



## 풍력 및 비중선별에 의한 혼합폐플라스틱 재질선별 기술개발

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### BACKGROUND ( I )

- Amount of mixed plastic waste generation (2006) in Korea :  
1,750,000 t/y (2002 : 870,000 t/y)  
(Annual plastic waste generation : ~ 4 million tons)
- Mixed plastic waste contains 2.4 ~ 4.0 % PVC and can not be  
used as fuel, material and/or feedstock recycling processes.  
(PVC content in the plastic waste should be less than 0.3wt.%  
for utilization).
- Separation technology is needed to remove PVC and other  
impurities from plastic waste to expand recycling of the  
mixed plastic waste.



## BACKGROUND (II)

- Extended Producer Responsibility (EPR) system has been adopted in 2003 to expand recycle and reuse of waste resources at producer side.
- Plastic packaging materials (i.e., containers, trays, film sheets, etc) are included as one of EPR items.
- Due to expansion of the EPR system, amount of the mixed plastic waste generation has been drastically increased.

Table 1. Generation of mixed plastic waste.

Year	2002	2003	2004	2005	2006	비고
Mixed Plastic Waste	870	890	1,500	1,700	1,750	

(Unit :1,000 tons)

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## CHARACTERISTICS OF MIXED PLASTIC WASTE

- Plastic waste shows high PVC level because of stationery, toys, packaging materials for tools, cosmetics, medical supplies, etc.
- Mixed plastic waste is used for manufacturing of RDF resulting high Cl content (10,000~20,000 ppm) in the RDF products.
- In order to utilize mixed plastic waste in materials and/or feedstock recycling process, impurities such as PVC, PET, Aluminum foil, etc should be removed in advance.

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## GRAVITY SEPARATION TECHNOLOGY

- **AKW GmbH, Germany** : PE, PP, PS, PVC, PET separation from plastic waste by using combination of flotation and cone-type cyclone.
- **Henshel GmbH, Germany** : Various plastics are separated from the food containers consisting of PO, PS, PVC, Al by using the sink-and-float and hydrocyclone (capacity 1.5 ton/h).
- **KHD, Humboldt Wedag AG** : PO and PS are recovered by using 2-stage centrifugal process (SENSOR process).
- **Ahin Company, Japan** : PUR, ABS, PVC are recovered from waste automobiles by using hydrocyclone.

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## SPECIFIC GRAVITIES OF PLASTICS

Plastics	S · G
PP	0.90 ~ 0.92
LDPE	0.91 ~ 0.93
HDPE	0.94 ~ 0.96
PS	1.03 ~ 1.06
PET	1.35 ~ 1.38
PVC	1.32 ~ 1.42

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## R&D OBJECTIVES

### ↓ Main objectives

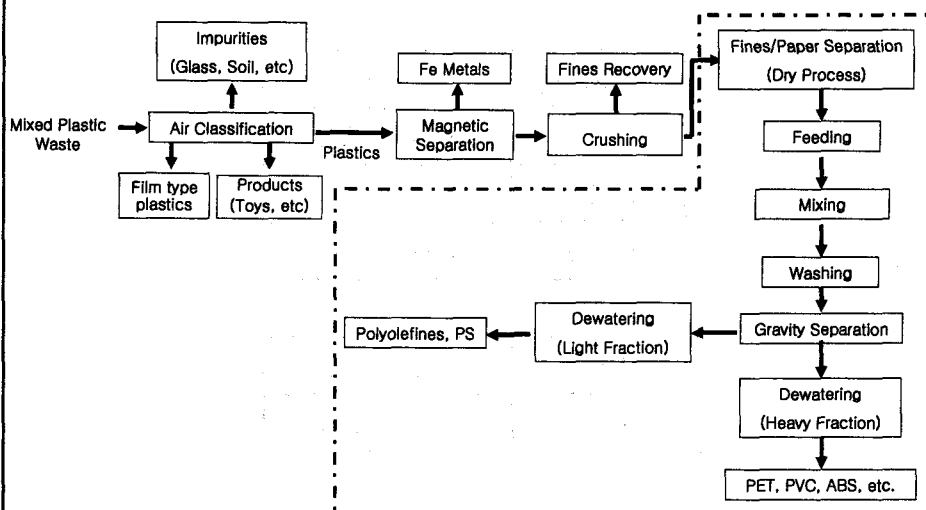
- Development of gravity separation system to recover polyolefins and PS plastics containing less than 0.3 wt.% PVC from mixed plastic waste generated from households.
  - Development of gravity separation system with capacity of 0.5 ton/hr.
  - Final products of PO and PS with less than 0.3 wt.% PVC and less than 10% moisture content.
- Commercialization of the gravity separation system (i.e., PLASOR) will be achieved in the near future.

