(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 071 080 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.06.2009 Bulletin 2009/25

(51) Int Cl.:
E01C 19/10 *(2006.01)*

(21) Application number: **08405298.4**

(22) Date of filing: **04.12.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(30) Priority: **11.12.2007 CH 19272007**

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(54) Method for upgrading and recovering energy from bituminous aggregates

(57) Method for upgrading and recovering energy from bituminous waste aggregates BWM by means of transfer of heat generated by the elements 6 which do not make direct contact with said bituminous waste aggregates BWM, where said material is situated in an oxygen-free environment.

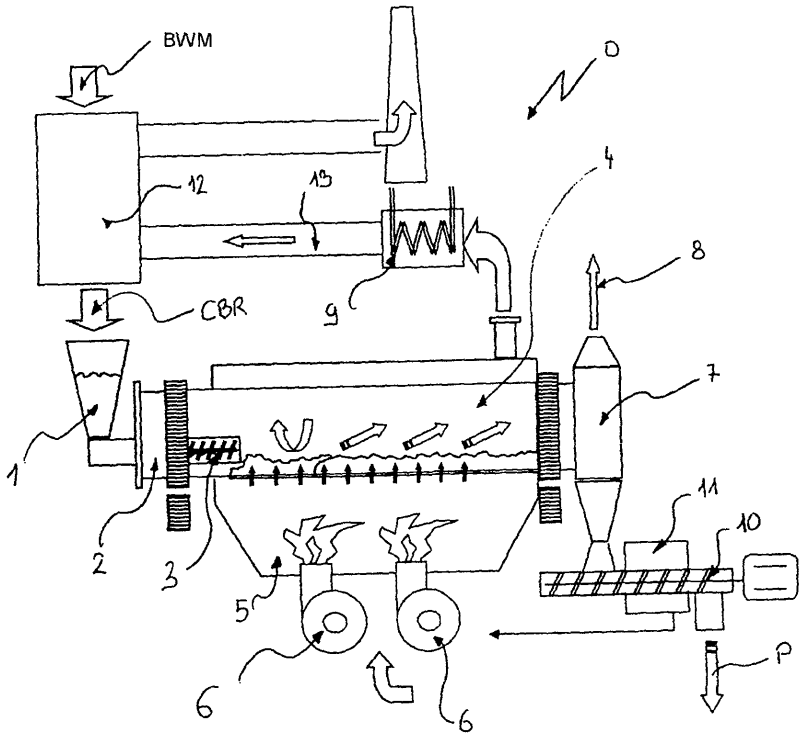

FIG. 1

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Description

[0001] The present invention relates to the sector of methods and plants used for converting, by means of a heat treatment, bituminous waste aggregates into materials which can be reutilised in the same field of application.

[0002] In the present description, by way of a non-limiting example the following are regarded as bituminous waste aggregates: the granular material obtained from milling and screening of road surfaces, bituminous residue and other waste from the production of road asphalt such as, for example, the end-of-production remainders, batches of unused asphalt, batches of road asphalt which do not satisfy the product specifications and therefore cannot be used and any other material which is composed of mixtures of mineral (for example calcareous or siliceous) aggregate and natural or petrochemical bitumen.

[0003] The present invention concerns a method for upgrading and recovering energy from bituminous aggregates as described in the preamble of Claim 1, as well as a means for implementing said method as described in Claim 5.

[0004] With the method according to the invention it is possible to convert the waste material mentioned in the second paragraph into the following products:

- a bituminous mixture of aggregate and bitumen having a temperature suitable for mixing with additives in order to generate a product which can be directly used and has superior characteristics;

- a bituminous mixture of aggregate and bitumen having a temperature suitable for its direct use as a new road surface layer with intermediate characteristics;

- a clean and tar-free aggregate which can be used as an aggregate for the preparation of new bituminous mixtures.

