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Method for utilising waste materials

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METHOD FOR UTILISING WASTE MATERIALS

The invention relates to a method for utilising waste materials of all descriptions, in which unsorted, unprocessed industrial, domestic and other specified refuse which may contain pollutants in solid and/or liquid state.

The known waste disposal processes fail to provide a satisfactory solution to the growing problem of waste, which plays a considerable part in damaging the environment.

Discarded industrial products of composite materials, such as vehicles and domestic appliances, as well as oils, batteries, varnishes, paints, toxic slurries, medicaments and hospital waste are subject to special strict legally prescribed disposal regulations. Domestic refuse, however, is a heterogenous mixture, not subject to control, which can contain virtually all kinds of specific types of waste and organic components, which is disposed of without reference to the damage it might cause to the environment.

Domestic refuse is stored unsatisfactorily in dumps from which foul gases and carbon dioxide escape uncontrolled into the atmosphere, polluted liquids and eluants from the dumped waste contaminate the ground water.

It has already been proposed to compost the organic components of domestic refuse and sewage sludge, in order to reduce the amount of waste to be treated. This, however, overlooks the fact that these organic materials are heterogeneous and contain many non-degradable toxic constituents such as chemicals, drugs and heavy metal residues which survive in the compost and are put back into the biological cycle via plants and animals.

Again, it is sought to reduce the amount of refuse by recycling what are regarded to as valuable materials. This overlooks the high costs of separate collection and processing such waste; repeated recycling only increases the costs and environmental damage while reducing the usability of the products thus obtained.

In known refuse incineration plants the materials being disposed of pass through a broad range of temperatures up to about 1000°C. At these temperatures, residual mineral and metallic materials remain unmolten. The energy which is contained in the remanent solid materials is wasted. The brief dwell time of the waste material at elevated temperatures and the large-scale generation of dust when large volumes of nitrogen-rich air are blown for combustion into the loose waste materials favour the dangerous formation of chlorinated hydrocarbons. One must therefore resort to submitting the waste gases from refuse incineration plants to after-burning at higher temperatures. In order to justify the high capital costs of such plants, the abrasive and corrosive hot waste gases are fed with their high dust content through heat exchangers. During the relatively long dwell time in the heat exchanger, new chlorinated hydrocarbons are formed through de novo synthesis, which combine with the entrained dust and give rise to highly toxic filtrates. The resulting damage and high costs of eliminating them can scarcely be estimated.

Despite the high technical requirements of the present state of the art, some 40% of the waste treated remains after incineration in the form of ash, slag and highly toxic filtrates, which can be compared so far as risk is concerned to radioactive waste and require costly disposal. In order to reduce the volume that must be dumped, it is known to separate out the metallic components from the rest and put them to specific uses. The remaining ashes and slags undergo a high temperature melting process with high energy costs. The slag is, on account of the heterogeneous starting material which has to be melted, inhomogeneous and still contains a substantial proportion of organic particulate residues which, because they are enclosed by the liquid melt, fail to be oxidised.

As a result of shock cooling of the melt in a waterbath, an heterogeneous granulate is formed of the melt which shatters randomly at thermal fracture zones, which allows the included pollutants to elute again. A high energy content of some 200 litres of fuel oil per tonne of melt is wasted, because the granulated melt can only be used as filler in road construction or the like.

The pyrolysis processes used to date in conventional reactors have a broad temperature spectrum like those used in refuse incineration. In the gasification zone, high temperatures are the rule. The hot gases produced are used for pre-heating the still unpyrolysed waste material, and are subsequently cooled down and pass through the dangerous temperature zone in which chlorinated hydrocarbons are formed.

All known pyrolysis processes on unsorted, loose and undrained waste material fail to provide a satisfactorily gas-permeable bed, require excessive energy costs with inadequate gas recovery and long dwell time in the reactor. Because of the heat flow and the internal gas pressure, large quantities of dust are produced which need a large filtration capacity. If water gas is produced, then it is necessary to add superheated steam generated separately, that is to say to introduce steam from outside. The remanent solid material is as a rule not melted but must be separately disposed of and in that regard it is comparable to a conventional refuse incinerator plant.