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## DEVELOPMENT OF GRAVITY SEPARATION SYSTEM

### 1. Process Flow Sheet



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## DESCRIPTION OF THE PROCESS

Process	Description
1. Air Classification	• 4 products can be obtained with vibration, blowing and suction mechanisms (capacity ~1 ton/h).
2. Magnetic Separation	• To remove Fe metals from plastic materials after air classification.
3. Crushing	• One-shaft shredder with 8 rotors/compression feeding and forced discharging system are adopted.
4. Fines/Paper Separation	• Removal of fines and/or paper from feeds (capacity 500 kg/h).
5. Feeding	• Screw-type feeder at fixed rate with capacity of 500 kg/hr.
6. Mixing	• High-speed mixer capable of converting hydrophobic particles to hydrophilic.
7. Washing	• Compulsory abrasion method is adopted to remove impurities from plastic particles.
8. Gravity Separation	• Centrifugal mode with one motor is applied to save energy, and to discharge heavy and light fractions to opposite directions, respectively.
9. Dewatering	• 2-stage dewatering process with vibration and centrifugal and/or vortex, 2 dewatering units are applied for light and heavy fractions, respectively.
10. Wastewater Treatment	• Process water is recycled after filtration, and sludge is recovered and can be used as RDF after drying.

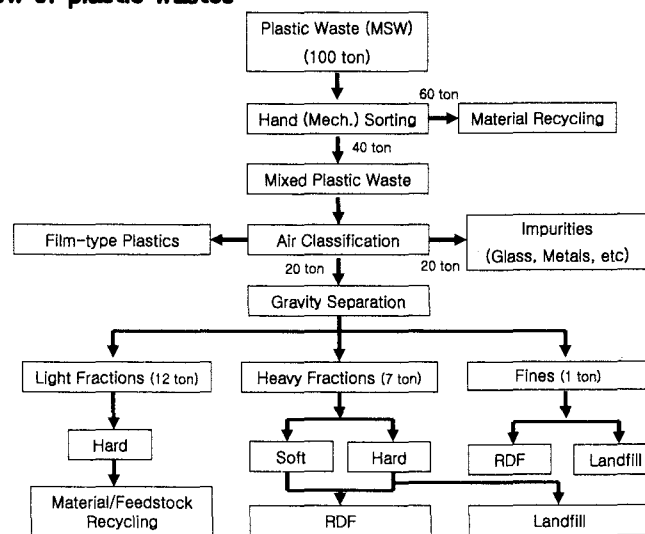
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## DEVELOPMENT OF GRAVITY SEPARATION SYSTEM

### 2. Mass flow of plastic wastes



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 Gravity Separation System (PLASOR)

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■ Air Classification Unit



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 Gravity Separation System (PLASOR)

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■ Extruder

■ Magnetic Separator



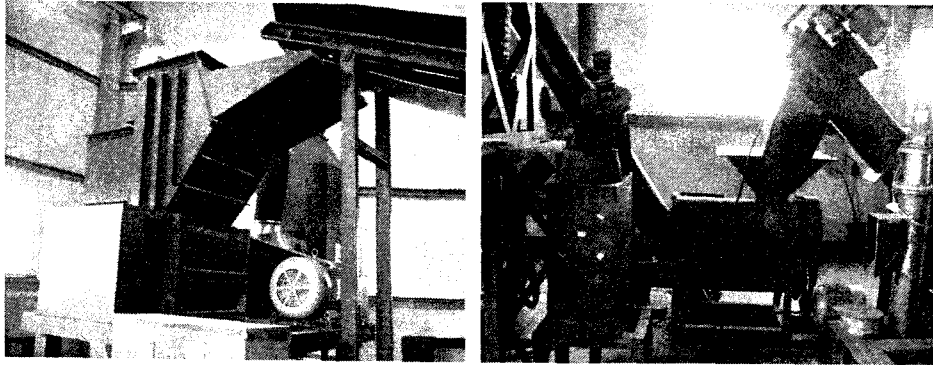
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 Gravity Separation System (PLASOR)

■ Crushing Unit

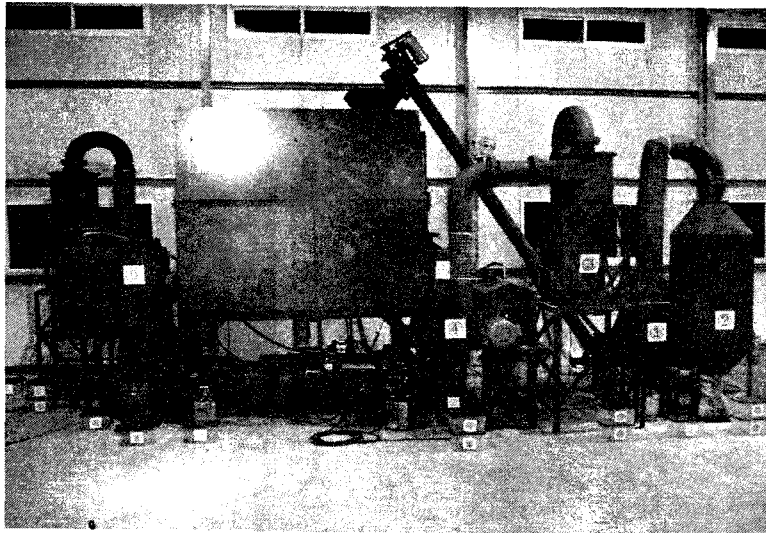
■ Feeding System



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 Gravity Separation System (PLASOR)



