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(54) **COAL PASTE FOR USE AS FUEL AND METHODS OF USING SAME**

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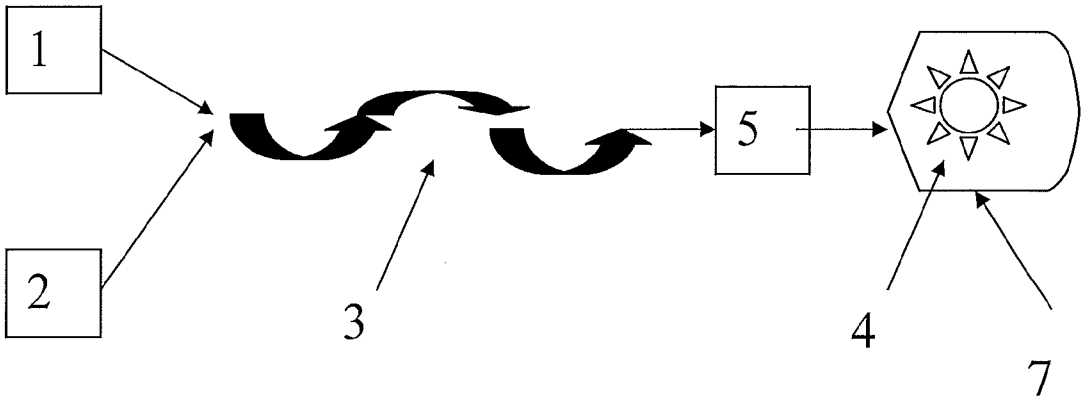
(57) **ABSTRACT**

The present invention relates to the use of coal to form a paste that can be used as a fuel or incorporated with other fillers to form pellets or briquettes. The paste is formed from crushed or powdered coal mixed in a liquid fuel and may be used as is or may be mixed with a carrier fuel prior to combustion or it could be mixed with other biomass fillers to produce a solid fuel.



