

MOBILE THERMAL DESORPTION UNIT: Small scale contaminated sites solution

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Summary

Laboratory semi-pilot tests of thermal desorption proved its high efficiency in removal of different types of contaminants from different types of matrices. It can be also used for treatment of dangerous substances but for that detailed laboratory research is needed to prevent dangerous situations. Based on results of semi-pilot tests mobile thermal desorption pilot plant with indirect heating system was designed, constructed and tested. Modular system allows high variability especially for off-gas treatment system. Dimensions of the system, its capacity of 1 – 2 tons per hour and low demand of electric power make the unit useable also as a full scale system for remediation of smaller contaminated sites. Functional tests of pilot unit were carried out with pesticides contamination with promising results.

Keywords: thermal desorption, pesticides, mobile unit, POPs

Introduction

Besides of commercial activities DEKONTA is working on development of new innovative technologies. Through years several research projects focused on thermal desorption have been carried out. Based on results of the research projects a mobile unit of continuous indirectly heated thermal desorption technology was designed and constructed. This system has low demand of electrical power and can be powered by diesel generator set.

Thermal desorption is very effective and fast remediation technology which can be used for treatment of various types of contamination – petroleum hydrocarbons, PCBs, pesticides, mercury etc. It removes contaminants from soil, sludge or sediments by heating the input material in “hermal desorber” to evaporate the contaminants. Evaporation changes the contaminants into vapors (gases) and separates them from the solid material. The final temperatures vary from relatively low temperatures up to 600 °C. Thermal desorption itself doesn't deal with vaporized contaminants so additional technology for off-gas treatment is needed - mostly the incineration or condensation. Incineration destroys evaporated substances, condensation enables to concentrate contaminants and reuse them, recycle them or just radically cut down the amount of toxic waste. In case of chlorinated substances as pesticides or PCBs dechlorination methods as base catalysed dechlorination (BCD) or gas phase catalytic reduction (GPRC) can be used as part of whole technological system.

Research and Development

Thermal desorption research and testing in DEKONTA is mainly focused on system upgrade and lowering of initial and operational costs. Different types of samples are tested to find out if the thermal desorption would be suitable or not. Laboratory or semi-pilot testing can bring valuable information about material behavior, e.g. its tendency for lumping or sintering, and about off-gas quality which can be very important in case of safety.

Set no.	Incoming concentration ENP (mg.kg ⁻¹)	Pressure (mbar)	Final temperature (°C)	Efficiency (% wt.)	Condensate pH	H ₂ S (ppm)	SO ₂ (ppm)	CO (ppm)
1	166 500	150	355	75	3.2	> 13 000	2 100	5 000
2	203 800	150	352	79	1.6	> 13 000	3 000	2 600
3	102 300	150	356	93	2.7	> 13 000	150	2 500
4	91 400	50	356	98	2.5	> 13 000	3 000	4 000
5	144 700	50	356	99	1.8	> 13 000	500	2 700
6	59 300	50	357	99	3.3	> 13 000	3 100	5 000
7	155 100	50	360	99	3.0	> 13 000	3 000	4 500
8	176 500	800	355	15	2.1	> 13 000	100	1 600

Tab. 1: Semi-pilot desorption trials of acid oil sludge.

Main research testing is carried out in semi-pilot laboratory unit which can be mobilized if needed. Besides standard samples dangerous materials are also tested, e.g. highly flammable samples, acid sludge from petro chemistry with risk of high concentrations of methane and hydrogen in off-gas, NORM containing samples when tests must be carried out on site, PCDD/F containing samples when tests should be carried out on site. Examples of obtained data are shown in tables below - Tab. 1 shows results obtain from testing of acid oil sludge, Tab. 2 show data from testing of pesticides containing soil.

Methane and hydrogen concentrations were held under 2 % vol. by continuous dosing of nitrogen so they are not mentioned in the table.

Set no.	Incoming concentration S OCP (mg.kg ⁻¹)	Pressure (mbar)	Final temperature (°C)	Efficiency (% wt.)
1	180	50	350	97
2	365	50	352	98
3	230	50	350	99
4	80	50	351	> 98
5	415	50	353	98

Tab. 2: Semi-pilot desorption trials of pesticides containing rubble.

Mobile unit description

Mobile thermal desorption unit which was constructed in DEKONTA was designed as modular system. This makes the transport and the use of the unit easier because the system is now more variable – condensation module or catalytic oxidation module can be used for off-gas treatment or if needed they can be connect in series. With this the unit can be used for treatment of various types of contaminants without any significant changes in the whole system.

Pilot plant consists of these main parts:

- rotary kiln (Fig. 1)
- off-gas pretreatment (Fig. 2)
- supply unit 1 – nitrogen supply, water supply
- supply unit 2 – control room.

Rotary kiln can continuously process 1 – 2 tons of input material per hour. Off-gas is dusted off by cyclone and fine filter. If needed, off-gas can be cool down by quenching system. Endpoint of this technology can vary according to contaminant type and aim of the pilot test as mentioned above. System can be inertized by nitrogen from one of supply units.

Unit was designed as pilot testing unit and its size is determined by demand of mobility. Still even as pilot scale unit it can be effectively used as smaller sites where excavating and transport of thousands of tons wouldn't be possible. Contaminants can be handled (destroyed or concentrated) on site.

Rotary kiln has these parameters:

- capacity: 1 – 2 tons per hour
- diameter: 1.2 m, length: 8 m
- rotation: 0 – 10 rpm
- indirect heating system
- temperature: 400 -500 °C



Fig. 1 Rotary kiln of continuous thermal desorption pilot unit.



Fig. 2 Off-gas pre-treatment module of continuous thermal desorption pilot unit.

Functional tests prove sufficient efficiency for treatment of different types of matrices contaminated by various types of contaminants. Results from pesticides contamination are summarized in Tab 3. As end-pipe technology condensation was used. Condensate was then treated by incineration. Depending of input properties as moisture content and contamination type pilot unit can be effective solution for some contaminated sites. It can't be used as full scale application for oil sludge lagoons remediation but for some local mercury, PCB or pesticide contamination pilot unit can be very promising – it offers relatively fast and very efficient solution with low initial costs because the unit can be used repeatedly. Operational costs depend on many factors and are specific for each site – mainly on fuel price and its availability, transportation distance and costs and availability of competent subsuppliers.

Conclusion

DEKONTA has experience with various types of contamination even with dangerous materials explosive or poisonous. Experiences gained through semi-pilot tests were turned into design and construction of mobile pilot thermal desorption unit with indirect heating system. Functional tests proved that unit can be effectively used for treatment of soil contaminated by chlorinated pesticides and other POPs.

Set no.	Contaminant	Incoming concentration (mg.kg ⁻¹)	Efficiency (% wt.)
1	DDT	164	> 95
2	Σ HCH	360	> 98.5
3	HCB	282	> 97
4	Σ OCP (HCH, DDT)	620	> 96

Tab. 3: Desorption pilot trials for pesticides contamination.