Performance of the PCB Waste Treatment Facility for Recycling of PCB containing Transformers and Capacitors, in JESCO/Osaka JAPAN

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Abstract
The Osaka PCB waste treatment facility with 2 tons PCB treatment capacity per day was successfully put into the commercial operation in autumn 2006. Engineering and integration for major 3 kinds of batch system technologies; cleaning, vacuum thermal extracting and decomposition system by catalystic hydro-dechlorination were executed carefully and achieved high performance of treatment and high recycling aim, as well as safe operation for environment. Its test result shows in this paper.

Introduction
In 1974, production, import and use of Polychlorinated Biphenyls (PCB) were totally prohibited in principle by Japanese law. In the past, many plans were made to treat PCB to make it harmless, but none of the plans were acceptable to residents living in their vicinity due to lack of reliability in their safety. For fear of contamination to the environment through the loss of PCB during long-term storage, leakage due to deterioration of containers, etc., the Law Concerning Special Measure against PCB waste was enacted in July 2001.
The Japan Environmental Safety Corporation (JESCO), a Japanese government owned organization, is to take the role of the construction and operation of the regional PCB Waste Treatment facilities to treat the PCB wastes (defined as PCBs, oils containing PCBs, material coated by PCBs, material soaked with PCBs, PCB-adhered material, or material enclosing PCBs) at several locations nationwide.
The Osaka PCB waste treatment facility ordered by JESCO was constructed and completed in autumn 2006. Its trial operation, performance test and final acceptance test were carried out in spring and summer 2006 and its results are reported in the later part of this paper. The facility is located in Maishima District in Osaka City and is scheduled to treat PCB waste stored in Kansai area (6 prefectures) in 9 years. The photo shows the bird view of 2 plant buildings in this facility.

Fig. 1 The photograph of the Osaka PCB Waste Treatment Facility

Materials and Methods
The Osaka PCB waste treatment facility could be carefully studied and executed the engineering work to perform the safety operation and reliable treatment for ensuring the environmental measure and positive recycling of the by-products from this facility.
To treat the very various kinds of PCB waste in nominal capacity of 2 tons per day, its facility has the

receiving and handling system, the scrapping and cleaning system, the vacuum thermal extracting system, PCBs decomposing system, sampling and PCB concentration analyzed system, shipment for transfer between 2 separated areas, crashing and separation equipment, its utility equipment and monitoring and operation data processing system.
Its facility consists of the different kind of batch treatment process, mainly; ultra-sonic cleaning in vacuum chamber[4], 4 sets of vacuum thermal recycling system (VTR), concept of which is described in Fig. 3, and 2 lines of decomposition system by catalystic hydro-dechlorination, concept of which is indicated in the Fig.4, in order to secure the PCB waste treatment.

Fig.2 General Concept of Process Flow Diagram for PCBs treatment plant facilities in Osaka/Japan