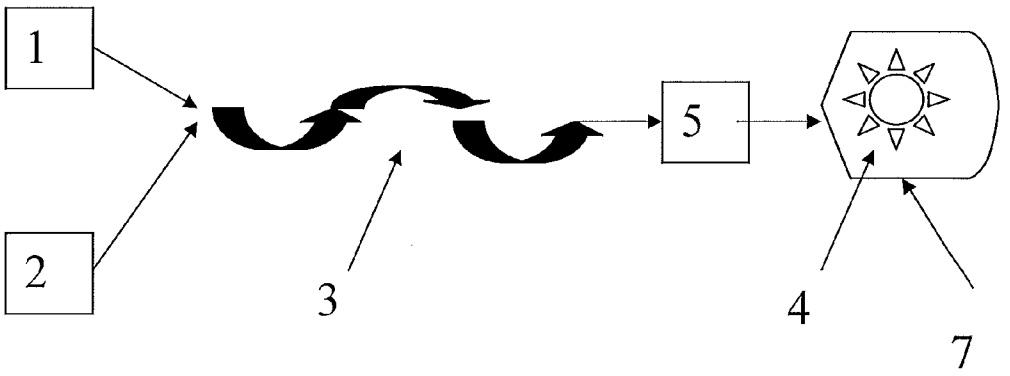


Figure 1

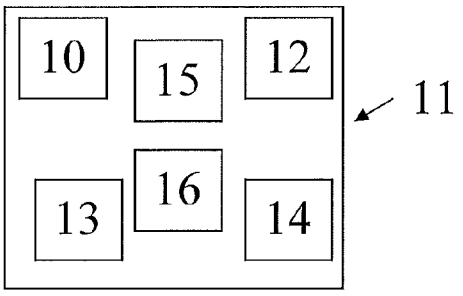


Figure 2

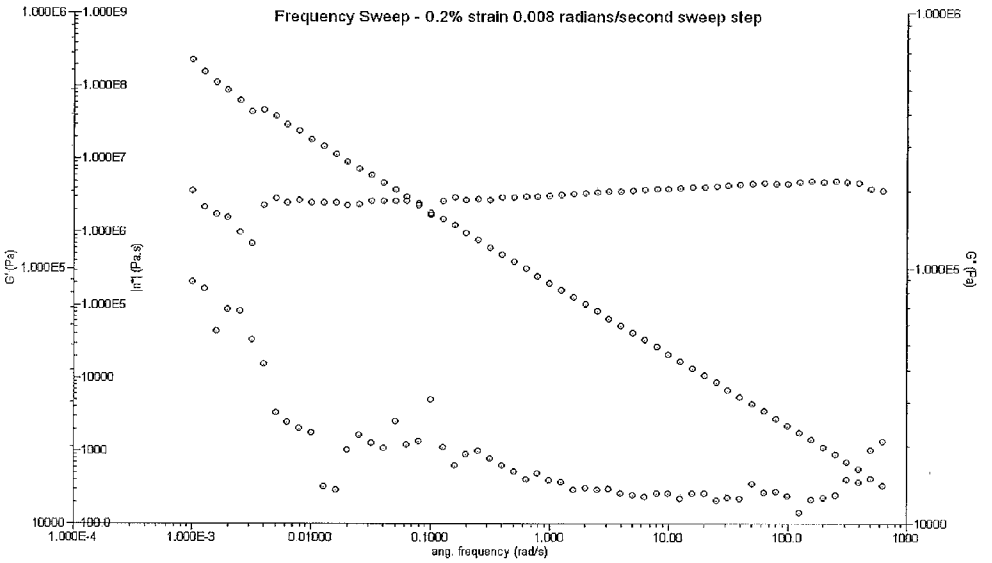


Figure 3