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## CHARACTERISTICS OF SEPARATION SYSTEM ( I )

- Gravity separation technique is being used to separate heavier plastics ( $S.G > 1$ ) from lighter one ( $S.G < 1$ ) : Separation efficiency  $> 99.65\%$ .
- Final product (Polyolefins, PS) contains less than 0.3 wt.% PVC.
- In dewatering process, vibration and centrifugal/vortex methods are adopted to achieve lower moisture contents (Heavy fractions 1~3%, Light fractions 3~10%).
- Fines and/or paper fractions are removed before feeding into the gravity system and also rejected during and after dewatering .
- One-step crushing unit is applied to produce less than 15mm size fractions and therefore, final products can be used in material and/or feedstock recycling processes.

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## CHARACTERISTICS OF SEPARATION SYSTEM ( II )

- Gravity system has high efficiency with low water and electricity consumption.
- Wastewater is recycled after filtration and SS level in wastewater is very low because fines and/or paper fractions are removed in advance before and during gravity separation process.
- Gravity system can be applied to mixed plastic waste with high contamination (plastic waste from landfill can also be treated).
- Nine products are separately recovered from mixed plastic waste by using the gravity system and most of products can be utilized.

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## EXPERIMENTAL

### ■ Mixed Plastic Waste Samples

- Samples were collected from 4 different cities (Total : 1357.3 kg).
- The plastic ratios in the samples were varied 39~57%.
- Major components in the plastic-based samples after hand sorting were analyzed using the representative sample.

Items	Paper, Dust	PO (PE, PP)	PS	PET, PVC, ect	Glass, Sand	Total
Mass (g)	1,620	8,747	1,833	3,958	622	16,820
Ratio (%)	9.63	52.0	10.9	23.53	3.94	100

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## EXPERIMENTAL

- Air classification tests on mixed plastic waste were conducted at feed rate of 1ton/h.
- Result of air classification test on mixed plastic waste.

Items	Plastics	Products (Toys, etc)	Soil, Glass, Metals	Total	Remarks
Feed	349 (45.8%)	335 (44.0%)	78 (10.2%)	762	Total amount of film-type plastics : ~ 2.4%
After Separation	302 (40.0%)	417 (55.0%)	40 (5.0%)	759	· Separation efficiency : ~ 98% · Plastic recovery : 90~95%

(Unit : kg)

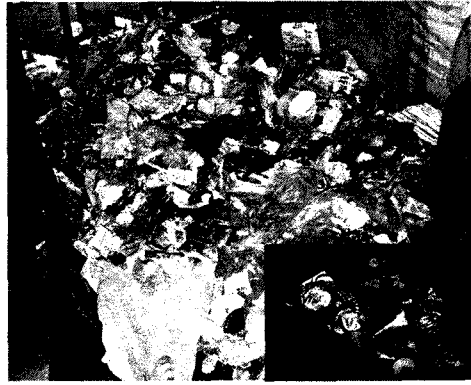
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## EXPERIMENTAL



■ Mixed plastic waste



■ Recovered plastics after air classification

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## EXPERIMENTAL

- Crushing unit is developed with 8 rotor system.
- Rotor type and crushing efficiency.

Items \ Type	3 rotors	6 rotors	8 rotors	Remark
Power	50HP	70HP	70HP	
Crushing Efficiency (kg/h)	300	380~390	500~650	<ul style="list-style-type: none"> <li>· PO(Soft) : 30~50% increase</li> <li>· PO(Hard) : 50~70% increase</li> </ul>

- Result of crushing tests on plastic wastes

Items	Film	PET	PE/PP	MSW	Remark
Crushing Amount (kg/h)	640	522	623	421	Plastics must be compressed to reduce crushing time.

