SEPARATION AND RECOVERY OF OIL FROM OILY WASTE MATERIALS USING ANAEROBIC THERMAL DESROTPION UNIT TECHNOLOGY

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ABSTRACT

RLC Technologies, Inc.'s Anaerobic Thermal Desorption Unit (ATDU) is an ex-situ, non-incineration technology designed to separate hydrocarbons from various matrices including oilfield waste, soil, sludge, sand, filter-cake, tank and tanker bottoms, organic-based hazardous waste and contaminated soil in a non-oxidizing atmosphere without destroying the hydrocarbons. This paper briefly discusses the successful application of ATDU in treatment of different waste streams in particular oily sludge, drill cuttings, organic-based hazardous waste processing and contaminated soil remediation. Detailed process description along with major ATDU system components description and function are discussed.

BACKGROUND

Traditional disposal and storage methods for oily waste, drill cuttings and hazardous waste materials in pits, landfills or ocean dumping are becoming less popular by governments influenced by internal needs for better waste disposal practices and external pressure by various regional and international regulatory agreements. Combination of environmental regulations attempting to establish better standards of care in the oil producing countries of the world combined with attractive oil prices provide a unique economically driven opportunity for recovery of the oil from the waste material as a sellable product. The ATDU process has been used extensively for oil separation and recovery throughout the world including countries in the Middle East, Southeast Asia, North America, and the Caribbean.

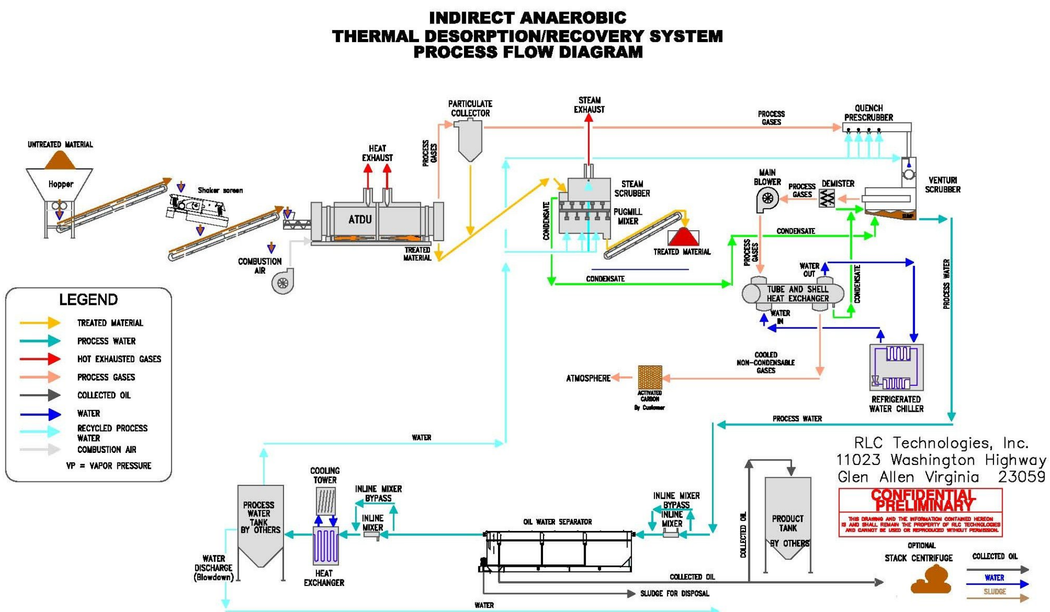
ATDU TECHNOLOGY APPLICATION

ATDU process has been in use for over a decade while processing oily sludge waste generated at oil refineries and petrochemical plants, tank and tanker bottoms received at marine waste processing facilities, drill cuttings from on- and off-shore operations, organic-based hazardous waste (US EPA defined RCRA waste) and remediation of soils contaminated with a wide host of chlorinated and non-chlorinated hydrocarbons. ATDU has had a successful track record in processing oily matrices with elevated hydrocarbon content. Traditionally the most effective technology for processing oily waste with elevated hydrocarbon was various forms of incineration technologies. This process while effective in removing the hydrocarbons was not capable of recovering any hydrocarbons for beneficial recycling. The hydrocarbons were typically burned inside the system with some heat recovery. ATDU has been utilized at several refineries including Exxon-Mobil, Conoco-Phillips and Hess in North America as an “on-site” remediation tool for processing certain oily refinery waste; a RCRA classified hazardous waste in the US. By having the waste processed on-site at the refinery the material does not have to be transported to an off-site incineration facility. The ATDU’s effective hydrocarbon removal and recycling capabilities, its ease of regulatory emission permitting process and its greater acceptance by the general public have been key factors in its popularity among the refineries and the cleanup contractors in North America. The ATDU process is subject to USEPA’s regulations under Subtitle X which is substantially different and less stringent when compared to those applied to the incineration technologies which have to comply with extensive (and expensive) Subtitle O emission guidelines. RLCT’s ATDU system is currently the only system of this type currently permitted to process RCRA hazardous waste in the United States for recovery of the hydrocarbons for recycling, an alternative to traditional incineration systems that are substantially more expensive to build and permit. This enables ATDU system owner operators to realize their return on their investment more rapidly when compared to traditional expensive incineration systems.