[0005] The use of bituminous waste mixes in the asphalt industry has already been known for some time. The aim of reusing said mixes is associated with the possibility of converting a waste material with its associated disposal costs into a sellable product.

[0006] At present the waste mix is recycled by mixing it in well-defined maximum percentage amounts with the virgin bitumen being produced. This recycling is therefore necessarily performed at the premises of an asphalt manufacturer, something which proves to be on occasions a disadvantage owing to the large distances involved and the costs for transportation of the waste mix and the dependency on the virgin asphalt manufacturer who may impose their own commercial and technical conditions. These restrictions are such that in practice most of the bituminous waste mix is not recycled, but is disposed of in a tip with the inevitable costs and consequences for the environment.

[0007] According to the most common and widespread practice there are two techniques for using the waste bituminous mix, which may be ideally distinguished depending on the associated quantity of recyclable waste.

[0008] Both the techniques are implemented on the apparatus normally used for production of virgin asphalt, i.e. using virgin materials such as quarry aggregate and natural bitumen or bitumen produced by petrochemical refineries.

[0009] In this type of known plant the virgin aggregate which will form part of the asphalt is heated inside a direct-flame rotating drum. The combustion fumes of the burner, which is situated at the top of the rotating drum, heat the aggregate material by means of direct contact. The fumes which pass through the drum are then extracted and conveyed to a bag filter which performs dedusting thereof.

[0010] The aggregate material thus heated is then transferred into a storage silo which is suitably heat-insulated.

[0011] At the time when the asphalt is required, the hot aggregate material is mixed together with the bitumen and any other additives and then discharged into the transportation means which will transport it to the place of use.

[0012] In connection with recycling of the bituminous waste mix the first possibility offered consists in adding the waste to the virgin aggregate and heating the two together inside the furnace.

[0013] This possibility is limited as regards the maximum quantity of waste which can be used and which usually may not exceed 30% in the mixture with the virgin aggregate.

[0014] This limitation is a consequence of the fact that heating is performed with a direct flame and the virgin aggregate must be heated to a temperature in the region of 150°C. Greater quantities of bituminous waste mix in the mixture with the aggregate results in large quantities of bitumen which, as a result of the heat and the burner flame, partly bums or at least generates volatile organic compounds which, not being retained by the bag filter, would be introduced into the atmosphere with consequent air pollution.

[0015] In the case where the fraction of bituminous waste mix in the mixture with the virgin aggregate must be increased, the current technology uses two drums in parallel. The two drums have an identical design: both of them are of the direct-flame type.

[0016] While one of the drums is used solely to heat the virgin aggregate, the second drum is used to heat solely the bituminous waste mix. While the first drum may operate at the normal working temperature, for example 150°C, the second drum, for the reasons already mentioned beforehand, is limited to a maximum temperature of 90°C.

[0017] Mixing of the aggregate and bituminous waste mix which are heated separately is then performed at the mixing stage during production of the asphalt.

[0018] The smoke point, i.e. the temperature at which a substance produces smoke, in the case of bitumen is around 180 - 200°C in an oxidizing atmosphere.

[0019] With this technology it is possible in theory to produce asphalt starting solely with waste mix and without the need for virgin aggregate. In practice this possibility is never used since the bitumen contained in the heated mix has nevertheless undergone partial oxidation which alters the physical characteristics thereof due to partial contact with the fumes and since the low exit temperature of the mix is such that the plant must produce asphalt of the "LEA" (warm) type, requiring therefore the addition of special additives which have a not insignificant cost.

[0020] The use of direct-flame heating also has the disadvantage of being very disadvantageous from an energy point of view, requiring a very high specific fuel consumption. High consumption is associated in particular with the fact that the combustion fumes exiting from the drum are still very hot and therefore still contain a lot of energy which can only be partly recovered.

[0021] In order to overcome these problems a technology for heating the mix using steam as the energy vector instead of a direct flame has appeared on the market. This technical solution is described in PCT/FI91/00221 which specifically cites the possibility of also heating only the bituminous waste mix.

