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THERMAL-DESORBER

HYDROCARBONS CONTAMINATED SOLID WASTE DECONTAMINATION SYSTEM

KMT International Inc. *presents Thermal-Desorber system to remove hydrocarbons from contaminated solid waste.*

The system is designed to thermally remove hydrocarbons from contaminated soil and sludge. The recovered hydrocarbons utilized as oil for further sale or use. Part of recovered hydrocarbons is return for process heating.

System can process various materials such as:

- Hydrocarbons contaminated soil (results of oil or fuel spillages, etc);
- Solid fraction after processing sludge from oil ponds or lagoons on centrifuge;
- Sediments from oil and bunker oil tanks;
- Spend catalysts used in oil refineries, etc.

System can be supplied in two major configurations: mobile or stationary. Mobile system designed on two tracks and contains power generator which provides electric power required for system operation. System can be erected on site during 4-5 working days. Stationary unit will require external power supply connection and building for system set up. Both systems are explosion and fire proof. The system consists of several units. Major components include: material preconditioning unit, thermal extraction unit, environmental control unit and quench condensing scrubber.

Note: In order to process hydrocarbons contaminated soil and sludge's from oil ponds material, should be screened to remove large rocks and metal objects. In addition materials have to be mixed, to average hydrocarbons content.

Material with following parameters can be process on Thermal-Desorber system:

- Hydrocarbons up to 25% (by weight);
- Water up to 30 (by weight).

Materials after processing have hydrocarbons level below 0.5% (by weight).

Pic.1. General view of mobile Thermal-Desorber

System performance:

Mobile system throughput - up to 2 m^3/hour,
Stationary system throughput - up to 10 m^3/hour.

1. Process description

Incoming material processed on a material preconditioning unit, is placed in the live bottom feeder by a front end loader. The live bottom feeder has a variable speed drive and a pair of counter-rotating screws that meter and move material to the feed conveyors. System of screw conveyors feeds material into the indirect fired rotary kiln. The kiln is an externally heated rotating stainless steel cylinder. The solid material is conveyed through the kiln by slope and its rotation. The kiln shell is heated by the hot gases passing over its outside. The hot metal of the kiln shell then heats the solids as they contact it. During the process the water and hydrocarbons are vaporized from treated material. Material after thermal desorption process has extremely low residual concentration of hydrocarbons that allows safely disposal.

If concentration of hydrocarbons in feed material is in range 15%-25% (by weight) and water has specific content, then it is possible to run a process without external fuel. Feed material will be heated by burning extracted light hydrocarbons. If there are not enough vaporized gases to heat kiln then external fuel will be used.

Heating feed material results in hydrocarbons and water evaporating. The gases vaporized in the kiln are sent to the direct contact quench scrubber. The quench scrubber cools, condenses, and cleans the gases. The gases that condense below operating temperature of the quench scrubber are absorbed and cooling by the scrubbing media (oil). The remaining clean gases are sent to the kiln combustion chamber, and the hydrocarbons are burned.