The USEPA has also adopted this technology as a viable and proven soil remediation tool at well over thirty Superfund sites throughout the country including a highly publicized Universal Oil Product (UOP Superfund Site) located near the New York Giant’s football stadium where ATDU was used to remove Polychlorinated Biphenyls (PCBs) and Polycyclic Aromatic Hydrocarbons (PAHs) from the contaminated soil. This technology has been used at substantially larger number of privately funded cleanup projects in North America. This technology has also been used internationally to cleanup contaminated soil at some high profile sites in Sydney, Australia (Homebush Bay), Hong Kong (Dioxin contaminated Cheoy Lee Shipyard was cleaned-up to become the site of Disney’s theme park) and is currently being considered as a possible technology for the cleanup of dioxin contaminated soil at the former Union Carbide site in Bhopal, India. The ATDU owes its success to several key factors when compared to traditional incineration technology: 1) high levels of hydrocarbons in the ATDU do not create thermal loads and process difficulties typically encountered in incineration and direct fired thermal processing technologies; 2) sufficiently high concentrations of oils in the waste can justify the recovery cost while considering the beneficial resale value of the recovered product in combination with the ecological protection; therefore, a value added process. And 3) since it is not considered an incineration technology by the regulators and the grass root environmental organizations throughout the world; it has become the treatment technology of choice for the cleanup of chlorinated (and non-chlorinated) hydrocarbons contaminated sites worldwide.

ATDU PROCESS DESCRIPTION

Within this paper, the Company's ATDU equipment is described with the main focus being on the oily waste (refinery streams, drill cuttings, tank and tanker bottoms) processing. When processing the above streams, typical ATDU plant is composed of several major subsystems (or skids) that work together in concert. These include (1) feed unit, (2) the indirectly heated rotary drum, (3) treated solids cooling unit, (4) vapor recovery unit, (5) primary water treatment unit made up of oil water separator, (6) and central process controls.



FEED PREPARATION & METERING, CONVEYING UNIT

The main components of a typical feed system include single or dual-feed hoppers for waste material storage. The hoppers are furnished with variable speed driven screw auger systems in the bottom for discharge of difficult to convey material. This mechanism of discharge is also known as the "live bottom" design. Each hopper is furnished with a walking platform around top for cleaning and maintenance access to the screening grizzly over the feed hopper. The grizzly is used to screen large particles from entering the hopper/ATDU. The feed hopper can be charged using a front-end loader or crane operated clam-shell type bucket. The hopper can be furnished with cover to control VOC emission between loadings. As material is discharged from the hopper it travels via single or dual enclosed conveyors before reaching the inlet of the ATDU. En-route the material travels over a belt scale where the feed rate to the ATDU is monitored and adjusted as necessary. The ATDU feed rate is controlled by adjusting the speed of the rotation of the screw-auger system in the feed hopper bottom while all other conveying components operate at constant speed. Material preparation and pre-treatment might be necessary during certain projects to assure good material conveying and thermal treatment. Oily waste material with elevated free liquid (oil and water) level are recommended to undergo some type of physical liquid separation prior to thermal treatment. Drilling mud with elevated liquid content may have to be pretreated to assure sufficient consistency prior to thermal treatment. Material pretreatment is one of the most important factors-often time overlooked-in the successful thermal treatment operation.