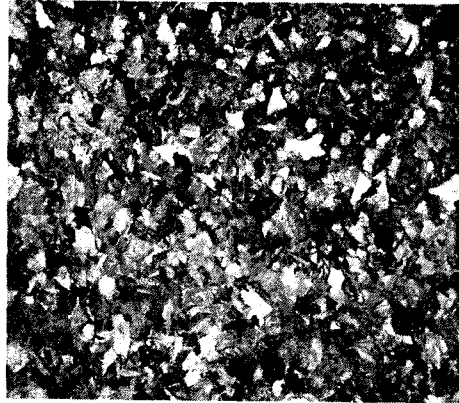
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## **EXPERIMENTAL**



■ Plastic wastes before crushing



■ Plastic wastes (size <15mm)  
after crushing

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## **EXPERIMENTAL**

- Gravity separation tests were carried out on plastic waste at feed rate of 500~600kg/h.
- Feed : Mixture of samples obtained from 4 different cities.
- Feed Size : 12~15mm (Max. size 20mm).
- After separation test, about 126kg sample was used to analyze the separation efficiency.

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## RESULTS FOR GRAVITY SEPARATION TESTS (500 kg/h)

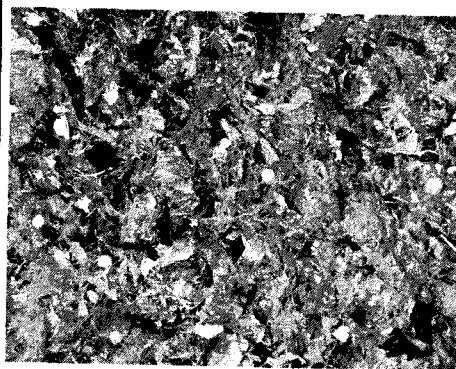
Section	Paper Dust, etc.	Light Fraction					Heavy Fraction			Total
		PO (PE, PP)	PS	PET	PVC	Fiber, etc.	PET, PVC	PS	PO	
Mass (g)	10,000	66,800	2443	456	18	448	26,000	20,000	N.D	126, 165
Ratio (%)	7.93	52.95	1.94	0.36	0.01	0.35	20.61	15.85		100.0
Total		63.54 %					36.46%			
Moisture (%)		10.7 ~ 12.6 %					2.5~4.5%			

- The light fraction contained 1.3% of PET, PVC, Fiber, etc. and PVC content in the light fraction was less than 0.026%.
- The results of the separation show that over 70% of the light and heavy fraction (PE, PP, PS) could be recycled.

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## EXPERIMENTAL



■ Light fractions PO (PE, PP, PS, EPS, PSP) after gravity separation



■ Heavy fractions (PET, PVC, ABS, PS, etc) after gravity separation

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## FINAL PRODUCTS AND USAGE

Products		Composition	Characteristics	Usage
Film-type Plastics	① Soft plastics	PE	Film type ( > 8500Kcal/kg)	Material, Feedstock Recycling
Fines/Paper	② Inorganics	Sand, Ceramic, PVC/ PET, etc	Mainly inorganics	Landfill (<1%)
	③ Organics	Paper, Fiber, PO type	High calorific value	RDF
Light Fractions	④ Hard plastics	PE, PP, PS	Hard particles, Low moisture content	Material, Feedstock Recycling
	⑤ Fines	PO (Film type)	Utilization is possible after dewatering	RDF, Feedstock
Heavy Fractions	⑥ Soft plastics	PET label, etc	Low PVC content	RDF Fuel (4000~4500Kcal/kg)
	⑦ Hard plastics	PVC, PET, ABS, PS, etc	High PVC content	RDF after PVC removal
	⑧ Fines (Hard)	PVC, PET, ABS, etc	High PVC content	Landfill
	⑨ Fines (Soft)	PO	Utilization is possible after dewatering	Material, Feedstock Recycling

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## ECONOMIC ANALYSIS

- Small space(<200m<sup>2</sup>) is needed for the system installation, and the PLASOR system has high separation efficiency and low operational cost in relation to the other processes  
(Water consumption : 880ℓ/d, Electricity requirements : 110~130 kWh).
- The PLASOR system with automation can be operated by two operators.
- The price of the PLASOR system (capacity of 1 ton/h) including air classification and crushing unit is in the range of \$ 800,000.

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## APPLICATIONS

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- The products obtained from the PLASOR system can be utilized in material and/or feedstock recycling, reduction materials for blast furnace, gasification, RDF for cement kiln and/or energy sources for boilers.
- The PLASOR system can be applied to the following areas.
  - PVC/PE separation from waste cables.
  - Plastic recovery from the automobile ASR and home electric appliances.
  - Recycling of waste agricultural film.

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## CONCLUSION

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- The gravity separation system with capacity of 1 ton/h has been developed to enhance the recycling of mixed plastic waste.
- The system consists of air classification, magnetic separation, crushing and gravity (centrifugal) process.
- The plastics recovered contain PE, PP, PS with less than 0.35 wt.% PVC and 5~10% moisture content.
- The heart of the PLASOR system is a combination of an effective mixing /washing and one-step centrifugal separation. In addition, fines and/or paper fractions are removed before feeding into the system.
- The PLASOR system shows low water and electricity consumption, and can be operated by 2 operators.

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