AUSTRALIA 658297

Patents Act 1990

PATENT REQUEST: STANDARD PATENT

We, being the persons identified below as the Applicant, request the grant of a patent to the persons identified below as the Nominated Persons, for an invention described in the accompanying standard complete specification.

Full application details follow:-

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[54] Invention Title: "Method for Treating Soil Contaminated with Hydrocarbons"

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ASSOCIATED PROVISIONAL APPLICATION DETAILS

[60] Application No.: P-003381
Date: 22nd June 1992
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Dr. Siegfried Emanuel Tischler and
Pt. Limbahasri Saktibuana
By their Patent Attorneys
HALFORD & CO.

G.R. Davidson

File: C 93 003

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NOTICE OF ENTITLEMENT

(To be filed before acceptance)

We, Dr. Siegfried Emanuel Tischler and Pt. Limbahasri Saktibuana, of Kuningan Dukuh Patra IV/64, Kuningan, Jakarta, Indonesia and Wigo Building, 2nd Floor, Jalan Kapten Tendean, Kav. 39, Jakarta 12790 Indonesia, respectively, being the applicants in respect of Application No. 39922/93 state the following:-

The persons nominated for the grant of the patent are the actual inventor, Dr. Siegfried Emanuel Tischler, of Kuningan Dukuh Patra IV/64, Kuningan, Jakarta, Indonesia, and Pt. Limbahasri Saktibuana, of Wigo Building, 2nd Floor, Jalan Kapten Tendean, Kav. 39, Jakarta 12790 Indonesia, to whom said actual inventor has assigned partial rights to the invention.

The persons nominated for the grant of the patent are the applicants of the basic applications listed on the patent request form.

The basic application listed in the request form is the first applications made in a Convention country in respect of the invention.

DATED this 25th day of January, 1995.

Dr. Siegfried Emanuel Tischler and
Pt. Limbahasri Saktibuana
By their Patent Attorneys
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G.R. Davidson

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(54) Title
METHOD FOR TREATING SOIL CONTAMINATED WITH HYDROCARBONS

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(56) Prior Art Documents
US 5170726
US 5164158
US 5118629

(57) Claim

1. A method for treating soil contaminated with organic compounds comprising the steps of:

straining the soil through a rotary air lock;

producing streams of indirectly preheated primary air and secondary air; with an air blower and preheating assembly;

introducing the strained soil and a hot gas stream including the preheated primary air into a fluid bed oxidiser at a sufficient temperature and pressure and for sufficient residence time to oxidise the hydrocarbons and produce a mixture or treated solids and process gas; and

separating the treated solids from the process gas.

.../2

10. A method for treating soil contaminated with organic compound comprising the steps of:

feeding strained soil through a rotating air lock a stream of primary air passing through a pre-heating assembly and then into an oxidiser chamber;

producing a stream of secondary air into a gas manifold surrounding the oxidiser chamber and in communication with a perforated wall;

producing secondary air through perforated wall to combine with the gas-solids mixture of primary air and soil for forming a fluidized mixture at a sufficient temperature and pressure and for sufficient time to oxidize the organic compounds and form a gas solids mixture comprising treated soil and gas; and

separating the process gas from the treated soil.

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ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Invention Title: "Method for Treating Soil Contaminated with Hydrocarbons"

The following statement is a full description of this invention, including the best method of performing it known to us :

Backgroud of the invention

This invention relates to a method for decontaminating soil or other solids that have become contaminated with organic such as hydrocarbons. More particularly, it relates to the use of a fluidized bed oxidiser to destroy the contaminants present in the soil.

Growing environmental awareness has caused recognition of the potential environmental and health hazards associated with soil that has become contaminated with hydrocarbons. Tanks for storing hydrocarbons such as crude oil or products such as gasoline or diesel sometimes develop leaks resulting in discharge of a portion of their contents into the surrounding soil. Over time the hydrocarbons can accumulate in the soil eventually causing contamination of nearby water supplies.

An inexpensive way for decontaminating such contaminated soil is desirable. It is preferred that the equipment for decontaminating such soil be somewhat portable so that it can be taken to the site of contamination avoiding the relatively expensive process of moving large quantities of soil to a central processing facility.

Summary of the invention

According to the invention, soil that has become contaminated with hydrocarbons is decontaminated by mixing the soil with a hot gas stream containing oxygen in a oxidiser chamber of a fluid bed oxidiser. The temperature of the hot gas stream should be sufficient to cause spontaneous combustion of the light hydrocarbons from the soil immediately upon contact with the hot gas stream. The gas stream is also performing pneumatik conveying through the assembly. The heat generated by the exothermic

combustion reaction causes the vaporisation and combustion of the rest of the hydrocarbons present in the contaminated soil, leading to flash oxidation.

