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(54) Peat composition and their manufacture.

(57) A process for the removal of water from a wet material comprising combustible organic solids to form a solid autothermally combustible fuel comprises the steps of contacting the material with a dewatering liquid comprising a water-immiscible solvent and dissolved water-in-oil emulsifier and then extracting a water-in-oil emulsion from the mixture wherein the wet material is preferably pre-treated with an absorbent material comprising a water swellable polymer to effect preliminary drying of the wet material.

PEAT COMPOSITIONS AND THEIR MANUFACTURE

Large natural resources of raw peat are potentially a very rich source of fuel. At present however, the problems of dewatering raw peat to a solids level at which the peat is autothermally combustible have the result that peat is not widely available as a fuel for commercial use.

The usual way of dewatering peat involves filtering under pressure but unfortunately filtration is difficult to perform and in practice cannot reduce the water content sufficient to render the peat authothermally combustible (eg not more than about 60% water).

Dewatering of peat can also be carried out by a process in which peat is disentangled by subjecting it to a breaking step, for instance in a conventional peat breaker. The disentangled peat is then slurried in water containing a flocculating agent and is then filtered. Filtration can be under pressure, for instance in a pressure filter for instance a belt press.

Existing processes for drying peat have either failed to give sufficiently low water content or have used so much energy that they are inefficient.

A process according to the present invention for the removal of water from a wet material comprising combustible organic solid to form a solid autothermally combustible fuel comprises the steps of contacting the material with a dewatering liquid comprising a water-immiscible solvent and dissolved water-in-oil emulsifier and then extracting a water-in-oil emulsion from the mixture.

The process of the invention is particularly suited for the dewatering of peat to render it sufficiently dry to be useful as a fuel, although it may also be useful for drying other wet organic solids to be subsequently used as fuels.

We have found that by carrying out the process of the invention water which remains in wet materials such as peat, even after conventional drying processes, can be removed to form a product which has a calorific value which renders it suitable for use as a fuel.

In the process, in order to maximise the efficiency of the process, the emulsion that is extracted from the mixture is cracked into a solvent layer and aqueous layer, and the solvent is recovered and recycled into the contacting step. Cracking of the emulsion may be carried out by known means, for instance by changing the pH, usually by acidifying the emulsion and also includes the addition of a common salt eg calcium chloride. Any debris which remains at the interfacial layer is in general discarded. In a recycling process, although the recycled solvent may contain some residual emulsifier, in general it is necessary to add more emulsifier to the solvent to form a satisfactory dewatering liquid. Furthermore, since some solvent is discarded with the aqueous layer and interfacial layer, and some is retained in the product, it is necessary to continuously add solvent in the recycle process. Usually at least 50%, preferably at least 75% and more preferably more than 80%, for instance up to 90%, of the solvent is recycled. Sometimes it may be desirable to clean the solvent after use in several cycles to remove undesirable components dissolved in the solvent. The solvent may, for instance be distilled.

The contacting step is generally in the form of slurrying, and is carried out in a vessel with stirring in order to ensure satisfactory mixing of the components. A suitable mixing device is a Heidolph stirrer, for instance used at a setting of 250 to 300 rpm. Preferably the mixer is fitted with a paddle stirrer to promote good contact of components, rather than intense shear. The time of mixing is sufficient to ensure good mixing and is preferably at least one or two minutes, and generally does not need to be more than about 60 minutes, usually less than 30 minutes, for instance 5 to 20 minutes. Were the resultant slurry subjected to a higher rate of stirring or shear, then the time may be less. It is in general found that it is not advantageous, or is even disadvantageous, to prolong the shearing period or to increase the intensity of mixing beyond the minimum required for good contact of the components.

The extraction of the emulsion from the mixture is in general carried out by the processes of the type used for dewatering aqueous flocculated peat slurries. The extraction thus generally includes filtration, preferably pressure filtration, for instance on a belt press. The material is suitably subjected to a pressure of at least 5 bar, preferably at least 10 bar for instance about 15 bar.

The wet material, which is usually peat, which is subjected to the defined steps of the present invention, has preferably already been subjected to a preliminary drying step or a plurality of such steps. For instance peat may be subjected to the conventional slurrying in water containing a flocculant followed by pressure filtration. The process of the invention also covers processes including such a preliminary step.