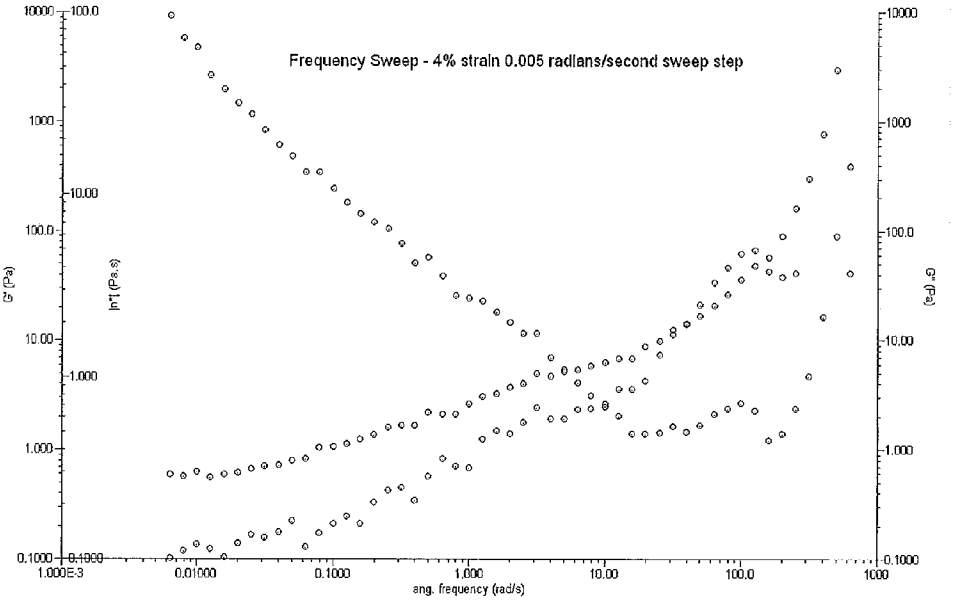


Figure 4

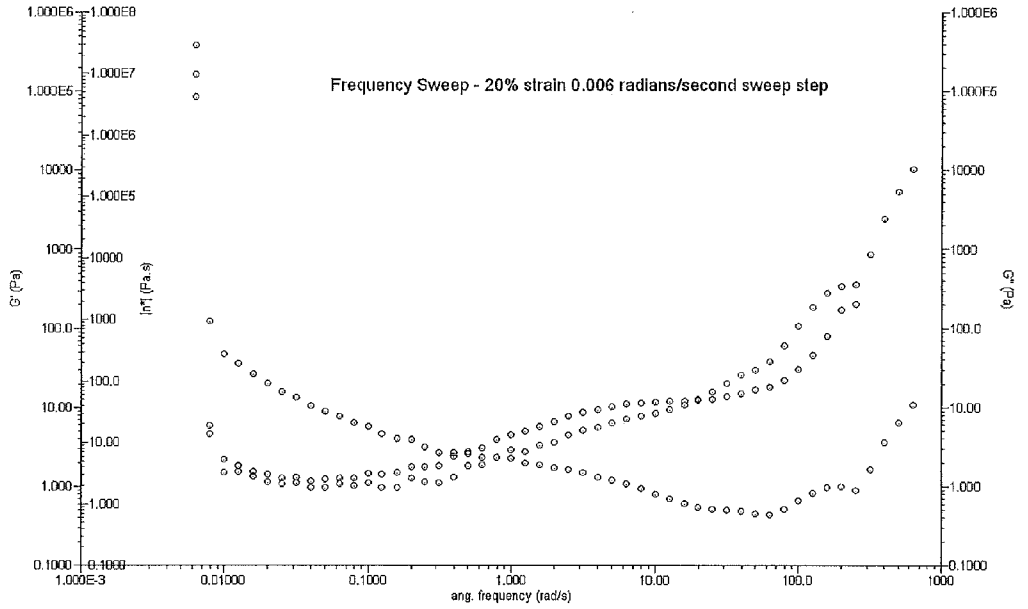


Figure 5

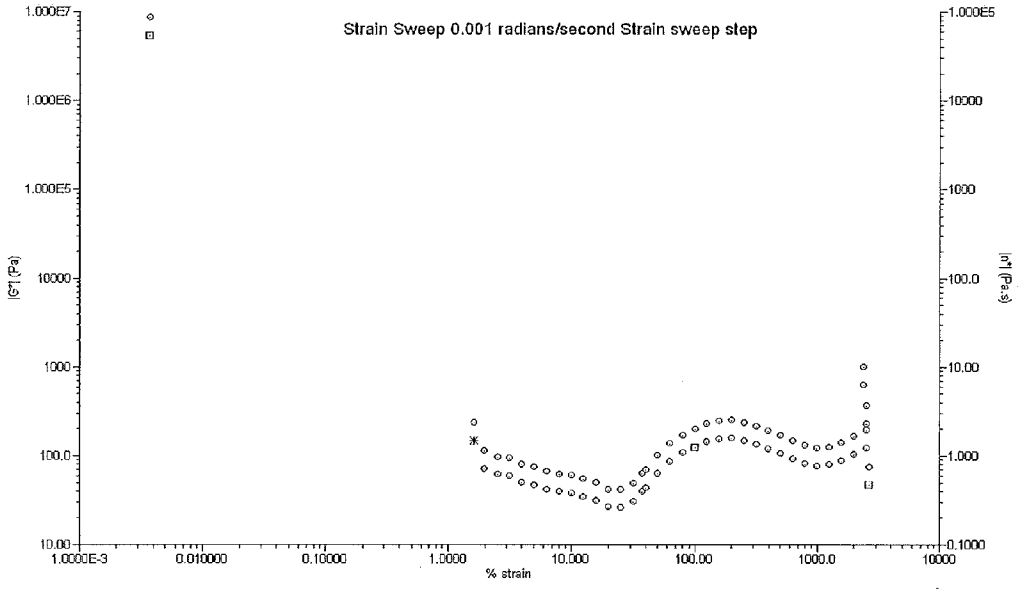
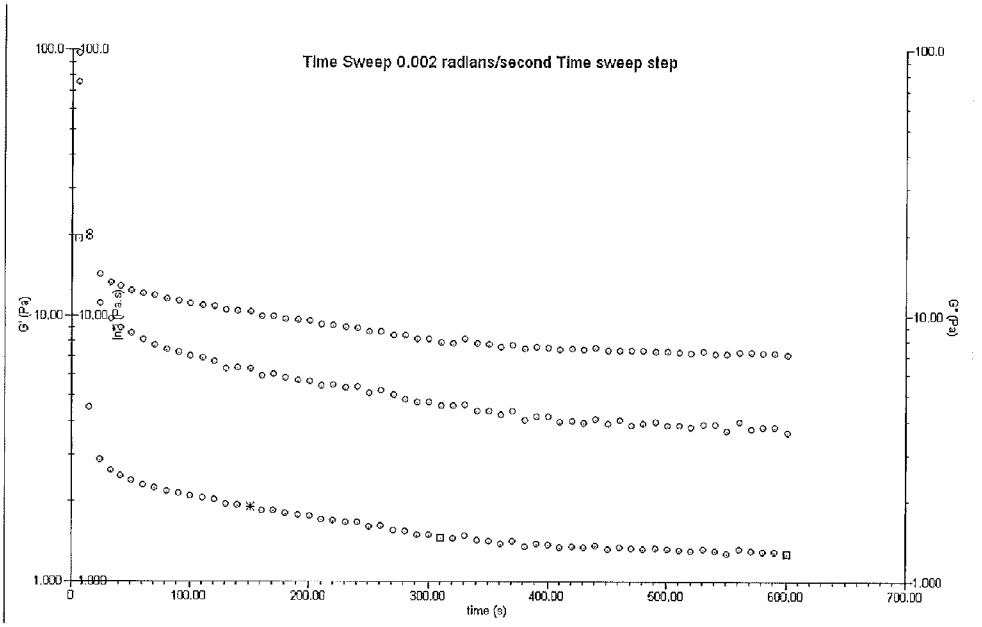