The hot gas stream (primary air) is preferably provided by an air-blower, parts the proceeds from which are indirectly heated in a suitable assembly; and introduced into the oxidiser; the rest of the air (secondary air) is ducted into a concentrical outer cylinder around the oxidiser. Through a plurality of perforations the secondary air enters the oxidiser chamber to provide insulation of the oxidiser wall from both heat and abrasion.

The soil is introduced into the stream of primary air prior to it entering the preheating assembly; it is introduced as relatively small particles by straining through a rotary air-lock.

The secondary air is introduced targentially into the outer cylinders; as it enters the oxidiser through perforations in its wall, it keeps the soil and hot gas mixture in a fluidized state. The oxidiser is in five stages increasing diameter. This maintains ± constant speed by accomodating the ever increasing gas volume. Turbulent conditions of the fluid phase are created by the tangential introduction of secondary air and by the non-linear adjustment for increased gas volume.

The product of the incinerator is a gas-solid mixture of treated soil and process gas comprising excess hot gas and combustion products. The gas-solid mixture is vonveying itself to means for separating the decontaminated soil from the process gas. Preferably one or more cyclone separators are used for this separation step. The process gas from the cyclone separator can be further treated by conventional means to remove air pollutants that might be present.

The temperature and pressure of the oxidiser chamber are controlled by varying the speed of the air-blower and variation of the thermal energy introduced in the preheating assembly. Temperature can be further controlled by controlling the amount of secondary air. The fluidized bed oxidiser is preferably arranged on an adjustable incline so

that the residence time can be controlled by adjusting the incline.

Brief Description of the Drawings

The features of the specific embodiment of the invention are illustrated in the drawings wherein:

Fig.1 is a schematic blok diagram illustrating the process of the invention; and

Fig.2 is a plan view in section of a fluidized bed oxidiser (STAGE).

Detailed Description

The present invention relates to a method for decontaminating sand, soil or other solids that become contaminated with organic materials such as hydrocarbons by incinerating the contaminants in a fluidized bed oxidiser. While the method presented is useful for treating virtually any noncombustible solid, the description of the method is directed to the decontamination of soil in order to simplify the discussion. However, it should be recognized that the term soil is to be broadly understood to include other noncombustible solids as well, as long as the maximum grain diametris 1 mm.

Referring to Fig.1, feed comprising soil 6 that has become contaminated with hydrocarbons is introduced to an inverted conical hopper 10 which feeds strained soil 12 to a fluidized bed oxidiser 20. The feed is strained by forcing the soil through a rotary air lock 14 located below the delivery from a trommel/mixer/homogeniser 13A. The hopper is preferably capable of holding up to about ten metric tons of contaminated soil; from it a screw conveyor 10A is extracting a measured portion of feed and delivering it to a conveyor belt 10B, which elevates the feed to the trommel. The weight of the feed causes it to be strained through the rotary air lock to create small particles about one millimeter in diameter. The rotary air lock may be a

perforated plate having a plurality of holes, each about five millimeters in diameter.

From the air lock the feed drops into the preheating assembly 13B and is pneumatically conveyed into the preoxidiser chamber 13C of the fluidized oxidiser.

In the preferred embodiment, as shown in Fig.1, primary and secondary air are provided by the proceeds of an air-blower produces high volume air 52. Portions of the air-blower circumference are ducted away 60 to provide for secondary air.

In the preheating assembly, the primary air is preheated to a temperature in excess of the Flash Point of the hydrocvarbons by way of indirect heating within metal pipes 32. These pipes are sited within a containment 33 area into which burners 34 deliver heat. In the pre-oxidiser chamber 13C the preheated fluid phase is undergoing turbulent motion within an aerodynamically shaped chamber to assure homogenisation good mixing of the gaseous/solid phase. The flue gas is drawn from this containment area and ducted to a venturi nozzle 34A after which the flue gas is admixed to primary air to provide a temperature booster and provide for spontaneous combustion within the oxidiser chamber of the fluidized bed oxidiser. Sufficient oxygen and temperature levels should be maintained in the oxidiser chamber to cause the lighter hydrocarbons present to spontaneously ignite. Oxygen and temperature levels are controlled by the air-blower speed setting and the amount of thermal energy introduced into the preheating assembly by the burners. The heat generated by this exothermic combustion propagates through the fluidized bed to vaporize and burn the other heavier hydrocarbons present in the contaminated soil by way of flash oxidation.

