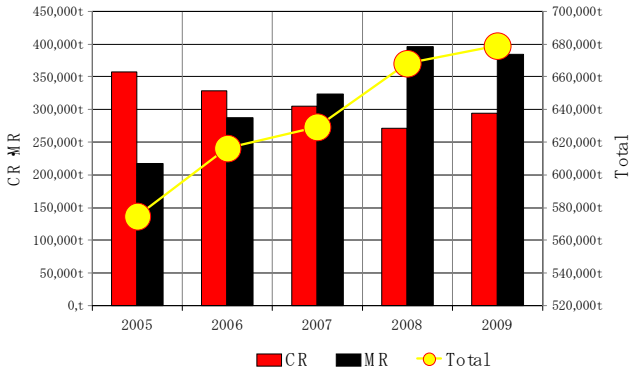

Fig.1 The bid Amount of municipal waste plastics
bv MR and CR and their total amount

However, the bid amount of MR and CR respectively showed in Fig.1 suggests that MR has been holding the more bid amount of municipal waste plastic these 3 years. In 2008, the bid amount of MR reached 400,000t, a maximum amount, while this of CR was 255,000t. Because of recycling policy drawn by Japanese government, the recycling method of MR is holding the dominate position though lower recycling rate it reached.

1.2 Liquefaction System outline

In 2000, Sapporo Plastics Recycling Co., Ltd. (SPR) was established in Sapporo-shi, Hokkaido and started operation with 14,800t/y capacity. Up to now, it has been operated commercially for near ten years. There have been 76,800t waste plastics treated by SPR which is shown in Fig.2. Last year (2008), an investigation of cascade recycling* was carried out. (*Cascade recycling is a new recycling model that MR wastes are processed by CR (liquefaction) mixed with municipal waste plastic.)

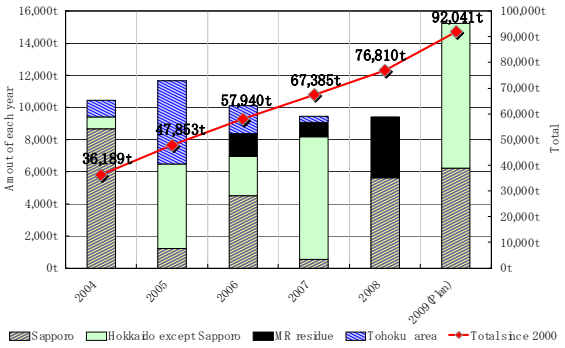

Fig.2 The Achievement of SPR

Fig.3 shows the composition of waste plastic each year from 2000 to 2008. Polyvinyl chloride (PVC) and polyethylene terephthalate (PET) which are unsuitable for liquefaction are contained. Liquefaction process functional outline of SPR is shown in Fig.4. The liquefaction plant is operated with a unique characteristic of installed dechlorination process. Through heating plastic pellets at 350℃ by electric heater, they are melt and hydrochloric gas yielded

by thermal decomposition of PVC is carried over and hydrochloric acid is produced by absorbing into water. With this process, reclamation oil is gained with less chlorine. Moreover, benzoic acid (C_6H_5OOH) which occurred by the thermal decomposition of PET caused corrosion and clogging. The operational troubles caused by PET was solved by adding hydrated lime ($Ca(OH)_2$) to plastic pellets [3,4]. Presently SPR is maintaining safety and stability in operation. Almost all of waste plastics except foreign material and water have been reclaimed and recycled. In 2008, 9,425t waste plastics were treated. The hydrocarbon oil as recycled product with 51wt%, the gaseous fuel with 13wt%, the solid fuel with 20wt%, the heavy oil sludge with 5wt% and the hydrochloric acid as by-product with 1wt% were reclaimed respectively. Aluminum, used as packages of boil-in-the-bag foods, is also started recycling.

