Plastic Waste Recycling by Entrained-Flow Gasification

Takatoshi SHOJI*, Kenjiro SHIDOH, Yoshihiro KAJIBATA, Atsushi SODEYAMA
Chemical & Environmental Research Department
Akashi Technical Institute Kawasaki Heavy Industries, LTD
E-mail : shoji_takatoshi @ toh.khi.co.jp FAX: +81-78-921-1689

We conducted the study of entrained-flow gasification of waste plastics to develop high efficient energy recovery system. Waste plastics, after crushing, were fed into a gasifier with air. In the gasifier, organic substances were at first pyrolyzed and partially combusted and then converted into synthesis gases (CO, H_2,) at a high operation temperature (over 1,300℃). Other inert compositions, such as ashes and metals in the waste were melted to slugs and/or condensed on bag-filters. Impurities in the product gases, such as dusts, heavy metals and hydrogen halides, were removed by the bag-filters and a water scrubber. Solid hydrocarbons (chars) extracted by a hot cyclone and the bag-filters were conveyed to the gasifier again. Obtained gasification characteristics are as follows; lower heat value (LHV) of product gas was over 1,000 kcal/Nm^3 and the cold gas efficiency was approximately 60%.

Introduction

Post consumer and industrial plastics waste, usually incinerated and/or landfilled, are high calorie materials same as coal, oil and other oil products. Nowadays these wastes have been tried to convert to feedstock materials or RDF (refuse derived fuels) [1].

We have conducted the feasibility study of plastic waste recycling by way of entrained-flow gasification since 1995. In 1995, a 3kg/h feed rate test apparatus was started to study the partial combustion characteristics. Next study has been done by using an entrained-flow 100 kg/h bench-scale gasification equipment since 1996. Through the tests, we confirmed the good gasification characteristics of sorting plastics of municipal waste and other industrial waste plastics.

Materials and methods

Figure 1 shows the schematic flow of the 100kg/h gasification test equipment for mixed plastics. The core of the equipment is an entrained-flow gasifier (Coal

Partial Combustor; called CPC) with the inner diameter of 300 to 500 mm. The gasifier consists of the pyrolysis zone (vertical furnace) and the partial combustion and gasification zone (horizontal furnace).

Before gasification, waste plastics were fragmented under 8 to 25 mm with a shredder in order to promote their devolatilization. The other pretreatment for wastes included metal separation and combustibles drying if needed. Figure 2 shows a schematic drawing of the plastic wastes pretreatment process. Note that separating paper, woods, and ash is not required in this process.

In the gasification process, crushed plastics transferred with air were at first pyrolyzed and partially combusted and then converted into synthesis gases. Ash contained in wastes was melted at the lower portion of the vertical furnace and flowed out through the slag hole of the horizontal CPC. The estimated residence time of the material fed in the gasifier was approximately a second.