To produce an ecologically acceptable, usable pure gas, pyrolysis gases usually go through a cracking plant before washing. It is also known to utilise the internal heat energy of the hot gases by using a heat exchanger. This produces chlorinated hydrocarbons because of the dwell time of the gases in the heat exchanger, and these are released when the recovered gases are put to use for heating.

A substantial disadvantage of the use of shaft furnaces for refuse incineration is klinkering and bridging of the pyrolysing material in the furnace, so that such reactors are equipped with mechanical aids, such as poker bars, vibrators and the like, which have not so far, however, given a satisfactory solution to the problem.

Rotary drum and cyclone gasifiers, because of the mechanical wear on the furnace walls by the partly sharp-edged waste material, are subject to high downtimes, extremely high dust generation and require technically complicated, gas-tight sealing. This leads to substantial maintenance requirements with correspondingly high costs.

To avoid the disadvantages of the above-described refuse incineration and pyrolysis processes, it is also known to decompose waste materials and toxic substances over a mineral or metallic high temperature melt bath or to feed the waste into a melt bath in order to ensure a fast pyrolytic decomposition of the waste materials at high temperature. The main disadvantage of such a procedure is that liquid or wet waste cannot be used on account of the risk of explosion and that because of the high pressures generated the gases which form do not have a sufficiently long dwell time in the melt to decompose organic pollutants. Even with dried but undegassed organic waste the gas pressure from the decomposing organic matter is so high that it cannot have a sufficiently long dwell time. The melt products are saturated after a short time with carbon particles which cannot be oxidised because they are enclosed in the molten liquid, so that further addition of waste material is pointless.

In another known thermal refuse disposal process, mineral and metallic components are first separated from organic, the separated organics are dried and then pulverised. The resulting powder is fed into a high temperature melt bath or an incinerator at a suitable temperature and immediately decomposed, and thus the pollutants destroyed, by blowing in oxygen or oxygen-enriched air.

Although from an ecological standpoint, this process gives satisfactory results, it still has considerable disadvantages. For instance, liquid waste or other material in composite form cannot be dealt with. The resulting costs cannot be entertained.

The above described incineration and pyrolysis processes all suffer the disadvantage that liquids or solids evaporated during the incineration or pyrolitic decomposition are mixed with the gases produced by combustion or pyrolysis before they reach the temperature and dwell time in the reactor necessary for destroying all pollutants. The steam is not useful for making water gas. On that account, after-burning chambers are usually provided in incinerators and cracking stages in pyrolysis plants.

In the present invention is proposed a method of the aforementioned kind, which no matter what starting material is contained in the material to be disposed of, avoids the above referred to disadvantages, so that no harm at all can result to the environment and that at the same time valuable intermediate or finished industrial products with many and varied applications can be reclaimed from the residual materials while minimising the technical requirements and operating costs.

The invention comprises a method for processing waste materials of all desriptions, in which unsorted, untreated industrial, household and/or other specified refuse which may contain pollutants in solid and/or liquid state, as well as discarded industrial goods, are brought to a high temperature and undergo thermal decomposition or conversion and the resulting solid residues are converted to a high temperature melt with maximum energy benefit, characterised in that the product to be processed, unbroken or broken into large pieces, together with any liquid component present and without losing its heterogeneous and composite structure is batchwise compressed to compact packets which are fed into a channel heated to more than 100°C while being held together by maintaining the pressure loading thereon;

that the compacted material is held sliding in contact with the walls of the channel so as to keep it held together until any liquids initially present are vaporised and the internal mechanical restoring forces of the individual waste material components have been relaxed and the organic components have at least partially taken on the role of binder;

and that the shapewise and structurally stable solid conglomerate in this state, expressed in lumps from the channel, is fed into a high temperature reactor maintained at at least 1000°C over its entire volume.