Figure 6


Time Sweep 0.002 radians/second Time sweep step
100.0
10.00
1.000
G' (Pa)
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10.00
1.000
G" (Pa)
0
100.00
200.00
300.00
400.00
500.00
600.00
700.00
time (s)

Figure 7

COAL PASTE FOR USE AS FUEL AND METHODS OF USING SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to the use of coal in devices that use liquid fuel so the use of liquid fuels is partially offset by the use of coal. More particularly, the invention relates to using a paste composed of coal, binder, surfactant and the liquid fuel which may be used in place of fuel which is entirely liquid such as gasoline, diesel, oil, and ethanol or converted into a solid pellet. The paste is formed from crushed or powdered coal mixed in a liquid fuel and may be used as is or may be mixed with a carrier fuel prior to combustion or it could be mixed with other biomass fillers to produce a solid fuel.

[0003] 2. Description of Related Art

Definitions

[0004] As used herein, "paste" is a thick viscous fluid such as a semi-liquid colloidal suspension, emulsion, or aggregation.

[0005] As used herein, "gel" is a solid three-dimensional network that spans the volume of a liquid medium and incorporates islands of solid particles within the matrix of the gel.

[0006] Within this invention paste and gel are used interchangeably.

[0007] The use of coal as a solid fuel is known in the art. However, the use of lump coal is difficult in noncommercial applications while the use of powdered or pulverized coal presents inhalation and explosion hazards. Because of these problems, many applications use liquid fuels such as oil, gasoline, diesel, or ethanol. Furthermore, for noncommercial devices such as automobiles, home furnaces, small engines, etc., liquid fuels are typically easier to inject into a combustion chamber than solid fuels such as coal. However, these liquid fuels, which are largely petroleum products, are more expensive than coal. The supplies of petroleum are more limited and are largely located in volatile areas. A method of making a coal based portable fuel is needed to provide for the growing mobile and home heating energy needs of an ever growing global population.

[0008] The following patents are representative of the coal mixtures that have been utilized to either reduce the complexity of the transfer of coal or to produce a substitute fuel for use in oil burning machines.

[0009] U.S. Pat. No. 5,313,915 issued to McDowell, et al. describes a coal slurry fuel supply and purge system for locomotive engines is disclosed.

[0010] U.S. Pat. No. 4,306,883 issued to Eckman describes Process for forming coal-oil mixtures under selected conditions of temperature and shear.

[0011] U.S. Pat. No. 4,089,657 issued to Keller describes a method of preparing a stabilized suspension of carbon in hydrocarbon fuel.

[0012] U.S. Pat. No. 5,096,461 issued to Frankiewicz, et al. describes separable coal-oil slurries having controlled sedimentation properties suitable for transport by pipeline.

[0013] U.S. Pat. No. 4,950,307 issued to Najjar, et al. describes a method for preparing a high-solids concentration low rank coal slurry by dehydrating the coal.

[0014] European patent Application number: 82109860.5 describes coal-oil slurries containing a surfactant.

[0015] The disclosures of the above patents are incorporated herein by reference.

[0016] Rudolf Diesel, the inventor or the diesel engine, initially studied coal powder as a fuel for his original engine, but handling issues and explosion hazards caused him to abandon the technology. The prior art is replete with coal oil and coal water mixtures that all succumbed to the problems of the coal separating from the carrier liquid. General Electric Co., other companies and inventors have spent a considerable amount of time and money on mixture of coal and water and coal and oil suspensions as fuel. U.S. Pat. 5,313,915 issued to McDowell, et al. describes a coal slurry fuel supply and purge system for locomotive engines. U.S. Pat. No. 4,306,883 issued to Eckman describes Process for forming coal-oil mixtures under selected conditions of temperature and shear. U.S. Pat. No. 5,096,461 issued to Frankiewicz, et al. describes separable coal-oil slurries having controlled sedimentation properties suitable for transport by pipeline. U.S. Pat. No. 4,950,307 issued to Najjar, et al. describes a method for preparing high-solids concentration low rank coal slurry by dehydrating the coal. U.S. Pat. No. 4,089,657 issued to Keller describes a method of preparing a stabilized suspension of carbon in hydrocarbon fuel. European patent Application number: 82109860.5 describes coal-oil slurries containing a surfactant.