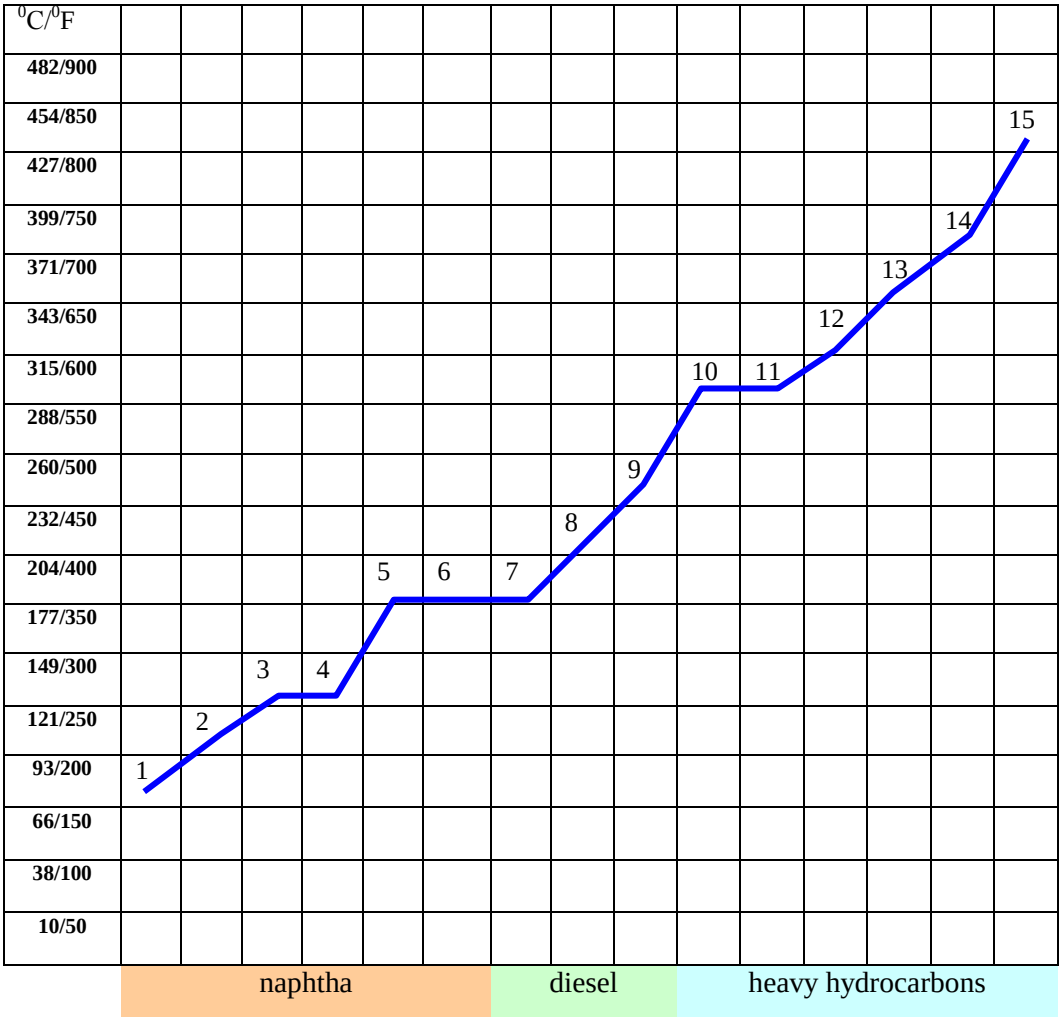
Processed material from the kiln removed by screw conveyor. Material is cooled during it is conveyed by discharge water cooled screw conveyor to 90-100°C. Processed material is collected in a self dumping container.

Processed material contains miniscule amounts of hydrocarbons and is environmentally safe, it can be reused in material preconditioning unit to achieve desired material characteristics or disposal, or can be farther processed (for example in briquette press).

2. Theory of operation

Hydrocarbons extractions are achieved by heating feed material so the level of hydrocarbons becomes volatile and evaporate.

Feed material may contain mixture of different hydrocarbons. Oil sludge is a mixture of mostly heavy hydrocarbons, which are thermal resistant. If centrifuge was used in first stages then light hydrocarbons will be extracted and mostly heavy hydrocarbons will be left in source material. Thus material after centrifuge (cake) contains mostly heavy hydrocarbons with high evaporation temperatures.



Pic. 2. Hydrocarbons characteristic evaporation temperatures (C/F).

1 - gas
2 - toluene
3 - ethyl benzene
4 - xylene
5 - phenol
6 - gasoline (90%)
7 - naphthalene
8 - kerosene
9 - diesel (90%)
10 - low temperature PCBs
11 - pirene
12 - high temperature PCBs
13 - paraffin wax
14 - asphalt
15 - tar

Thermal-Desorber system should provide:

- Feed material heating to required temperatures;
- Required material residence time to evaporate all hydrocarbons contained in feed material;
- Low oxygen level (partial vacuum) to prevent burning of hydrocarbons inside process vessel.