Any originally present void space may be reduced to a minimum by the batchwise compaction of the waste material, for example discarded industrial products such as whole refrigerators, washing machines, electrical and electronic equipment, large parts of dismantled vehicles which still have a mixture of materials and composite structure, together with unsorted and untreated refuse and liquid waste, resulting in the solid copmponents being interlocked by mechanical forces and by their shape. Any excess liquids present may be forced together with the compact packets produced into an elongate, externally-heated channel, whereby to form a gas sealing plug at the entrance to the channel which takes on the function of closing the channel on account of being gas-tight. The liquids do not have to undergo any separate treatment, nor is there any need to heat up air, which has especially high thermal insulation, in the usual large volumes. The thermal conductivity of the compact packet made by the compaction step is substantially increased on account of its high metallic and mineral content and high density. A higher capacity for disposal can be achieved even in small installations, without requiring costly preparation treatments, such as separate collection and technically demanding preparation, shredding, splitting up, drying and briquetting.

For starting off the process it is further typical that the compact packets in question are forced into a channel heated to more than 100°C while being held together by maintaining the pressure loading thereon, in which they are held while gas pressure builds up in contact with the walls of the channel so as to hold it together only until the accompanying liquids and volatile substances are vaporised and the internal mechanical restoring forces of the individual components have been relieved and until the accompanying organic components have at least partially taken on the role of binder. Pyrolytic decomposition of the organic components in the channel does not take place in this process, though a partial decomposition can be quite desirable. It is sufficient to bind all the fine particles and produce shapewise and structurally stable lumpy agglomerates. At the start of the method according to the present invention, after a short dwell time of the waste material in the heated channel, a compact connected body is formed in which the fine particles and dust introduced with the waste material are bound, and with sufficiently rapid evolution of gas at the surface regions of the body with increased pressure a rapid heating through of the waste material is ensured and at least components of the organic constituents are so plasticised that the restoring forces of the components of the waste are relieved. With such contact with the walls as holds them together, the waste material packets and gases which continue to form in them pass through the heated channel in the process direction. The waste materials are thus stuck, sintered and bonded together and give off moisture so that dust- free, shapewise and structurally stable, lumpy agglomerates are formed by the exit from the channel. These lumpy solid agglomerates passing out of the end of the channel and falling into the shaft of a high temperature gasifier are the prerequisite for a gas-permeable, dust-free bed in the subsequent high temperature reactor and the complete high temperature gasification that is carried out there.

The thermally pretreated compact packets become, according to the invention, unpressurised as soon as they leave the heated channel and can be compared with briquettes in the high temperature gasifier. The high temperature reactor is characterised in that it is kept at at least 1000°C over its entire volume. Thus at least the organic components at the surfaces of the incoming compact packets or of lumps breaking off them are suddenly carbonised. The briquetted lumps form with their internal energy a loose, gas-permeable bed in the high temperature gasifier.

The gas permeable bed may be formed and maintained from the lumps of solid material within the high temperature reactor up to the level of the heated channel.

The level of the top of the bed of solid material may be kept constant so that immediately after emerging from the heated channel the organic components of the lumps of solid material are immediately pyrolytically decomposed at least in the outer regions.

The formation of explosive gas mixtures in the system as a whole is precluded by the thermal treatment in the channel. All the gaseous and solid waste materials stay long enough subject to high temperature processing for all thermally reactive pollutants to be completely destroyed. Because the organic components of the lumps of solid material at least in the outer regions are pyrolytically decomposed immediately upon entering the high temperature reactor, clumping of the material in the column, bridging and sticking to the reactor walls are avoided. Above the bed is formed a carbon-containing bed through which passes steam from the liquid carried with the compaction of the starting material which is formed in the heated channel.

The steam formed by the thermal treatment of the liquid components of the waste materials in the heated channel, discharged under high pressure from the channe, may be passed over the surface of the bed through the carbon containing fluidised bed which is formed there from the thermally decomposed, carbonised edge regions of the carbon lumps (water gas reaction)

The start of the water gas reaction is advantageously ensured by this, without any externally produced steam being required. The gas permeable bed constitutes the prerequisite for the simultaneous start of the known Boudouard reaction.

The carbon constituents in the solid material bed may be gasified to carbon dioxide by the measured addition of oxygen so that the carbon dioxide is converted to carbon monoxide as it passes through the carbon-containing solid material bed.