[0017] These technologies have problems with the coal powder falling out of suspension of coal and water or coal and oil.

SUMMARY OF THE INVENTION

[0018] Bearing in mind the problems and deficiencies of the prior art, it is therefore an object of the present invention to provide a paste which includes a coal product for use as an energy source.

[0019] It is another object of the present invention to provide a paste which includes a coal product and which can be mixed with a flammable carrier liquid.

[0020] It is yet another object of the present invention to provide a coal paste wherein the coal remains in suspension within the paste.

[0021] An additional object of the present invention is to provide a paste which can be mixed with a bio-mass fiber to make the bio-mass hydrophobic.

[0022] A further object of the present invention to provide a coal paste which may be mixed with bio-mass to form a pellet when compressed with heat and pressure.

[0023] Another object of the present invention is to provide a method to form a paste which is formed from coal particles entrapped in a carrier that can be pumped.

[0024] A further object of the present invention is to provide a paste formed from coal particles that are mixed with fats or grease and can be mixed with bio-mass to form a pellet when compressed with heat and pressure.

[0025] Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

[0026] The above and other objects, which will be apparent to those skilled in the art, are achieved in the present invention which is directed to a paste for use as a combustible fuel, the paste comprising coal, a surfactant, a combustible carrier fluid and a binder. The paste may be a powder.

[0027] The surfactant may be selected from a group consisting of one or more of the following: Triton X-100, Triton X-114, ammonium C12-15 pareth sulfate, Sodium dodecyl

sulfate, CHAPS (3-[(3-cholamidopropyl)dimethylammonio]-1-propanesulfonate), Cholic acid, Tergitol-type NP-40, liquid Gantrez, soaps, Magnesium Isododecyl-Benzene-Sulfonate, Lauramido-Propylamine Oxide, Sodium Xylene Sulfonate or mixtures thereof and other surfactants that work with oils and alcohols.

[0028] The binder may be selected from one or more fats or grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any other oil.

[0029] The paste may include a bio-mass wherein the paste is dispersed evenly and is in communication with all the surfaces of the biomass to prevent hydration of the biomass from atmospheric water. The bio-mass may be selected from the group consisting of paper, wood, plastic, corn stocks, grass, unusable short fiber pulp from paper manufacturing process, solid waste from waste water plants, waste paper, waste card board and silage.

[0030] The binder may be selected from the group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, and any other oil.

[0031] The paste may include a mixture containing a biomass, a second binder and a waste carbon material wherein the paste is dispersed evenly and in communication with all the surfaces of the biomass to prevent hydration of the biomass from atmospheric water. The bio-mass may be selected from the group consisting of paper, wood, corn stocks, grass, unusable short fiber pulp from paper manufacturing process solid waste from waste water plants, waste paper, waste card board and unusable silage. The binder may be selected from the group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, and any other oil. The waste carbon may be selected from the group consisting of bio-solids from waste water treatment plants, sludge from paper manufacturing, sludge from brewing, wine making or distilling operations, manures and other agricultural waste.

[0032] Another object of the present invention is directed to a method for using a coal paste. The method comprises providing a paste including a coal product, a surfactant, a combustible carrier fluid and a binder, transferring the paste through a conduit wherein the transfer is initiated by a pump and allowing the paste to enter a combustion chamber for conversion to heat energy.

[0033] Another object of the present invention is directed to a paste for use as a combustible fuel including a coal powder and a binder wherein the coal powder is suspended within the binder and wherein the paste is may be transferred through a conduit. The paste transfer may be initiated by a pump.

[0034] With the continued increase in the price and volatility of the supply of petroleum-based fuels, the need for an alternative source of energy grows. The United States has large deposits of coal which, if they could be used to offset the use of petroleum, would greatly reduce the dependence on foreign oil and also provide a lower cost fuel source.

[0035] A fuel source for use in large scale implementation must address the following issues: Produce more BTU's than it takes to produce and transport, be easily transported, and be compatible with existing distribution systems.

[0036] Without accomplishing the above, the inertia to implement will be too great for a business to overcome.

[0037] Most current carbon-based energy solutions involve complex manufacturing processes or produce less energy (e.g. ethanol) than is used to make the fuel

[0038] Electricity used in plug-in hybrid solutions must be generated, transported and distributed by an infrastructure that is already out dated.