Proposed Thermal-Desorber system, due to carefully tailored system parameters, performs near full hydrocarbons extraction from feed material. To prevent hydrocarbons burn out inside process kiln low negative pressure is maintained by induced draft fan. Induced draft fan forces vent gas flow through scrubber where vent gas is cleaned by constant oil flow.

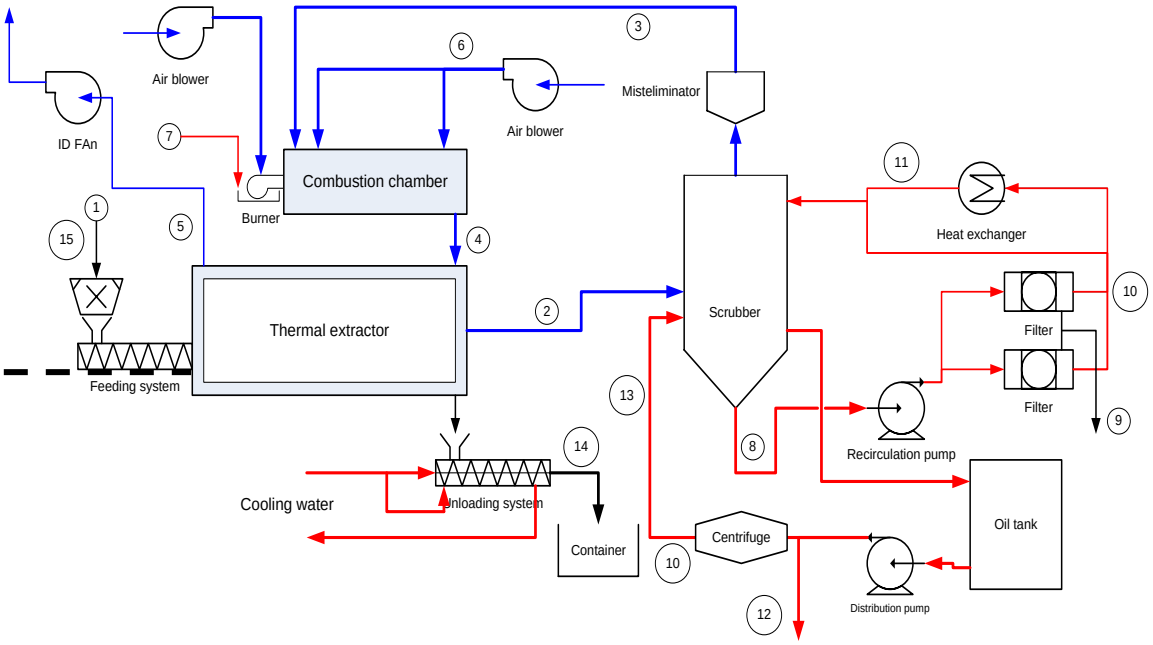
Extracted from source material hydrocarbons are utilized as following:

- Condensation in the quench scrubber;
- Burning in the combustion chamber where hot gases are used to heat source material in kiln drum, increasing system efficiency.

3. Main parts of Thermal-Desorber system

Whole system consists of several units:

- Feeding system;
- Thermal extractor and combustion chamber;
- Quench condensing scrubber;
- Unloading and cooling system
- Environmental control.



Pic. 3. General process diagram.

1 – feed material
2 – vent gases
3 – cleansed vent gases
4 – hot gases to heat kilns drum
5 – exhaust gases
6 – air for blower and quenching
7– fuel (diesel, natural gas)
8 – dirty oil
9 – sludge from filter
10– clean oil
11 – cooled oil
12 – excess oil
13 – fresh oil
14 – cleaned material
15 – lime (optional)

4. System design

4.1. Feeding system

Feed material (cake after centrifuge, oil sludge or contaminated soil) is placed in the live bottom feeder. The live bottom feeder has a variable speed drive and a pair of counter-rotating screws that meter the material to the feed transfer conveyor.

Pic. 4. Feeding system.

The feed transfer conveyor is an inclined tubular screw conveyor that transfers the material from the live bottom feeder to the feed injection screw conveyor. The feed injection conveyor is a special tubular screw conveyor with a pair of external bearings and a cantilever drive shaft. It is designed to allow the conveyed material forms a seal to keep air out of the process. The feed injection conveyor feeds the material into the indirect fired rotary kiln.