Alternatively or additionally the peat may be dried in a preliminary step by contact with absorbent materials, capable of absorbing the moisture. Such materials are subsequently removed from the peat. Examples of suitable materials are for instance water-swellable insoluble polymer particles. Suitable polymers are described in GB 1,573,201 and, are preferably of the type described in EP-A-0,195,550. Such polymer particles are for instance used by mixing disentangled peat with polymer particles and then separating the swollen polymer by sieving the mixture.

The material that has had the emulsion extracted may be subjected to a subsequent further drying step, or other treatment step, for instance to remove further solvent if desired. Such further steps include evaporation of water and/or solvent eg by heating.

The peat, or other wet material, generally has a water content of less than 90%, preferably less than 80%, more preferably less than 70% by weight prior to the step of slurrying in the dewatering liquid. Preferably the moisture content of the material after extraction of the water-in-oil emulsion is less than 80%, preferably less than 70%, and more preferably less than 60%. In general the amount of water which is removed from the wet material by the dewatering liquid at least 10%, preferably at least 20%, and even up to 25, 30 or more % of the total water present in the material before the contacting step.

It is preferred to minimise the amount of solvent remaining in the fuel and the amount of the solvent in the fuel is preferably less than 20% by weight, more preferably less than 15% by weight.

Solvents which are useful in the present invention are hydrocarbon solvents, generally petroleum solvents or other non polar solvents. The solvents should have as low a volatility as possible to minimise problems with handling the dried material. On the other hand the solvent should have a low viscosity in order to improve the amount of emulsion which can be extracted from the product and to give easier handling of the mixture during the process. Preferred solvents are kerosenes. Kerosenes consist of petroleum hydrocarbons having about 10 to 60 carbon atoms per molecule. Examples of preferred kerosenes include Exxol D240/270, Solvent 41 and SBP11.

The emulsifier can be any water-in-oil emulsifier which is soluble in the solvent and which is capable of forming an emulsion in the contacting process. Suitable emulsifiers are nonionic surface active agents, for instance fatty acid esters. Preferred emulsifiers include nonyl phenol-ethylene oxide condensate (Span 80) and sorbitan mono-oleate (Montane 80). The emulsifier is used in the dewatering liquid in a sufficient amount for emulsification of the water. The amount should be at least 0.1%, preferably at least 0.5% (by weight) based on the amount of solvent plus emulsifier. In general it is unnecessary to add more than around 10, or even more than 5%.

The dewatering liquid can contain other components in addition to the solvent and emulsifier. Such additives may be for altering the viscosity of the liquid and/or emulsion or for adding formation or cracking of the emulsion. The liquid may even include water and may therefore be an emulsion itself, such emulsions have been found to act as dewatering liquids.

The dewatering liquid is generally added to the wet material to give a ratio of wet material:liquid in the range of 1:1 to 1:10 (weight/kg:volume/l), preferably 1:2 to 1:5.

An alternative method of contacting, other than by slurrying, is by spraying the wet material with the dewatering liquid. The solvent is allowed to drain through the wet material, which is then pressed to remove water and excess solvent. Solvent can be recovered from the process by acid cracking, as described earlier, and can be re-cycled.

The process can be carried out on either small scale or large scale. An alternative large scale route would be a batch conditioning system.

Example 1

50 gram samples of wet peat (varying dry solids contents, DS) were slurried in 200 ml of a mixture of kerosene (Exxol D240/270) containing 5% Span 80 emulsifier. The slurry was mixed on a Heidolph at setting 0 (280 rpm) for 20 minutes before subjecting to pressure in a laboratory press. In each case a filtrate was removed (around 160 ml) and the final composition of the product assessed.

The peat having the higher dry solids content had previously been dried using water-absorbent polymer. The results are shown in Table 1 below.