Referring to Fig.2, the fluidized be oxidiser comprises three concentrically arranged hollow cylinders 24, an intermediate cylinder 26 and an outer cylinder 28. The fluidized bed oxidiser is arranged in an inclined configuration so that the flow through the oxidiser chamber proceeds in at least a partially upward direction.

The inner cylinder of the fluidized bed oxidiser forms the oxidiser chamber. This cylinder is approximately seven meters in length and consist of five successively larger dimensioned stages. The diameter increase - from stage - is governed by the overall size of the unit - it takes into account the increased volume of fluid phase in the oxidiser chamber and is aimed at keeping the overall speed of the proess ± constant. The secular speed variations within each individual stage as well as the tangential nature of introduction of secondary air will assist in keeping conditions of the fluid bed turbulent-assisting in thorough mixing of gaseous- and solid cmomponents and propagation of the combustion process from light to heavy hydrocarbons phases. The residence time of the fluid phase within the oxidiser can be controlled by varying the speed of the air-blower and the incline of the fluidized bed oxidiser.

The oxidiser chamber is surrounded by the intermediate cylinder; from it, it is separated by a perforated plate 30. Through the holes 36 secondary air is drawn from an annular space defined by the walls of the inner- and intermediate cylinder- according to the BERNOULLI LAW - into the oxidiser chamber. In this way the wall of the oxidiser chamber is insulated from both the temperature of the fluid phase as well as the abrasive action of the pneumatically conveyed soil particles. The introduction of secondary air serves the further purpose to provide additional oxygen for oxidation as well as causes the generation of turbulent flow. Speed increase caused by the gas-volume increase within the constan containment volume is offset by the speed decrease, as the fluid phase enters the next (larger) stage of the oxidiser chamber. As such variability occurs in five pulses, turbulent conditions prevail throughout the residence of the fluid phase within the oxidiser chamber.

An outer cylinder surrounds the intermediate cylinder forming a second annular space defined by the intermediate and outer cylinders that acts as a cooling gas chamber 42. Cooling gas channeled through the cooling gas channel is used to remove a portion of the heat generated by the

exothermic combustion reaction in the oxidiser chamber. To better improve the heat transfer, the intermediate cylinder includes external radial cooling ribs 44 that are spaced along its length and that extend outward from the intermediate cylinder approximately 0,5 meters into the second annular opening.

The oxidisation of the organic material in the contaminated soil produces a gas-solid mixture 72, containing treated soil, excess hot gas and combustion products. Most of the oxidation products are gases such as carbon dioxide, water vapour, but some solids such as ash may be present. Operation of prototypes has shown, that there is little - if any - ash presents. This points to total oxidation; hence the production of ANY MONOXIDES is theoretically not possible. As the maximum temperature reached in trials was well below 1000°C it can be safely predicted, that NO oxides of nitrogen are produced in the process. Depending on the presence of sulfur compounds within the hydrocarbons, the formation of oxides of sulfur has to be expected. In trial runs, such sulfurs contents were extracted by way of admixture of finely ground lime to the feed- leading to instantaneous generation of anhydrite/gypsum. The solid- gas mixture is directed to a gas-solid separator 80 containing the gaseous components indicated above and a treated solid stream 84 containing treated soil and possibly some ash.

In the preferred embodiment, cyclone separators are used to perform this separation step. Cyclone separators are used to perform this separation step. Cyclone separators are generally known and include a cylindrical chamber into which the gas-solid mixture is tangentially directed causing a vortex flow, whereby the inertia of the solid particles directs them to the walls of the chamber by centrifugal acceleration. Upon contact with the wall the solids drop to the bottom of the cyclone by gravity. In the preferred embodiment, the cyclone separator is lined with ceramic material to improve its abrasion resistance. A valve at the bottom of the cyclone separators is used to maintain a level

of solid particles and to control flow of solids.

While a single cyclone separators is described, it is clear that multiple separators may be used to improve the gas-solid separation. If multiple separators are used, they can be arranged in series, parallel or some combination of the two.

The process gas 82 the fluidized bed oxidiser exist the top of the cyclone separators and can be vented to atmosphere. However, if significant levels of pollutants are present in the process gas, it can be further treated such as by gas scrubbing or selective catalytic reduction in process gas treater 90. Treated process gas 92 can be vented to atmosphere. It is also possible to recover waste heat from the discharge of process gas by using a heat exchanger to preheat air that is fed to the oxidiser.