[0022] The particular feature of this type of technology consists in the energy heating vector. In this case a burner which is physically separate from the receptacle containing the material to be heated is used. The combustion flame is cooled by means of the injection of water which vaporizes generating a mixture of combusted fumes and steam which is then used for actually heating the material.

[0023] To summarise, the current technology has the following disadvantages:

- The water to be used for vaporization must be necessarily demineralized in order to prevent the formation of calcareous deposits in the pipes between the burner and receptacle containing the material. In view of the necessary use of water, demineralization thereof is very costly.

- During the operational transients or during start-up of the plant, situations may arise where the vaporized water condenses in the material to be heated, wetting it and therefore rendering it no longer usable.

- The fumes/steam mixture supplied for heating the material still contains oxygen owing to the fact that the burner fumes always contain an excess amount of oxygen in order to ensure total combustion of the fuel. This oxygen may interact with the bitumen contained in the material to be heated, changing its characteristics.

- The mixture of fumes intermingled with steam, after preheating the material, is released into the atmosphere without any treatment. This flow could, in particular in the case of anomalous operating conditions, cause the introduction into the atmosphere of polluting substances and dust. With a cold or humid climate the emissions into the atmosphere may also cause visible plumes of vapour which could render this technology unsuitable for use in inhabited zones.

- The use of heat with the fumes/steam mixture, as in the case of direct-flame heating, involves a very high specific fuel consumption.

[0024] The object of the present invention is to provide a method for upgrading and recovering energy from bituminous aggregates which overcomes the abovementioned drawbacks and in particular results in a lower vapour emission, lower energy consumption and an improved thermal balance. The advantages will be described in detail in the description of the invention.

[0025] The invention, namely the method for upgrading bituminous aggregates, is now explained more fully with reference to the accompanying drawing which illustrates, in a side view, an embodiment of the method in question provided solely by way of a example which is non-limiting since technical variations may always be made without departing from the scope of the present invention.

In said drawing:

[0026] Figure 1 shows a diagram of the method for upgrading bituminous aggregates.

[0027] The bituminous waste mix to be treated is charged into the hopper 1 equipped with a compartment system which allows separation of the environment from the internal atmosphere of the apparatus.

[0028] Double-clapper unloaders, rotary valves or pairs of guillotines may be used as compartment systems. From the hopper a conveying system 3 such as, for example, a screw feeder, belt or vibrating chute performs continuous feeding to the heating drum 2.

[0029] The heating drum is kept constantly rotating and heated externally until temperatures of the drum surface ranging between about 200 and about 550° are obtained, depending on the process to be performed.

[0030] The material fed to the drum is deposited inside it and, as a result of its temperature inside the inner part 4 of the combustion chamber 5, is heated to the desired temperature. The material in the drum occupies only the bottom part of the volume: as a result of rotation the material is continuously churned, always bringing fresh material into contact with the wall, thus increasing the heat exchange effect and mixing thereof.

[0031] The final heating temperature of the material is regulated by simultaneously varying the amount being fed and the speed of rotation of the drum (control of the stay time) and the surface temperature of the drum (control of the heat exchange power).

[0032] The drum is inserted inside a large-size combustion chamber lined with refractory material 5. The combustion chamber contains one or more burners 6 operating with liquid or gas fuel such as methane gas, LPG, gas oil or LSC oils. The same burners, in the case where the method used envisages the production of aggregate, are designed to burn also the gases and vapours resulting from pyrolysis of the bitumen contained in the bituminous starting mixture. In order to increase the energy yield of the system, the combustion air of the burners may be preheated inside a heat exchanger arranged so as to intercept the discharge fumes of the apparatus 9.

[0033] Pyrolysis is a thermochemical deposition process which is obtained by means of the application of heat and with the complete absence of an oxidising agent, in this case oxygen.