4.2. Thermal extractor and combustion chamber.

Our system is indirect heated thermal extractor unit. Feed material is heated during contact with hot kiln shell which is heated by hot gases generated in combustion chamber.

Rotated kiln drum is equipped with mechanical system that prevents material build up and agglomeration inside the kiln. In addition, mechanical system increases heat transfer and material mixing which provide better extraction of hydrocarbons from material. Processed material is unloaded at the unloading hood by a screw conveyor.

Special designed hoods and conveyors gaskets prevent air from entering inside kiln which as a requirement for indirect firing kiln. By eliminating oxygen inside the kiln, the reaction is limited to the vaporization of the water and hydrocarbons. Kiln drum is insulated by high quality ceramic fiber that resulted in low system weight and high system mobility.

Part of the gases extracted from feed material and not condensed in the scrubber, are burned in combustion chamber, lowering fuel consumption of the system.

The gases vaporized in the kiln are sent to the direct contact quench scrubber. There they cool, condense, and clean. The gases that condense below operating temperature of the quench scrubber are recovered in the scrubbing media (oil). The heavy hydrocarbons and the particulate are captured in the oil.

4.3. Quench condensing scrubber.

The scrubber consists of a vertical carbon steel vessel with multiple spray nozzles. The gas flow is counter-current to the oil flow. The oil is recalculated by a special low inlet head pump capable of handling hot oil. Dual parallel mist eliminators are provided to prevent liquid carry-over into the combustion chamber. A two stage filter system removes particulate from the oil. During system operation oil volume is constantly growing (depending on hydrocarbons content in feed material). Part of gases extracted from source material and not condensed in scrubber are burned in combustion chamber lowering fuel consumption of the system.

Pic. 5. Quench condensing scrubber.

Excess oil is flowing from the scrubber through loop seal to oil collection tank. From collection tank oil is pumped to centrifuge which removes particulate from the oil and adds clean oil to the scrubber. Dual parallel mist eliminators are provided to prevent liquid carry-over into the combustion chamber.

Pic. 6. Mist eliminators.

4.4. Unloading and cooling system.

Unloading system consist of inclined tubular screw conveyor. Conveyor have water cooled jacket and tubular shaft. It is designed that the ash forms a seal to prevent air from entering into the process.

Pic. 7. Unloading and cooling system.

4.5. Environment control unit.

Because processed material can contain fine particles, it is possible that air can be contaminated with dust when material is unloaded from system. To prevent air pollution system is equipped with air filter unit that collect dust by air filter from unloading zone through dust hood. Filter uses conical filter cartridges and has self-cleaning feature.

Pic. 8. Dust collector.

5. Control system.

Control system provides operator control of process either in manual or automatic mode. Control system has graphic user friendly interface and provides alarm messages and indication. Control system based on Allen-Bradley SLC-500 controllers.

Control system monitors all process parameters, including:

- Combustion chamber temperature;
- Kiln plenum temperature;
- Combustion chamber oxygen level;
- Kiln vent gas temperature;

- Kiln material exit temperature;
- Scrubbers oil temperature;
- Scrubber vent gas exit temperature;
- Scrubber oil level;
- Oil level in oil collecting tank.

In addition control system provides:

- Automated system startup and burner startup;
- System warm up;
- Automated process control;
- Automated system shut down.

Pic. 10. Operator graphic screens

6. Operation safety.

Operation safety provided by:

- Using sophisticated PLC based control system;
- Maintaining negative pressure inside process vessels;
- Hot spare autonomous diesel power generator;
- Emergency quenching system with nitrogen or water turned on by high temperature in monitored spots.

7. Advantages of proposed system.

- *Very low utilities consumption*
- *Less than four hour start-up and 2 hour shutdowny*
- *Simple and efficient vessel seals*
- *Low maintenance high efficiency scrubbing system*
- *High level of automation*
- *Very low weight*
- *Minimum site preparation*

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