Because of its simple and compact design, the equipment used in practising the present invention can be easily mounted on a flat bed truck, rail car, ship or barge so tahat the process can be somewhat portable and may be taken to the source of contamination. As the transportation of large quantities of soil to a central processing facility can be quite costly, this process can significantly reduce the treatment costs associated with soil remediation.

Once the soil has been treated by the process of the process invention, it can be safely used as fill or otherwise disposed without environmental risk. If the equipment is portable, the contaminated soil can be collected, treated and replaced at the same location.

The embodiments described for the process of the present invention are illustrative and are not to be limiting. Various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and the scope of this invention. The scope of the invention is defined in the following claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for treating soil contaminated with organic compounds comprising the steps of:

straining the soil through a rotary air lock;

producing streams of indirectly preheated primary air and secondary air; with an air blower and preheating assembly;

introducing the strained soil and a hot gas stream including the preheated primary air into a fluid bed oxidiser at a sufficient temperature and pressure and for sufficient residence time to oxidise the hydrocarbons and produce a mixture or treated solids and process gas; and

separating the treated solids from the process gas.

2. The method of claim 1 wherein the separating step is performed in a cyclone separator.

3. The method of claim 2 wherein separating step is performed in multiple stages of cyclone separators.

4. The method of claim 1 further comprising the step is performed of straining the soil from a hopper (via conveyor) through a rotary air lock.

5. The method of claim 1 further comprising the step of passing the proceeds of an air-blower through a pre-heating assembly forming the hot gas stream.

6. The method of claim 4 wherein the fluidized bed oxidiser is arranged on an incline whereby the hot gas and strained soil are introduced before the preheating assembly and the mixture of treated solids and process gas is produced from an upper end of the fluid bed oxidiser.

7. The method of claim 6 further comprising the step of varying the incline of the fluidized bed oxidiser for controlling the residence time.

8. The method of claim 7 further comprising the step of passing secondary air through a plurality of perforation defined by the wall of the oxidation chamber in order to:

maintain the fluid bed;

insulate the oxidiser wall from heat; and

insulate the oxidiser wall from abrasion.

9. The method of claim 1 further comprising the step of treating the process gas to remove atmospheric pollutants.

10. A method for treating soil contaminated with organic compound comprising the steps of:

feeding strained soil through a rotating air lock a stream of primary air passing through a pre-heating assembly and then into an oxidiser chamber;

producing a stream of secondary air into a gas manifold surrounding the oxidiser chamber and in communication with a perforated wall;

producing secondary air through perforated wall to combine with the gas-solids mixture of primary air and soil for forming a fluidized mixture at a sufficient temperature and pressure and for sufficient time to oxidize the organic compounds and form a gas solids mixture comprising treated soil and gas; and

separating the process gas from the treated soil.

11. The method of claim 10 wherein the separating step is performed in a cyclone separator.

12. The method of claim 11 wherein the separating step may be performed in multiple stages of cyclone separators.

13. The method of claim 10 further comprising the step of pre-heating the proceeds from an air blower.

14. The method of claim 13 wherein the fluidized bed oxidiser is arranged at an incline whereby the strained soil and hot gas are entering at a lower end and the mixture of treated soil and process gas is produced from the upper end of the fluid bed oxidizer and further comprising the steps of:

varying the speed of the air blower/volume of air in the fluid bed oxidiser; and

varying the incline of the fluidized bed oxidiser for controlling the residence time.

15. The method of claim 10 further comprising the step of introducing (supplemental) secondary air into the oxidiser chamber.