[0034] While heating the material in the presence of oxygen results in combustion which generates heat and produces oxidised gaseous compounds, when performing instead the same heating process in conditions where, however, oxygen is totally absent the solid material is subject to division of the original chemical bonds with the formation of simpler molecules in gaseous form.

[0035] The exchange of heat between the combustion fumes and the drum is mainly due to irradiation effects hence the need for a large-size refractory chamber in order to increase the irradiating state thickness and the re-irradiation effect.

[0036] The combustion fumes may be used to dry or pre-heat the mix or for other direct uses or may be passed through an exchanger 9 preferably used to preheat the combustion air of the burners 6 or else for other heat-related functions, for example in order to produce process steam, heating water or the like.

[0037] Depending on the process temperatures, heating of the mix may result in the formation of vapours and gases. At low heating temperatures, typically below 150°C, these are not formed so that the outlet 8 is solely composed of a flue for discharge into the atmosphere.

[0038] At higher temperatures, gases and vapours are formed, in particular in the case where said temperatures are within the pyrolysis range. In this case the outlet is combined with a device for suction of said vapours and gases, such as ventilators, blowers or Venturi ejectors. The suction device is regulated so as to keep the discharge hopper 8 and therefore the inside of the drum 4 always under a vacuum at the desired value (a few mbar). The vacuum is necessary in order to prevent part of the gases and vapours from being able to seep outside of the apparatus through the rotary seals with the consequent risk of fire or damage to objects or persons. The gases and vapours thus drawn off, having a high calorific power, are then conveyed to the burners 6 which are installed inside the combustion chamber 5, supplementing or replacing entirely the use of the primary fuel (natural gas, gas oil, or the like).

[0039] The evaluation of the energy contribution of the gases and vapours to the overall consumption of the apparatus depends greatly on the characteristics of the incoming bituminous waste mix, and can be determined in particular depending on its bitumen content and its moisture level.

[0040] The material, once it has reached the desired temperature, is then extracted from the apparatus from the bottom of the hopper 7 via a conveying system 10 such as, for example, a screw feeder, Redler conveyor or conveyor belt. Like the inlet, the outlet also has a compartment system of the same type.

[0041] In the case where the apparatus is used for the production of aggregate and in view of the high temperatures to which the material must be heated, the outlet system is also provided with a system for cooling the aggregate produced 11. The type of cooler depends on the conveying system used. In the example of the screw feeder, the latter is enclosed inside a duct through which the cooling fluid (for example air or water) is passed. The recovered heat may be used in a manner similar to the heat recovered from the combustion fumes of the apparatus.

[0042] In the case where the mix is heated to the pyrolysis temperatures, the aggregate produced also contains the residual carbon part resulting from pyrolysis. As already described previously said carbon part is, compared to the bitumen fraction converted into gas and vapour, of a limited amount. Essentially the carbon partly takes the form of a layer which covers the aggregate and partly takes the form of dust particles mixed with the aggregate as a result of rolling of the material inside the drum.

[0043] Normally the quantity of carbon contained in the aggregate does not create problems, but, if necessary, it is possible to separate it and extract it downstream of the apparatus according to the invention by means of screening.

[0044] The main advantages of the method according to the invention compared to the solutions currently known are now explained in detail.

[0045] The bituminous mix is heated in a controlled and inert atmosphere. Any bituminous vapours which may form

at high heating temperatures remain "pure" and in continuous contact with the material, therefore ensuring conditions which are ideal for maintaining the characteristics of the bitumen.

[0046] The bituminous mix is heated more slowly, thus avoiding the high temperature gradients which instead occur in the case of direct heating.

[0047] In fact, with direct heating, high temperatures tend to exist on the surface of the particles, while the temperatures are substantially lower at the centre of the latter. Since the bitumen is deposited on the surface of the particles, the result is that, although the particles have a relatively low average temperature which is below the smoke point and flammability point of the bitumen, in reality the surface temperature is substantially higher.