Indirectly Heated Rotary Drum

The primary function of the indirectly heated rotary drum is to vaporize the hydrocarbon contaminants and the moisture from the incoming waste material or solids. The indirect heated drum is the heart of the system. It is fabricated with heat and corrosion resistant low nickel alloy for design furnace service temperatures ranging in 800ºC – 1,200ºC. The rotary drum that is heated from outside while inside a stationary furnace where several burners provide the necessary process heat. As the drum shell is heated the energy is transferred to the contaminated feed material inside the rotary drum through conduction. The material inside are also heated through radiation from the rotary drum’s interior shell surface. The rotary drum shell material and the furnace burner capacity are designed to elevated material temperature up to 500ºC-600ºC, although these higher operating temperature ranges are rarely necessary for material processing under normal circumstance. By having the burners located inside the furnace the contaminated materials inside the rotary drum do not come in contact with the products of combustion from the burners. The drum’s material inlet and discharge are controlled via two airlocks designed to minimize air (oxygen) leakage into the drum. The inlet and discharge end of the rotary drum are equipped with custom designed seals to prevent air leakage. The contaminated material travel time through the rotary drum is controlled by the slope of the unit, number and location of the internal lifters and the rotational speed of the rotary drum. Typically the drum slope and the position and number of lifters are fixed; the rotational speed of the drum is the key feature that controls the retention time of the contaminated material inside the rotary drum. The required retention time inside the rotary drum to achieve any given cleanup goal is highly dependent on the free and bound moisture content of the waste material, solid’s physical characteristics such as particle size distribution, type of organic and inorganic compounds present in the waste stream and the vapor pressure of the hydrocarbons. During the treatment process as the oily sludge or drill cuttings travel through the rotary drum the hydrocarbons and water undergo evaporation (desorption) process while generating a very dry and contaminant-free solid stream. The processed solids that are very hot at this point are conveyed into a pugmill where they are mixed with water for cooling before being discharged. The material temperature is continuously monitored by thermocouples at the inlet and the discharge points of the rotary drum. The shell temperature is monitored at several points along the length of the unit to prevent overheating. The furnace stack gas discharge temperature is monitored very closely. A combination of the stack gas exit temperature, material exit temperature from the ATDU and the shell temperature are typically used to achieve optimum fuel consumption rate during plant operation. The atmosphere inside the rotary drum is under continuous negative pressure by the plant's induced draft (ID) fan. The desorbed vapors are transported from the rotary drum into the system's Vapor Recovery Unit (VRU). The ATDU is furnished with access doors for easy access for inspection, cleaning and maintenance of the lifters inside the rotary drum.

Treated Solids Cooling & Steam Scrubbing

The hot treated solids discharged from the rotary drum are conveyed to a dual-shaft pugmill for cooling. Each shaft is equipped with mixing paddles. Inside the pugmill the hot incoming solids are continuously mixed with water for cooling and dust control before being discharged from the pugmill. As hot material comes in contact with cooling water steam is generated. The generated steam is entrained with dust particles. A steam scrubber is placed on top of the pugmill where it condenses the steam and scrubs the dust out and back into the pugmill chamber. The pugmill is furnished with access doors for easy inspection, cleaning, maintenance and replacement/adjustment of the paddle tips. The pugmill can be used effectively for optional mixing of the hydrocarbon-free material at the point of exit with various additives such as lime or Portland cement to stabilize the residual metals prior to disposal if required. These additives can be stored in an on-site storage silo next to pugmill.

Vapor Recovery Unit

The main function of the Vapor Recovery Unit (VRU) is to condense and recover the desorbed hydrocarbons, water vapor and the solid particles present in the gas stream exiting the rotary drum. The VRU's standard material of construction is temperature and corrosion resistant stainless steel 304 grade plate. The VRU includes several main components including dry dust collector, quench section, venturi scrubber, separator, mist eliminator section, induced draft fan and condenser. The dry dust collector (cyclone) removes the coarse particles from the gas stream to minimize solids loading on the VRU and the water treatment unit of the system. Once the gases leave the cyclone they enter the quench section where the gas stream is cooled by direct contact with finely atomized water droplets via multiple nozzles. This water spray system also helps in knocking out additional solids from the gas stream. As the gas temperature begins to cool down the majority of the hydrocarbons begin to condense out by the time gases leave the quench section. The VRU is equipped with an integrated variable throat venture scrubber for removal of the fine solid particles from the gas stream entering the VRU. The dust laden gas stream and the process water collide, dispersing the liquid into droplets that the particles impact and become entrapped within. These droplets containing the fine solid particles are removed from the gas stream in a horizontal cyclonic separator downstream of the venturi. This venturi is designed with an adjustable throat to maintain the desired pressure drop across the throat as the gas volume changes. This feature assures that the same particulate removal efficiency is maintained as operating parameters change in the system. The gaseous effluents exiting the cyclonic separator pass through two mist eliminators to remove entrained water droplets before reaching the system ID fan. The mist eliminators are chevron type and are placed in series. They are easily removed for regular maintenance cleaning. The process ID fan is equipped with a variable speed controlled drive for sufficient draft through the system while continuously pulling the vapors through and our of the rotary drum, cyclone, separator and the venturi scrubber and then pushing these vapors through the condenser, the flame arrestor and activated carbon bed. Once the gases reach the condenser (indirect heat exchanger) their temperature is dropped to less than 10ºC to promote removal of the residual hydrocarbon vapors (the lighter hydrocarbons) from the gas stream. The cooling media for the heat exchanger is a mixture of water and glycol compound that is continuously cooled by a Freon based chiller system for optimum operation and minimum space requirement. Once the gases leave the condenser they travel through a flame arrester before being discharged into an activated carbon bed for final polishing prior to atmospheric discharge. The design of this heat exchanger allows for easy maintenance and scheduled clean-up. Several access doors are furnished within the VRU body for ease of inspection, scheduled maintenance, repairs and the required occasional cleanup to remove material buildup.