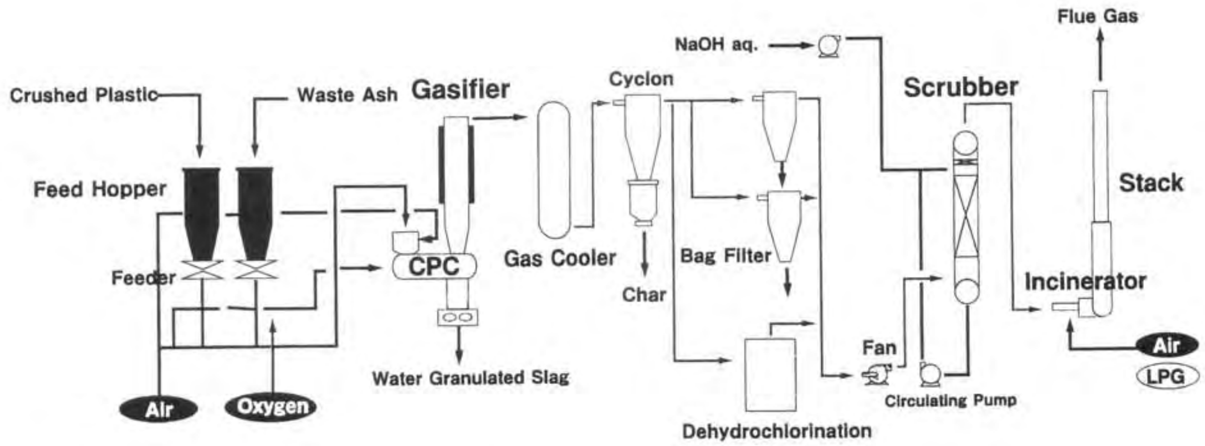

Figure 1 Schematic flow of gasification and gas purification test process

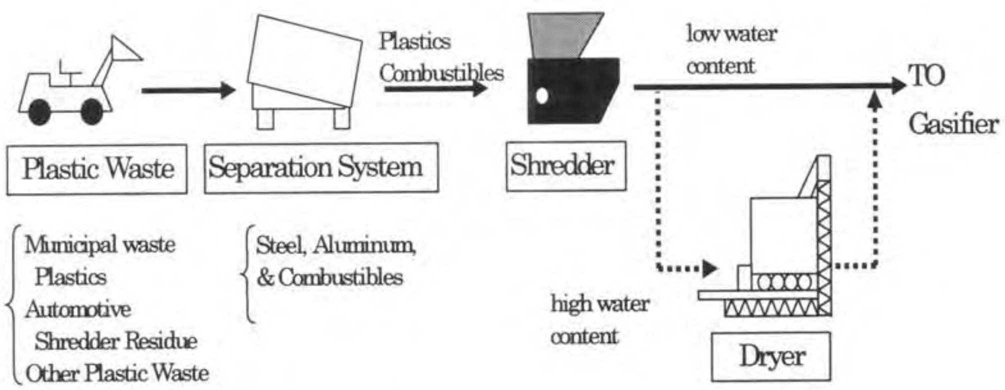

Figure 2 Schematic flow of plastic waste pretreatment test process

The synthesis gases with impurities were purified in the next gas clean-up process, which consisted of the gas quencher, the hot cyclone, the bag filters and the dehydrochlorination water scrubber. The hot cyclone separated ashes and char particles from the gas stream. A couple of bag filter were operated in turn and effectively catches fine particles . Because char particle size was so small like chimney soot (<10 μm), that a single filter system could not be worked well. Heavy metals such as arsenic, selenium, mercury, lead and copper were also removed in the bag filters.

Results and Discussions

The compositions of plastic wastes are shown in Table 1. Each waste has relatively high heat content (over 5,000 kcal/kg) and mainly consists of low density waste plastics which is suitable for short duration gasification reaction.

Figure 3 shows an example of gasification test result of the municipal waste plastics. In this case, feed oxygen concentrations were 30 and 45 vol. % and oxygen ratios, which were the ratio of input oxygen quantity compared with that of complete combustion, were 0.4 to 0.8. The test result shows the following gasification characteristics; the carbon conversion ratio obtained was over 90% and the cold gas efficiency was 50 to 60% under the oxygen ratio of 0.5 to 0.6. In this case, the lower heat values (LHV) of the product gas were ranged from 1,000 to 1,700 kcal/Nm^3.

Table 1 Test samples (wt %)

	Municipal Waste Plastics	Automotive Shredder Residue
C	68.40	58.00
H	8.60	7.30
N	1.20	1.36
O	8.10	6.38
Cl	3.40	3.41
T. S	0.06	0.64
ash	10.20	23.20
LHV (kcal/kg)	7,410	5,060

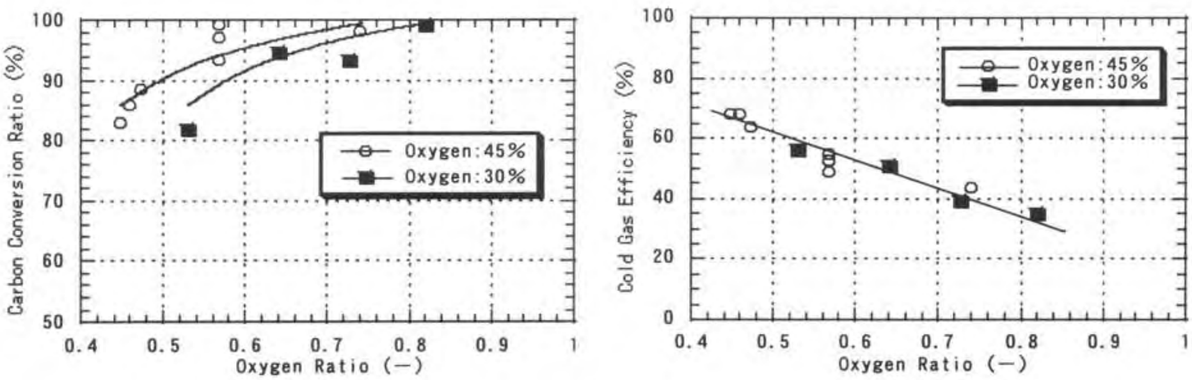

Figure 3 Gasification test results for municipal waste plastics

Table 2 shows the result of recovery gas and flue gas analysis. As can be seen, the recovery gas consisted mainly of CO, CO_2, H_2, and N_2. Small amount of CH_4, C_2H_4 and non-tar component were detected in the gas. The recovery gas also contained some impurities. The alkaline water scrubber (as shown in Figure 1) could effectively remove gas components such as sulfide (H_2S, COS), nitride (NH_3), and HCl.

Table 2 Result of recovery and flue gas analysis

Recovery gas				flue gas	
(%)		(ppm)		(ppm; 12 % O_2)	
CO	25.2	H_2S	90	CO	7.0
CO_2	11.2	COS	5	HCl	34.0
H_2	20.0	CS_2	< 1	SO_2	1.0
CH_4	1.60	HCl	1,600	NO_2	30.0
C_2H_4	1.90	Cl_2	< 0.1	dust	6.8
N_2	36.4	NH_3	160		
LHV (kcal/Nm^3)	1,740	CN^-	220		

Conclusion

Entrained gasification tests reveal that typical waste plastics are efficiently converted to clean fuel which is useful for a gas engine, a gas turbine and a co-generation system. Also the recovery gas can be applicable for feedstock materials under the feed gas condition with pure oxygen.

Technical points to be investigated are as follows:

(1) to obtain waste plastic gasification data for feedstock materials under the feed gas condition with pure oxygen

(2) to develop a reliable char recycling system which contains heavy metals

(3) to optimize operation conditions in the gasification of waste plastics with fluctuating heat content

References

1. Weissman, R. "Recycling of Mixed Plastics by the Texaco Gasification Process", Proceedings of the Symposium on Chemical Aspects of Plastics Recycling, 1996, 199-213