TABLE 1

Test		1	2	3
Emulsifier present		No	Yes	Yes
DS of Starting material (% wt)		23.2	23.2	38.0
Product Composition % wt	DS	25.4	21.7	28.9
	Water	48.0	46.0	32.0
	Kerosene	26.6	32.3	39.1

In tests 2 and 3 the filtrate had a hazy white appearance indicating that it is an emulsion. The results show that for Example 2, which is carried out according to the invention, the water:dry solids ratio is reduced from 3.3:1 to 2.1:1, indicating substantial displacement of water. Furthermore in test 3 which is also carried out according to the invention the water:dry solids ratio is increased from 1.6:1 to 1.1:1 again indicating substantial displacement of water. In test 1 where the kerosene contained no dissolved emulsifier, there appeared to be an increase in the water:dry solids ratio but this is probably an error and the results show that there is certainly practically no removal of water. In that example the liquid extracted from the slurry was virtually clear, with a very small amount of water at the base of the container in which it was collected.

Carrying out similar tests using other kerosenes, including Exxol 21, Spindle oil 50 and S41, all show similar improvement. Spindle oil 50 was least preferred since it is more viscous.

Example 2

The effect of more intense agitation on the slurry was investigated in this example.

95ml of S41 and 5ml Span 80 were added to each of 5 x 25g samples of peat (DS 38.7%).

Each of the samples were mixed as below:

1. Heidolph setting 'O' (~280 rpm) - 5 mins.
2. Heidolph setting 'O' (~280 rpm) - 20 mins.
3. Moulinex high-speed blender - 30 s
4. Moulinex high-speed blender - 60 s
5. Heidolph for 5 mins. then Moulinex for 30s

After pressing to dryness as in Example 1, the compositions of the final products were assessed. The results are shown in Table 2.

TABLE 2

Test No.	Percentage Composition			Wt Ratio Composition		
	DS	Water	Kerosene	DS	Water	Kerosene
1	40.0	43.5	16.5	1.00	1.09	0.41
2	39.5	47.0	13.5	1.00	1.19	0.34
3	38.3	47.0	14.7	1.00	1.23	0.38
4	37.7	48.0	14.3	1.00	1.27	0.38
5	39.0	43.0	17.9	1.00	1.10	0.46

These results show that no improvement in product dryness was obtained from use of longer or more intense mixing. In fact, from the appearance of the filtrates increased mixing seemed to be detrimental to the water/oil emulsification process.

Example 3

It was found that the water/oil emulsions formed during the process could be 'cracked' by the addition of conc. sulphuric acid. This produced a large amount of clear kerosene and a small amount of separated water (including the acid) with a thin layer of sludge at the kerosene/water interface. If the process is to be cost effective the kerosene should be reusable. An experiment was therefore carried out to determine the viability of recyling the kerosene.

Thus, 25g of peat (DS 37.8%) was slurried in 100ml of 'recovered' S41 and mixed on the Heidolph stirrer at setting 'O' for 5 minutes. Another sample of the same peat was slurried in a mixture of 98 ml S41 and 2 ml Span 80 before mixing in the same way. After separation of oil/water phase in the laboratory piston presses at 15 bar, the compositions of the final products were:

TABLE 3

Addition of Emulsifier	Percentage Composition			Wt ratio Composition		
	DS	Water	Kerosene	DS	Water	Kerosene
No further add^n	40.3	52.4	7.3	1.00	1.30	0.18
2% additional Span 80	41.6	50.0	8.4	1.00	1.20	0.20

The filtrate from the first sample was hazy pale yellow in colour and contained a few droplets of water. The sample containing extra emulsifier, however, gave a white, homogeneous filtrate.

It is evident from the result that although the recovered S41 does apparently contain a small amount of emulsifier, extra will have to be added in order to maintain the effectiveness of the process. However, the principle of reusing the recovered kerosene is confirmed. It was found that 87-90% of the solvent could be recycled.

Example 4

Comparative tests conducted on peat samples of DS 10.8, 23.1 and 38.4% gave the following results:

TABLE 4

Initial DS (%)	Percentage Composition			Wt. Ratio Composition		
	DS	Water	Kerosene	DS	Water	Kerosene
10.8	33.0	56.0	11.0	1.00	1.70	0.33
23.1	36.4	49.0	14.6	1.00	1.35	0.40
38.4	46.9	45.0	11.1	1.00	1.03	0.25

Thus, analysis done on the final products showed a significant increase in moisture content in line with the increase in moisture content of the starting material. This trend was much as expected.