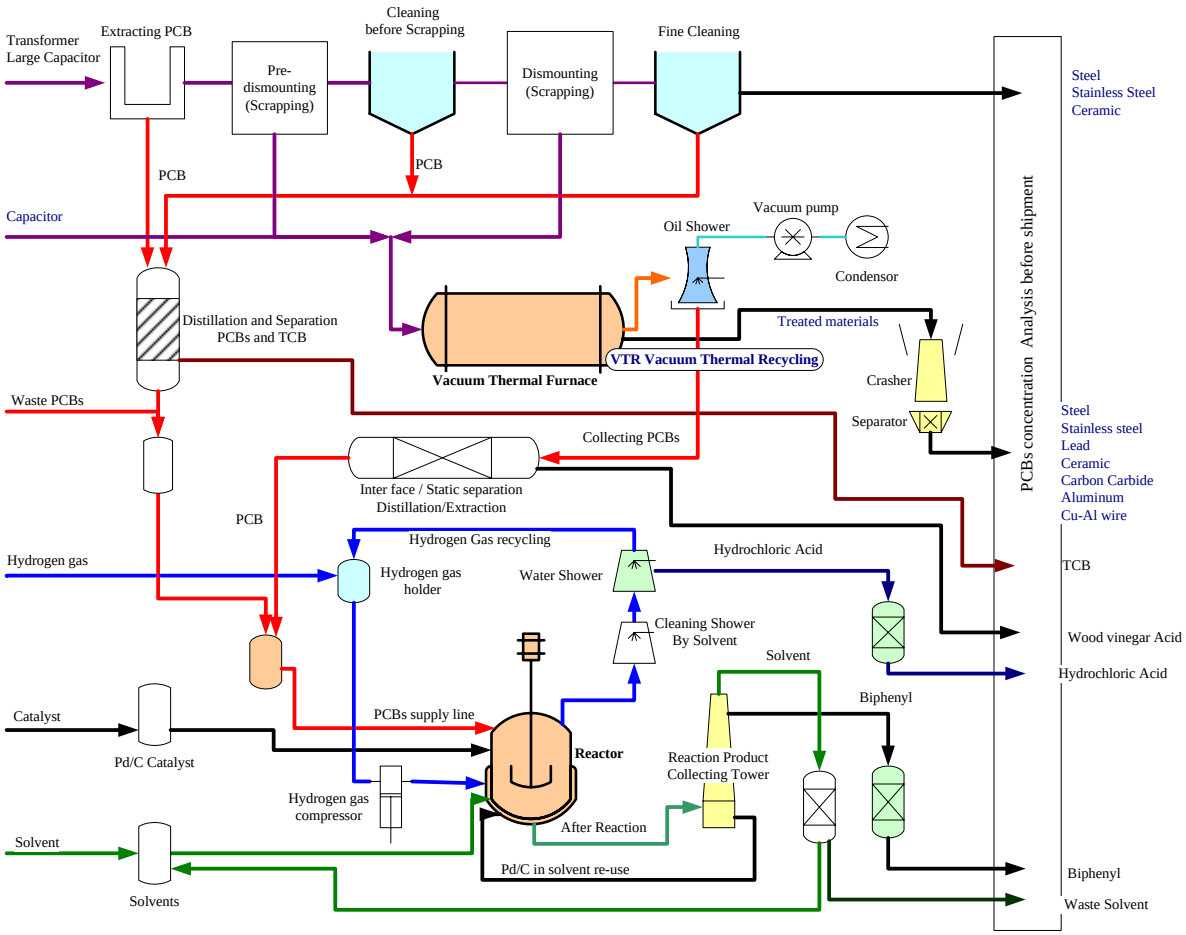
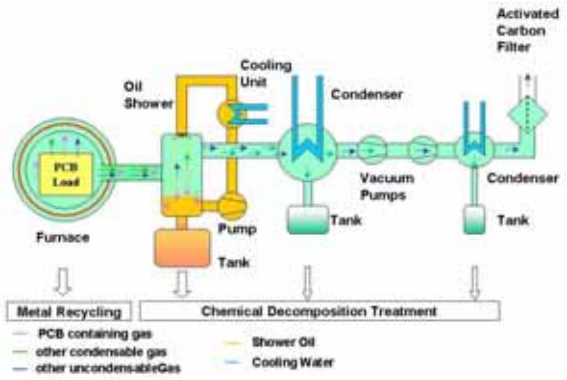
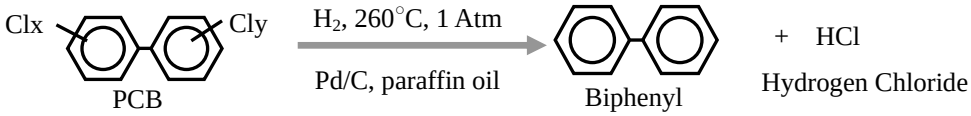


Fig.3 Process Scheme of VTR System[3]



In the vacuum furnace the material is heated up to a certain temperature until the PCB oil is evaporated. The PCB gas is lead to a special off-gas system to condense all the PCB vapors back to PCB liquids and collect them inside the closed vacuum tank.

Fig.4: Concept of Catalystic hydro-dechlorination (CHD) [1, 2)]



After the completion of its facility, the examination, confirmation, performance testing and final acceptance test were conducted in about 6months duration and its results are described in the next session.

Results and Discussion

Performance test and final acceptance test results shows the satisfaction that PCBs concentration of all samples after processing and reaction of this facilities were less values than the target values of detoxification (legal limiting standard value) as shown in the Table 1 and Table 2. The results of Dioxins concentration are referred to Table 3 and Table 4 respectively. Performance test results shows in SE and final acceptance test results shows in SF.

Table 1: Results of PCBs concentration of samples after detoxification process and decomposing reaction