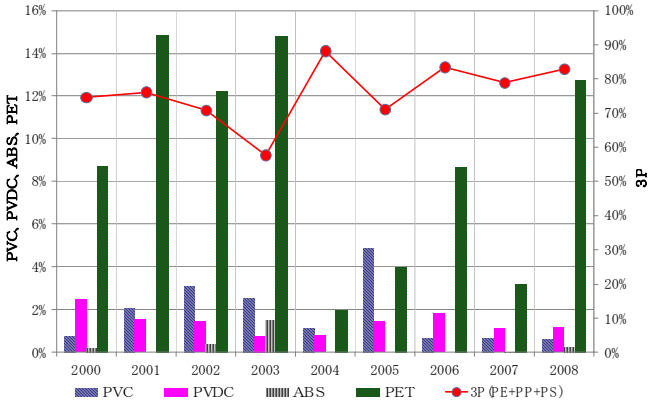

Fig.3 The composition of municipal waste plastic

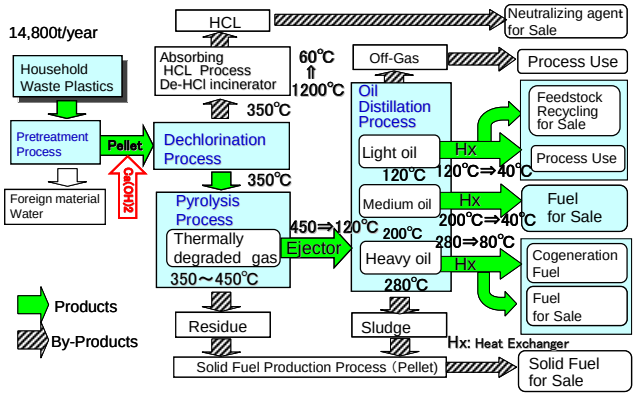

Fig.4 SPR process functional outline

1.3 Characteristic of dechlorination process

Fig.5 shows the characteristic of dechlorination process. Content of chlorine by percentage formed to hydrochloric acid and dropped to residue are compared in the presence of $Ca(OH)_2$ or not. In the case of 0% $Ca(OH)_2$ added, content of chlorine had a high percentage as 96wt%. Since adding $Ca(OH)_2$ to pellets before dechlorination process on December 24, 2000, content of chlorine in hydrochloric acid has decreased. On the other hand,

content of chlorine in thermally degraded residues has increased. It suggests that hydrogen chlorine removed in dechlorination process reacts to $Ca(OH)_2$ and $CaCl_2$ is formed and dropped to pyrolysis process. Inadequate addition of $Ca(OH)_2$ caused corrosion and clogging by increase of benzoic acid and pH of reclamation oil decreased. However, excessive addition of $Ca(OH)_2$ caused increase of thermally degraded residue. So the quantity of $Ca(OH)_2$ added is controlled by watching the pH of reclamation oil.

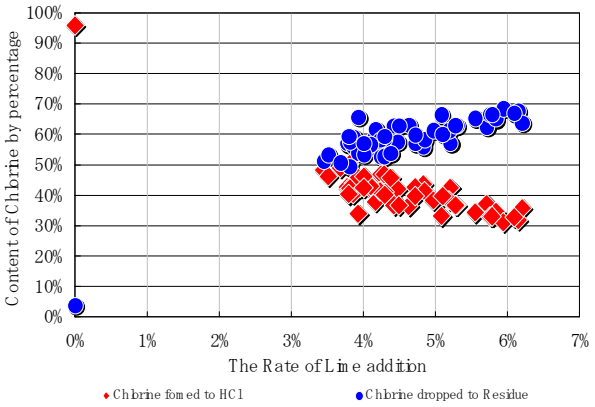

Fig.5 Characteristic of dechlorination process

2. Cascade recycling

A discussion about improvement of plastic package and container recycling is held in 2007. As a result, a combination of material recycling and chemical recycling could offset the disadvantage of one particular recycling method. [5]

As mentioned, cascade recycling is a new recycling combination that MR wastes are processed by CR (liquefaction) mixed with municipal waste plastic. In 2008, an investigation of cascade recycling was carried out by SPR. The concept of cascade recycling is shown in Fig.6.

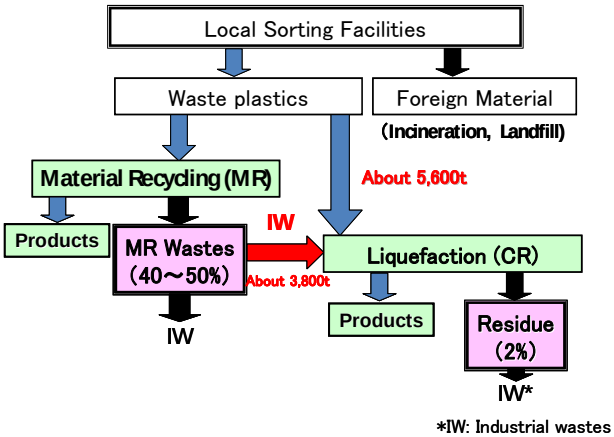

Fig.6 Process of cascade recycling

Through material recycling method, there are still 40~50% plastic wastes which are unsuitable to be reproduced as a raw material. They are accepted by SPR to process by liquefaction mixed with municipal waste plastics. Almost all of waste plastics except foreign material, other inadequate plastics and water has been reclaimed and recycled. There only 2% of residues need thermally recycling or landfill as the industrial wastes. So cascade recycling is considered as an efficient recycling combination and contribute to local feed stock recycling.

However, since PVC and PET occupied highly in MR wastes, an effect of the quantity of mixed MR wastes on the process of liquefaction and the quality of reclamation oil is discussed as followed.