The calorific value of the product of the test used on the DS 38.4 sample was calculated using the following figures:
Calorific value of peat (DCM) 18-25 MJ per kg.
Calorific value of kerosene = 36.4 MJ per kg.
From these values and the heat capacity and heat of vapourisation of water, the net calorific value of the peat is on average around 12.7 MJ per kg product. This compares well with coal, which has a calorific value of 16.75 MJ per kg.

Example 5

1 Kg. of high-humified Sphagnum raw peat from Sweden (DS 11.02%) was diluted with 3 litres of water to give a slurry of dry solids 2.49%.

400g. aliquots were treated with a 80:20 DMAEAgMeC1:ACM liquid dispersion copolymer before dewatering under pressure in the laboratory piston presses.

The dry solids of the combined products was found to be 28.16%.

A 50 g. sample of the dewatered peat was slurried in 200 cm^3 of a mixture of solvent (SBP11) containing 5% Span 80 emulsifier. The slurry was mixed on the Heidolph stirrer at setting 0 for 5 minutes before pressing on the lab. piston press at 15 bar. The composition of the final product was:-

TABLE 5

	DS	Water	Kerosene
Percentage Compn.	37.12	48.0	14.88
Wt Ratio Compn	1	1.29	0.40

The technique can be applied to sewage sludge and other organic slurries, as illustrated in Example 6 below:

Example 6

50g of primary sludge (DS 30.03%) was slurried in 200 cm^3 of a mixture of solvent (SBP11) containing 5% emuslifier (Montane 80). The slurry was mixed on the Heidolph stirrer for 20 minutes before pressing on the lab. piston press at 15 bar. The composition of the final product was:-

TABLE 6

	DS	Water	Kerosene
Percentage Compn	32.15	57.0	10.85
Wt. Ratio Compn	1	1.77	0.34

Claims

1. A process for the removal of water from a wet material comprising combustible organic solid to form a solid autothermally combustible fuel comprises the steps of contacting the material with a de-watering liquid comprising a water-immiscible solvent and dissolved water-in-oil emulsifer and then extracting a water-in-oil emulsion from the mixture.

2. A process according to any claim 1 wherein the water-immiscible solvent comprises a hydrocarbon solvent.

3. A process according to claim 2 wherein the water-immiscible solvent is a kerosene.

4. A process according to any preceding claim wherein the emulsifier is a non-ionic surface active agent preferably selected from the group comprising fatty acid esters.

5. A process according to any preceding claim wherein the amount of emulsifier is at least 0.1% by weight , and preferably at least 0.5% by weight, of the total amount of solvent and emulsifier.

6. A process according to any preceding claim wherein the de-watering liquid is added to the wet material to give a ratio of wet material:liquid comprised in the range from 1:1 to 1:10 by weight(kg):volume (l), and preferably comprised in the range from 1:2 to 1:5.

7. A process according to any preceding claim wherein the wet material has a water content less than 90%, preferably less than 80% and more preferably less than 70% by weight prior to contacting the de-watering liquid.

8. A process according to any preceding claim further comprising at least one preliminary drying step for the wet material.

9. A process according to claim 8 wherein the drying step comprises slurrying the wet material in water containing a flocculant followed by pressure filtration.

10. A process according to claims 8 or 9 wherein the drying step comprises contacting the wet material with absorbent material.

11. A process according to claim 10 wherein the absorbent material comprises water-swellable, insoluble polymer particles.

12. A process according to claim 11 wherein the polymer particles are separated from the dried material by sieving.

13. A process according to any preceding claim wherein the dewatering liquid is contacted with the wet material by slurrying using a paddle mixer.

14. A process according to claim 13 wherein the time period for mixing is at least 1 or 2 minutes and not more than 60 minutes, and is preferably in the range 5 to 20 minutes.

15. A process according to any preceding claim wherein the emulsion is subsequently cracked and the solvent recycled.

16. A process according to claim 1 wherein contacting comprises spraying the wet material with a dewatering liquid as defined in any preceding claim and allowing the solvent to drain through the wet material, which is then pressed to remove water and excess solvent.

17. A process according to any preceding claim wherein the wet material is wet peat.