Since the high temperature reactor has a temperature of at least 1000°C even above the fluidised bed, through which all gases must pass with a sufficiently long dwell time, it is ensured that chlorinated hydrocarbons are destroyed and long chain hydrocarbons cracked. Chlorinated hydrocarbons may include dioxins and furans. The formation of condensates, such as tars and oils, is reliably prevented.

The pollutant-laden synthesis gas heated to at least 1000°C may undergo a shock-cooling with water immediately after leaving the high-temperature reactor (thereby precluding a *de novo* synthesis of dioxins and furans) down to below 100°C, rendering it dust-free.

The melting of the solid lumps with the high temperature reaction within the reactor proceeds preferably at temperatures around 2000°C or higher. These temperatures are produced by the carbon gasification with the addition of oxygen.

In the melting zone of the high temperature reactor below the solid bed, the inorganic components, that is to say, all glasses, metals and other minerals, are molten down. A portion of the heavy metals contained in the solid materials is in elemental form by the measured addition of oxygen in the reducing atmosphere and forms layers with other components of the melt. The molten liquid is run off and separated out if required.

If in the high temperature processing with an exothermic process the larger part of the pyrolysis coke is burned or all of the oxidisable components of the residual material are oxidised and the mineral components completely liquified, this takes place at temperatures of about 2000°C and above. The melt drawn off is characterised by a largely inhomogeneous structure, however, when unsorted waste material is used. Higher melting components, for example carbon and also certain metals, are still present in their solid aggregate state and form inclusions, so that it is pointless to try to use the residual slag products.

It is therefore particularly advantageous and of importance for the present process that the residual products present in molten state, which normally still amount to one per cent by volume of the original waste material, undergo an additional after-processing, in which they are subject to a thermal homogenizing process using the recovered synthesis gas. The melt here remains at temperatures around 1800°C in an oxidising atmospher until it becomes a degasified homogeneous high temperature melt. In a variation of the process, the inhomogeneous melt coming from the high temperature reactor is first vigorously mixed in a container or a thorough mixing can even result from the running off of the melt. A sufficient volume of melt in a continuous process can be drawn off during or after the refining process as a result of density separation and can if desired even be fractionated. With the high temperature melt, inhomogeneous structures are completely eliminated, so that the possibility of even long-term elution can be excluded. This high temperature melt is characterised by a complete conversion of material with respect to the whole of the original starting material.

It is of particular advantage that the present method is finally characterised in that the product from the high temperature melt may be processed into a broad range of valuable industrial goods or valuable intermediate products. From the melt, a valuable industrial product approximating to a naturally-occurring such product, can be manufactured utilising at least a substantial part of its internal energy, thus without intervening cooling down. For example, the melt can be spun into mineral fibres, but, in addition, valuable machine parts, such as gears or the like, can be made by casting processes from the melt. Known extrusion, pressing, moulding and/or expanding processes can be used for other valuable industrial goods. Insulating bodies with low specific weight can be made using blowing processes. The viscosity of the high temperature melt can be prescribed optimally depending on the product and process, whether the casting, spinning, extruding, pressing, moulding or expanding process.

The synthesis gas which is initially produced may be used for heating the channel and the high temperature reactor, for refining the melt and for running an oxygen-producing plant through gas engines or turbines.

The compaction of the waste material may be carried out at a time and/or place remote from the subsequent process steps and in such a manner as to form free-standing transportable, at least temporarily storable packs with low odour-level and substantially sterile and of predetermined shape and size.

With the above described process it is for the first time possible to have a universal method of disposal which is comprehensive and avoids the need for separate collection and preparation such as shredding, dividing up, drying and briquetting as well as for recycling the materials in question of all descriptions. The entrained liquids are used to yield energy by the water gas reaction, all of the gaseous, liquid and solid waste products being held so long in a high temperature reactor at a minimum temperature of more than 1000°C that all pollutants are thermally destroyed. The re-formation of chlorinated hydrocarbons is totally precluded by shock cooling of the gases and any remaining materials run off in the liquid state can with optional separation of the metal fractions be converted to valuable industrial products utilising their own internal energy.