2.1 An effect of the quantity of MR wastes

2.1.1 Corrosion troubles (value of pH)

Fig.7 shows the relationship between the value of pH of reclamation oil and the content of MR wastes*. The value of pH went down to 6.5 or less when 45% or more MR wastes were mixed. This is because that benzoic acid (C_6H_5OOH) which caused corrosion troubles was increased occurred by the thermal decomposition of PET. Once the percentage of MR waste was controlled by less than 40%, value of pH was up from 7 to 8 that corrosion troubles do not occurred.(*Content of MR (%) = Quantity of MR waste/(Quantity of MR + Quantity of waste plastic))

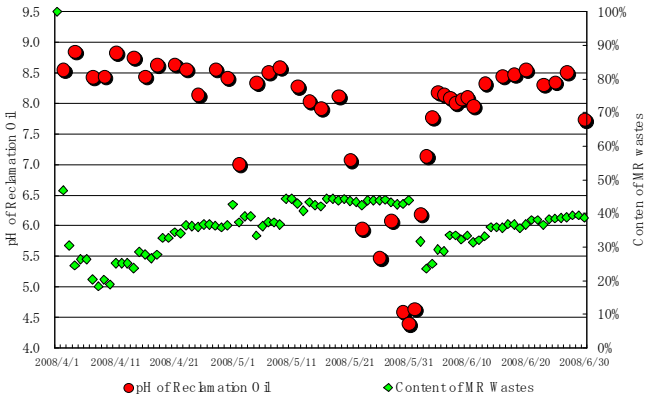

Fig.7 relationship between the value of pH of reclamation oil and the content of MR wastes

2.1.2 Yields of reclamation oil

Fig.8 shows the yields of reclamation oil, gas and residue when 1t of mixed waste plastic are treated by SPR. It suggests that yields of reclamation oil are decreased while those of gas and residue are increased with the increasing of the quantity of MR wastes. Y. Sakata's literature[6] shows that yields of reclamation oil are decreased while those of gas and

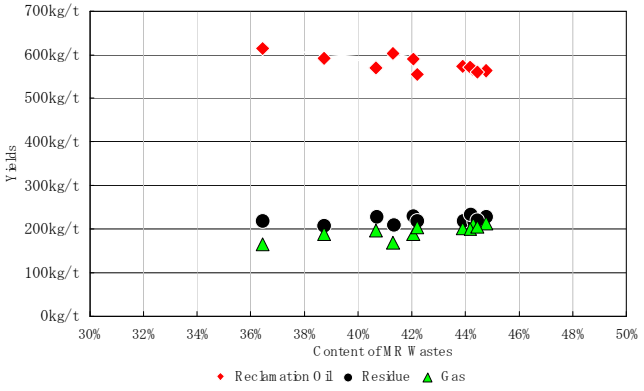

Fig.8 Yields of reclamation oil, gas and residue

residues are increased in the presence of PVC, and the same results with in the presence of PET. Since PVC and PET occupied highly in MR wastes, our investigation show the same tendency. The quantity of MR waste mixed is controlled to gain more reclamation oil.

2.2 Chlorine in reclamation oil

Fig.9 shows chlorine in reclamation oil separated to heavy oil, medium oil and light oil. They have little quantity of chlorine (<100mg/kg (ppm)) and maintain high quality of reclamation oil.

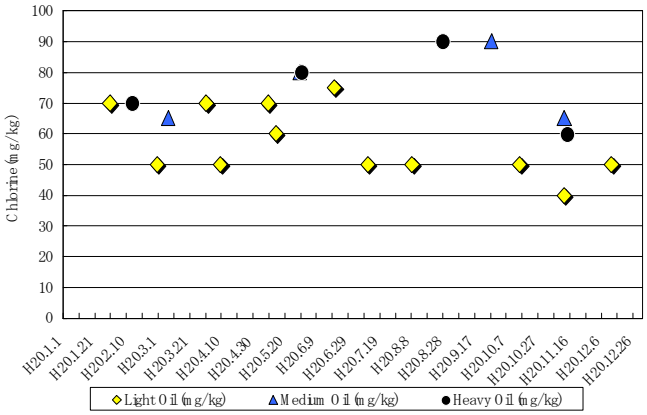

Fig.9 Chlorine in reclamation oil separated to heavy oil, medium oil and light oil.

2.3 Assessment of cascade recycling

Though the investigation of cascade recycling, it is demonstrated that cascade recycling is an efficient recycling combination and contribute to local feed stock recycling. However, it also shows the tendency that when MR wastes were mixed more than 40%, (a) the value of pH of reclamation oil went down, (b) corrosion troubles occurred, (c) the more MR wastes mixed, the less yields of reclamation oil we had. If the quantity of MR wastes keeps less than 40%, SPR is able to be operated safety and stability.

3. Conclusion

Through its technological improvements and operational know-how, SPR has been able to process the municipal waste plastics in almost all grades in qualities that contained PVC and PET without trouble. SPR can also process the waste plastics from material recyclers or mechanical recyclers and a more efficient recycle of waste plastics can be done combining mechanical and chemical recycling.

SPR has been able to recycle almost all except the water and the foreign material and has achieved a very high recycling rate such as 90% in 2008. Since PR is a commercial plant, we also do efforts on the improvement of productivity that the quality of by-products are guaranteed, including chlorine contained less than 100ppm, Sulfur contained less than 0.2% and Nitrogen contained less than 0.2%. In this year (2009), it is challenging the full capacity

operation that about 15,000t municipal waste plastics are waiting to be recycled and reclaimed.

On the other hand, cascade recycling which is an efficient recycling combination of material recycling and chemical recycling and contribute to local feed stock recycling has been demonstrate in 2008 by SPR. If the quantity of MR wastes keeps less than 40%, SPR is able to be operated safety and stability.

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