[0048] The throughput of any vapours produced during heating is substantially smaller than the throughput of vapours, smoke or any steam obtained in the case of direct fluid or flame heating. This results in a smoke-treatment system which is simpler, less costly and optimised only on the basis of the characteristics of the vapours to be treated.

[0049] As regards the heating fumes, in the case where natural gas or gas oil burners are used, no type of treatment is instead required since these burners are designed to comply with the emission limits (systems with a low emission of NOx, catalytic combustion systems, etc.) and at the same time ensure high combustion yield values.

[0050] The thermal balance of the heating process is substantially better than that of the existing technologies. In the case of heating systems based on a direct flame or with a mixture of fumes and steam, the combustion temperature must kept below certain limits in order to prevent burning of the bitumen. The heat exchange efficiency may be calculated in a simple manner, for example:

$$\frac{\text{Inlet T fumes material to be heated - Outlet T fumes from the material}}{\text{Inlet T fumes material to be heated - Surround. T}} * 100 = \eta$$

[0051] In the case, for example, of heating with a mixture of fumes/steam and assuming a fumes inlet temperature in the material of 350°C and fumes outlet temperature of 150°C with a surrounding temperature of 20°C, the thermodynamic heating efficiency becomes: $\eta = (350-150)/(350-20) * 100 = 60.6\%$.

[0052] In the case of the present invention, since the heat exchange occurs indirectly, it is possible to use combustion fumes at 1200°C. The temperature of the fumes at the outlet of the apparatus according to the invention is normally around 250-350°C.

[0053] Recalculating as above the heat exchange efficiency, in the worst possible case the following is obtained:

$$\eta = (1200-350)/(1200-20) * 100 = 72\%,$$

therefore 12% greater than in the previous case.

[0054] A possibility offered by the present invention relates to the production of aggregate using the bituminous waste mix as starting material. This is possible using heating temperatures of around 350-450°C. At these temperatures the bituminous fraction contained in the mix is converted by means of pyrolysis into gas/vapours and carbon. The largest part of the pyrolysis products consists in the gas and vapours fraction which also contains most of the calorific power of the bitumen.

[0055] With indirect heating this gaseous flow does not come into contact with flames and with oxygen so that it may be extracted from the apparatus according to the invention and used as a combustible gas for heating in place of or at least as a supplement to the primary fuel (natural gas or gas oil).

[0056] By exploiting the energy content of bitumen it is therefore possible to reduce substantially the specific energy consumption of the plant.

Claims

1. Method for upgrading bituminous aggregates in a reutilizable product (P) comprising as a starting material for said method a bituminous waste mix (BWM), said method comprising charging said mix (BWM) inside a rotating drum (2) where it is heated,
   characterized in that
   the bituminous waste mix (BWM) is charged inside the rotating drum (2) so as to be situated in an oxygen-free environment, inside the rotating drum (2) said mix is heated to a temperature of at least 300°C by means of heat

transfer from one or more heating elements (6) which are situated outside said rotating drum (2), so that they are not in direct contact with the bituminous waste mix (BWM), said temperature of at least 300°C is able to generate a process involving pyrolysis of the bitumen contained in the bituminous waste mix (BWM).

2. Method according to Claim 1, in which the gases and the vapours generated inside the rotating drum (2) by said method are recovered by means of special conveying means (13) and used as fuel for generating the heat necessary for heating the bituminous waste mix (BWM).

3. Method according to one of the preceding claims, in which the gases and the vapours generated inside the rotating drum (2) by said method are made to pass through a heat exchanger (9).

4. Method according to one of the preceding claims, in which the gases and vapours generated inside the rotating drum (2) by said method are used for pre-heating or drying the bituminous waste mix (2) before heating inside the rotating drum (2).