API Separator for Oil Water Sediment Separation

The condensates, residual fines/sediments and the water collected inside the VRU are treated in an above ground API type primary oil water separator. Depending on the material being processed by the ATDU the separator can produce water that has sediments and oil concentrations in the range of approximately 50 – 200 mg/liter. The API separator is a gravity separation device that works on the principle of Stokes Law which defines the rise velocity of an oil particle based on its density and size. The oil droplets float to the top and the sediments settle in the bottom of the separator tank. The recovered oil is collected using a stationary skimmer. The collected oil is continuously pumped into an above ground storage tank. The oil can undergo filtration or centrifuge to remove sediments and moisture further before it is used as fuel. It can be reused for drill mud blending or put back through refining process without major pretreatment. The recovered sediments/sludge is pumped from the separator using pneumatic pump and is recycled back into the ATDU process. Once the oil and suspended solids are removed from the influent in the API separator, the middle phase, water, is then pumped out to on-site storage tank for recycling. A portion of the recovered water is pumped into a plate and frame heat exchanger where it is cooled and reused as cooling process water for the VRU unit. The cooling media for the plate and frame heat exchanger is water. The water is continuously cooled inside a cooling tower. The cooling tower can be equipped with inlet air filtration system to minimize solids and slat particle from entering the unit; therefore, lowering the water-blow down rate and water makeup. The outlet of the cooling tower can be equipped with demisters to further reduce water loss. The API separator includes a fixed cover for VOC emission control. To minimize problems associated with the oil emulsions in the separator certain additives and or chemical treatment may become necessary during certain project for proper phase separation.

PROCESS CONTROLS & AUTOMATION

The entire ATDU plant is centrally controlled using traditional microprocessor-based components or custom designed PC windows based process control software using either Programmable Logic Controller (PLC) or Distributed Control System (DCS). Company furnishes PLC or DCS controls with integrated Human Machine Interface software (HMI) and graphic screens for effective plant control, monitoring, interlocking and data storage via standard key board and mouse. The computer based process controls offer real-time access to all key plant parameters. This feature is designed to enable the operator to improve system capacity, optimize fuel consumption, and protect the ATDU equipment against accidental malfunctions. On-site training by the factory trained technicians is furnished to familiarize the plant operators with all operational and maintenance aspect of the plant. Each plant is furnished with electric switchgear motor control center or power panel fully wired and tested at factory. The process control and instrumentation and electrical switchgear must be placed inside a clean room furnished with air conditioning system for long life and proper operation.

CONCLUSION

Our old practices of waste oil and contaminated soil storage and disposal are far from remotely addressing today's emphasis on environmental protection (subsurface soil, surface water bodies, groundwater and oceans) by various national and international regulatory bodies. The general public's awareness of the potential hazards associated with living near or downwind from contaminated waste sites and resentment of the same has been publicized from Nigerian villagers dilemma with oil-soaked agricultural fields to drill cuttings contaminated tropical forests of the Native tribes in Central and South America to the chlorinated hydrocarbon contaminated soil stored at the former Union Carbide plant in Bhopal, India. The only proven treatment method to effectively remove hydrocarbons from the oily sludge, tank and tanker bottoms and drill cuttings is the thermal process. The ATDU process offers a unique opportunity where the oily waste material can be processed while not only separating the hydrocarbons and generating a clean reusable solid but it also recovers hydrocarbons for beneficial recycling. The recovered oil can be recycled back into the refining process, back to drilling mud formulation, or cleaned and used to fire the ATDU burners or sold as fuel. In the case of contaminated soils the residual hydrocarbons are recovered using the same methodology for final disposal or treatment of the hydrocarbons depending on the toxicity.