CLAIMS

1. Method for processing waste materials of all desriptions, in which unsorted, untreated industrial, household and/or other specified refuse which may contain pollutants in solid and/or liquid state, as well as discarded industrial goods, are brought to a high temperature and undergo thermal decomposition or conversion and the resulting solid residues are converted to a high temperature melt with maximum energy benefit, characterised in that the waste materials to be processed, unbroken or broken into large pieces, together with any liquid component present and without losing its heterogeneous and composite structure is batchwise compressed to compact packets which are forced into a channel heated to more than 100°C while being held together by maintaining the pressure loading thereon;

that the compacted material is held in sliding contact with the walls of the channel so as to keep it held together until any liquids initially present are vaporised and the individual waste material components have been plasticized and any organic components have at least partially taken on the role of binding agent;

and that the shapewise and structurally stable solid conglomerate in this state, expressed in lumps from the channel, is fed into a high temperature reactor maintained at at least 1000°C over its entire volume.

2. Method according to claim 1, characterised in that any originally present void space is reduced to a minimum by the batchwise compacting of the waste material resulting in the solid components being interlocked by mechanical forces and by their shapes.

3. Method according to claim 1, characterised in that the structurally stable, solidified conglomerate expressed in lumps from the heated channel, dried and purged of light volatile components is immediately and directly introduced into the high temperature reactor.

4. Method according to claims 1 to 3, characterised in that a gas-permeable bed is formed and maintained from the lumps of solid material within the high temperature reactor up to the level of the heated channel.

5. Method according to claims 1 to 4, characterised in that the level of the top of the bed of solid material is kept constant, so that immediately after emerging from the heated channel the organic components of the lumps of solid material are immediately pyrolytically decomposed at least in the outer regions.

6. Method according to claims 1 to 5, characterised in that the carbon constituents in the solid material bed are gasified to carbon dioxide by the measured addition of oxygen, so that the carbon dioxide is converted to carbon monoxide as it passes through the carbon-containing solid material bed (Boudouard reaction).

7. Method according to claims 1 to 6, characterised in that the steam formed by the thermal treatment in the heated channel from the liquid components of the waste material therein, discharged under high pressure from the channel, is passed over the surface of the bed through the carbon containing fluidised bed which is formed there from the thermally decomposed, carbonised edge regions of the carbon lumps (water gas reaction).

8. Method according to claims 1 to 7, characterised in that all the chlorinated hydrocarbon compounds are decomposed in a zone above the fluidised bed heated to at least 1000°C, and long chain hydrocarbon compounds formed during the thermal decomposition of organic components are cracked while the formulation of condensates, such as tars and oils, is prevented.

9. A method according to claim 8 wherein the group of chlorinated hydrocarbons includes dioxins and furans

10. Method according to claims 1 to 9, characterised

in that pollutant-laden synthesis gas heated to at least 1000°C undergoes a shock cooling with water immediately after leaving the high temperature reactor (precluding a de-novo synthesis of dioxin and furan) down to below 100°C and rendered dust-free.

11. Method according to claims 1 to 10, characterised in that the metallic and mineral components formed in the gasification of carbon with oxygen are melted at temperatures above 2000°C and drawn off and separated in their liquid state by known separating processes.

12. Method according to claims 1 to 11, characterised in that the high temperature melt, principally mineral, remaining after the high temperature gasification is held in the liquid phase in an oxidising atmosphere until a completely refined, degasified and homogenous melt is produced with a composition approximating that of a naturally occurring such product.

13. Method according to claims 1 to 12, characterised in that valuable industrial products are made by extrusion, pressing, moulding and/or expanding processes on the homogenous high temperature melt utilising at least a substantial part of the energy contained in it.

14. Method according to claims 1 to 13, characterised in that the synthesis gas which is produced is used for

heating the channel and the high temperature reactor, for refining the melt and for running an oxygen-producing plant through gas engines or turbines.

15. Method according to claim 1, characterised in that the compaction of the waste material is carried out at a time and/or place remote from the subsequent process steps and in such a manner as to form free-standing transportable, at least temporarily storable packs with low odour-level and substantially sterile and of predetermined shape and size.

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