5. Device (D) for implementing the method according to one of the preceding claims, comprising a feeding device which conveys the bituminous waste mix (BWM) inside a rotating drum (2)
characterized in that
the rotating drum (2) is housed inside a chamber which is thermally insulated and lined internally with refractory material (5).

6. Device according to Claim 5, where said device is provided with means for hermetically sealed extraction of the treated material (7), designed to separate the solid product from the air products (8).

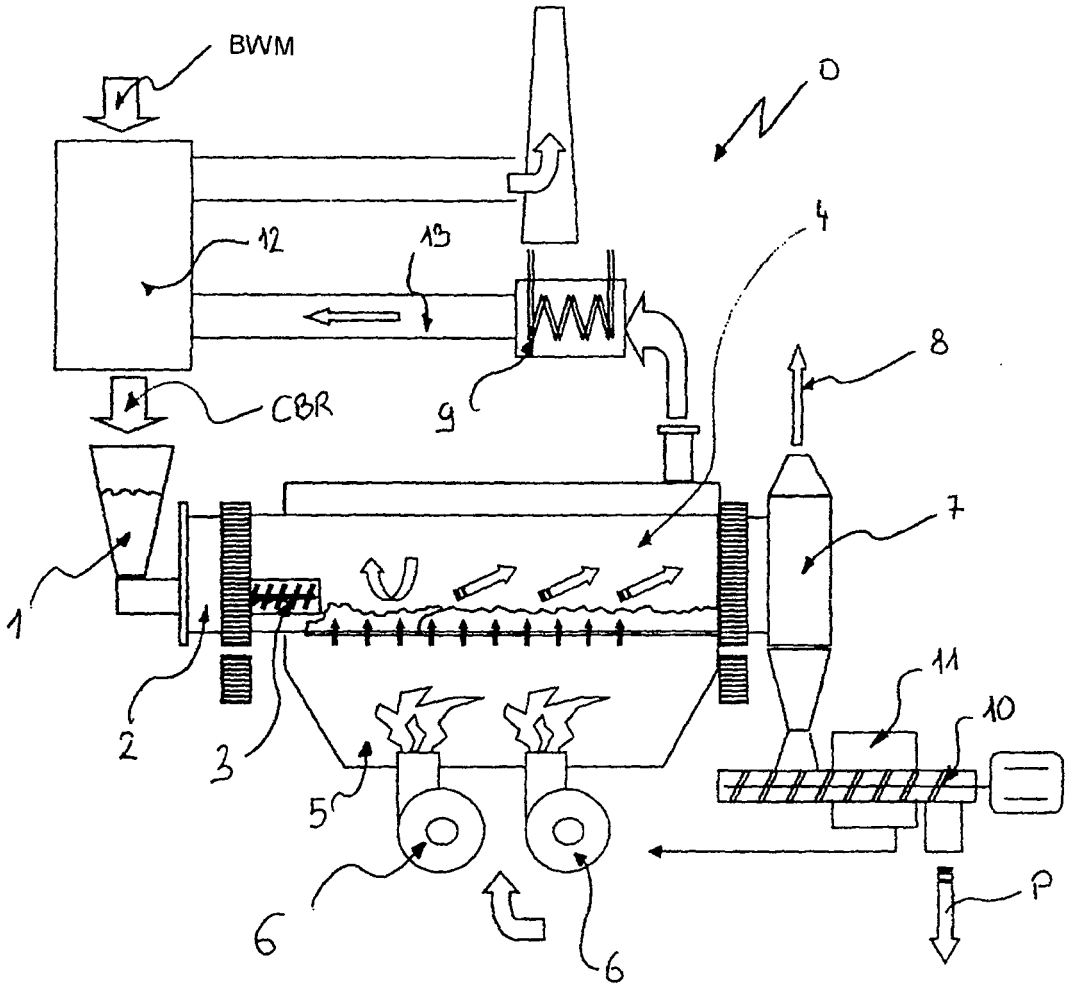

FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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