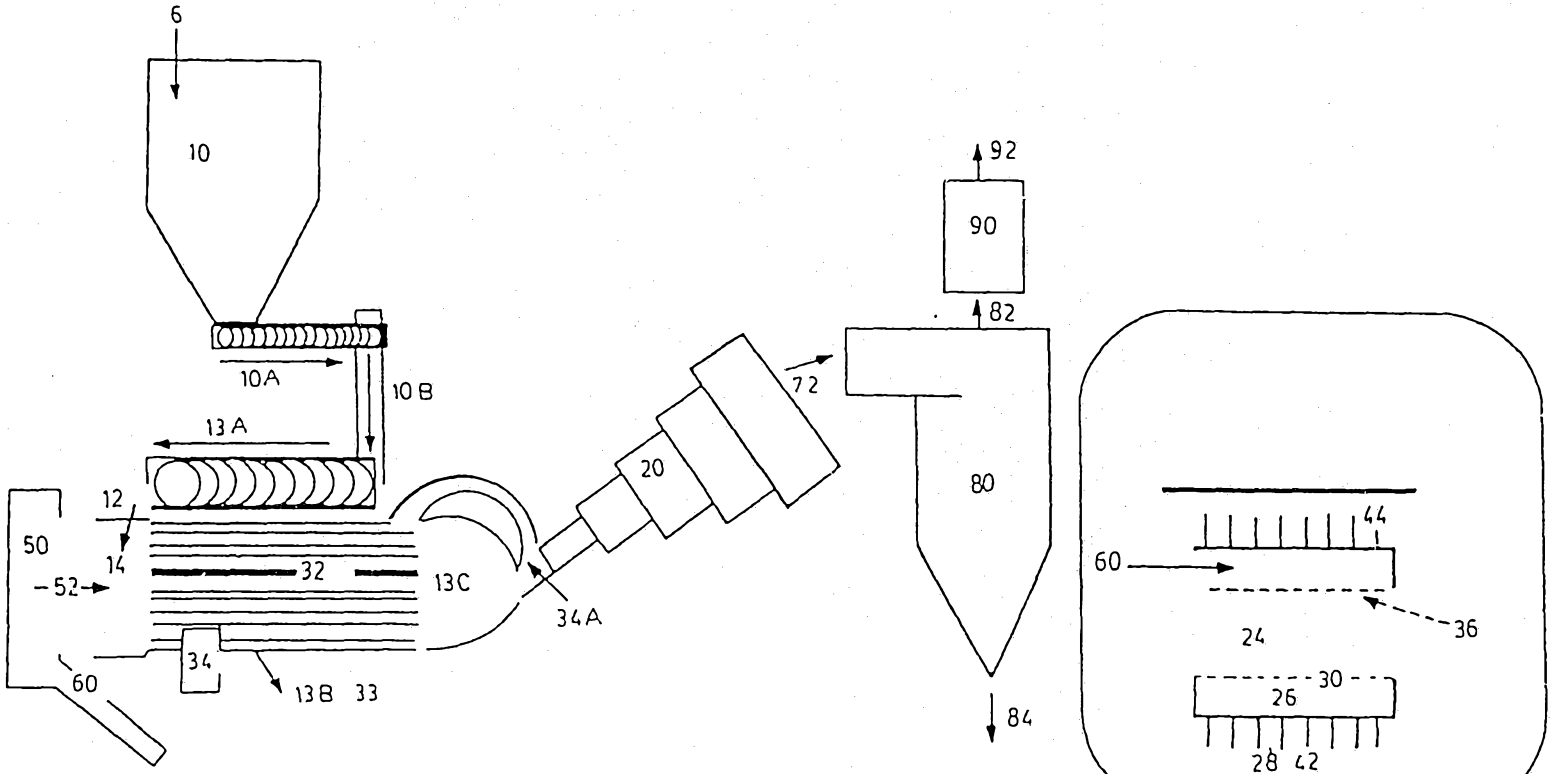
16. The method of claim 10 further comprising the step of treating the process gas to remove atmospheric pollutants.

DATED this 25th day of January, 1995.

Dr. Siegfried Emanuel Tischler and
Pt. Limbahasri Saktibuana
Patent Attorneys for the Applicant:
HALFORD & CO

A B S T R A C T

A method for treating soil that has become contaminated with hydrocarbons or other organic material includes straining the contaminated material through a rotary air lock (14) into the pre-heating assembly (13B) and pneumatic conveying by primary air into an oxidation chamber (13C). Secondary air is directed into an oxidation chamber through a plurality of perforations in the wall of the oxidation chamber to combine with and sustain the fluidised state of the soil-gas mixture. The hot gas is preferably produced by passing the proceeds of an air blower (50) through a pre-heating assembly (32). The oxidiser is arranged at an incline so that the gas solid mixture of hot gas and contaminated soil flows upwardly. The temperature of the fluidised bed is controlled by the temperature of primary air so that lighter hydrocarbons spontaneously ignite in the oxidation chamber. The exothermic combustion causes the remaining organic material present in the contaminated soil to vaporize and burn. The product of this process - termed FLASH OXIDATION - is a mixture of treated soil, excess hot gas and gaseous and solid oxidation products. This mixture is separated such as by one or more cyclone separators (80) to produce treated soil and process gas.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10A
10B
13A
12
14
50
52
32
13C
34A
20
72
92
90
82
80
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34
60
13B
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Fig • 1

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Fig • 2