Process	Object	Treated Samples	Number of test batches	Test results (PCB concentration)	Target value of detoxification[1]
Cleaning Process	Drum can	Steel、Stainless-steel	SE : 10	<0.2～0.334 mg/kg	less than 0.5
	Transformer Housing	Steel	SE : 28	<0.2 mg/kg	less than 0.5
			SF : 29	<0.2～0.209 mg/kg	less than 0.5
	Insulator	Ceramics	SE : 4	<0.2～0.414 mg/kg	less than 0.5
			SF : 2	<0.2 mg/kg	less than 0.5
TCB Distillation	Transformer oil	TCB(Tri-chloro benzen)	SE conti.	0.11～0.23 mg/kg	less than 0.5
			SF conti.	0.093～0.4 mg/kg	less than 0.5
Vacuum Thermal Evaporation Process	Capacitor Cabinet case	Steel、Stainless steel	SE : 15	<0.04 μg/100cm^2	less than 0.1
			SF : 5	<0.04 μg/100cm^2	less than 0.1
	Capacitor H- Voltage terminal	Lead	SE : 15	<0.002 mg/kg	less than 0.01
			SF : 5	<0.002 mg/kg	less than 0.01
	Capacitor Insulator	Ceramics	SE : 14	<0.002 mg/kg	less than 0.01
			SF : 4	<0.002～0.002mg/kg	less than 0.01
	Capacitor Element	Carbide	SE : 15	<0.0005mg/L	less than 0.003
			SF : 5	<0.0005mg/L	less than 0.003
		Aluminum foil	SE : 15	<0.002mg/kg	less than 0.01
			SF : 5	0.002～0.005 mg/kg	less than 0.01
	Transformer Core	Si-steel plate	SE : 6	<0.04μg/100cm^2	less than 0.1
			SF : 2	<0.04μg/100cm^2	less than 0.1
	Transformer Coil	Cu(Al)-wire	SE : 6	<0.002 mg/kg	less than 0.01
			SF : 2	0.003 mg/kg	less than 0.01
	Transformer Insulation paper	Carbide	SE : 6	<0.0005 mg/L	less than 0.003
			SF : 2	<0.0005 mg/L	less than 0.003

Note *[1]: Units of target value of detoxification[1] are same as Test results (PCB concentration) indicated in left column of this table.

Table 2: Results of PCBs concentration of samples after decomposing reaction

Process	Object	Treated Samples	Number of test batches	Test results (PCB concentration)	Target value of detoxification[1]
Decomposing by Chemical treatment (Catalytic hydro-declorination)	Distillated PCB	After reaction	SE：2	0.16〜0.21 mg/kg	less than 0.5
	Separated PCB	After reaction	SE：26	0.13〜0.29 mg/kg	less than 0.5
			SF：24	0.14〜0.35 mg/kg	less than 0.5
	Product from process	Hydrochloric acid	SE：28	<0.001 mg/L	less than 0.03
			SF：24	<0.001 mg/L	less than 0.03
		Biphenyl	SE：28	0.16〜0.38 mg/kg	less than 0.5
			SF：24	0.20〜0.43 mg/kg	less than 0.5
		Pyroligeneous acid	SF：1	＜0.0009 mg/kg	less than 0.5
	Used solvents	Waste solvents	SE：28	0.087〜0.10 mg/kg	less than 0.5
			SF：24	0.010〜0.17 mg/kg	less than 0.5
		Distillated waste solvents	SE：28	0.031〜0.10 mg/kg	less than 0.5
			SF：24	0.038〜0.051mg/kg	less than 0.5

Note *[1]: Units of target value of detoxification[1] are same as Test results (PCB concentration) indicated in left column of this table.

Table 3: Results of Dioxins concentration in the decomposed liquid after reaction

Run No.	1	2	3	4	15	27	39	51
PCDDs/DFs (ng-TEQ/g)	0.000013	0.000014	0.0004	0	0.00071	0.000009	0	0
Co-PCBs (ng-TEQ/g)	0.00033	0.00031	0.00020	0.00024	0.00064	0.00019	0.00018	0.00024
mono-hydroxy PCB (ng/g)	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1
di-hydroxy PCB (ng/g)	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1

Table 4: Results of PCBs and Dioxins concentration in the biphenyls

Run No.	1	2	3	4	15	27	39	51
PCBs (mg/kg)	0.32	0.35	0.28	0.38	0.32	0.32	0.32	0.29
PCDDs/DFs (ng-TEQ/g)	0.000011	0.0021	0.029	0.000008	0.000009	0.000013	0.000009	0
Co-PCBs (ng-TEQ/g)	0.00016	0.00023	0.0022	0.00067	0.00016	0.00020	0.00015	0.00013
mono-hydroxy PCB (ng/g)	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1
di-hydroxy PCB (ng/g)	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1	N.D<1

Acknowledgements

The authors hereby would like to express the heartfelt appreciation to all the member of the Osaka PCB waste Treatment Facility and JESCO members in Japan, who have been paying the very kind advices and deep considerations for the planning, construction, testing and operation.

As well, the authors hereto appreciate to partners/members for this project; Kanden Engineering Co., Ltd (for the decomposition system), Z.E.R.O. Japan Co., Ltd. (for the vacuum thermal recycling system (VTR) and Toshiba Corporation (for the cleaning process).

References

1. Ohno M, Hirata K, Organohalogen Compounds, 1997, 31,405-409
2. Noma Y, Ohno M, Sakai S, Fresenius Environmental Bulletin, 2003, 12, 302-308
3. Ohbayashi H, Saitoh S, Z.E.R.O. Japan Paper for UNEP, Geneva, Swiss, 2004, 6
4. Adachi A, Kawano K, Nishizawa K, Toshiba Review 2007, Vol.62, No2, 46-49