[0039] Oil-based fuels are becoming more expensive and difficult to acquire, i.e. the rapid rise in oil prices in 2008.

[0040] Many alternate energy solutions are complex and will require change in consumption practices and distribution (i.e. electrical wind power generation does not address home heating fuel or diesel utilization.

[0041] The invention creates a self-contained paste dispensing system making powdered coal a safe and easily transported fuel source. It eliminates the explosive nature of powdered coal and it can be easily retrofitted into existing oil burner systems. Coal dust has a large surface area which makes the combustion of coal dust capable of producing large amounts of energy. When greases and binders are added, the paste can be used to minimize the hydrophilic nature of biomass fillers, thus eliminating expensive drying processes and improving specific energy (BTU/lb.) output.

[0042] Coal dust or powder has far more surface area per unit weight than bulk coal which makes it a preferable source of energy generation. Coal dust/powder however is more susceptible to spontaneous combustion limiting its usage.

[0043] When used in power plants, coal is ground into a dust/powder using a coal mill or pulverizer. The resulting product, called powdered coal or pulverized coal, is then generally used in coal-powered power plants for electricity generation. The pulverized coal is a significant dust explosion hazard, as large quantities are suspended in air for transfer from the mill to the power plant.

[0044] To improve the safety of the pulverizing process, the invention proposes to grind the coal in a wet state using water and then creating a paste of coal which incorporates a combustible carrier fluid liquid such as ethanol, diesel fuel, methanol, etc. and the pulverized coal. The resulting paste is similar in consistency as commercially available tooth paste. The paste can be loaded into cartridges for use by conventional screw pumps to feed a furnace burner or added to a biomass filler to create a stable solid fuel.

[0045] Also, stabilizers such as surfactants can be added to the paste to prevent the combustible carrier fluid from separating from the coal and biomass filler. These surfactants include Triton X-100, Triton X-114, ammonium C12-15 pareth sulfate, Sodium dodecyl sulfate, CHAPS (3-[(3-cholamidopropyl) dimethylammonio]-1-propanesulfonate), Cholic acid, and NP-409 full name of NP-40 is Tergitol-type NP-40, which is nonyl phenoxypolyethoxylethanol), liquid Gantrez, soaps, Magnesium Isododecyl-Benzene-Sulfonate, Lauramido-Propylamine Oxide, Sodium Xylene Sulfonate or mixtures thereof and other surfactants that work with oils and alcohols.

[0046] Also, binders and fats and grease can be added to the mixture to insure that a paste is formed from the mixture. These can be selected from fats or grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any other oils which are available. These binders and fats and grease make the paste more viscous which allows the paste to be ejected under pressure from a cartridge or moved with a pump such as a screw pump.

Wallpaper adhesive is an adhesive based on modified starch and/or methylcellulose, used to fix wallpaper to walls.

[0047] Currently the prior art has focused on the injection of a mixture of coal and water (referred to as "CWM") or mixture of coal and oil (referred to as "COM") into a compression ignition reciprocating internal combustion engine such as a large, medium-speed, multi-cylinder diesel engine, burner system. This method poses problems not typically encountered in the injection of pure liquid fuels.

[0048] When using such a mixture there are fine particles of coal which can cause excessive rates of wear and premature failure of components in a fuel injection system.

[0049] CWM or COM fuels include coal particles from less than 30% (by weight) to as much as 60% and in the range of from 0.1 to 50.0 microns in diameter. These particles are abrasive and corrosive to the materials used in the fuel injection system. Furthermore, the ignition delay time of CWM is undesirably long; typically, five to six times longer than the ignition delay time of standard diesel fuel or heating oil, COM fuel ignition time can be significantly better because of the oil carrier used to create the liquid slurry.

[0050] Coal particles fall out of suspension over time for both CWM and COM which causes problems within the delivery system.

[0051] To solve these problems the COM and CWM slurries system need to minimize the distance the coal mixture is allowed to move prior to injection into the burner.

[0052] The invention can overcome these issues by forming a paste that can be delivered via tubing to the point of injection by high pressures and then mixing the coal paste with a small amount of readily ignitable pilot fuel carrier and inject it with the coal paste and carrier is desirable to promote burning.

[0053] Once a suitable paste can be made then the production of solid fuels such as pellets and briquettes is also possible. The paste can be added to other bio-mass fillers such as paper, wood, corn stocks, grass, unusable short fiber pulp from paper manufacturing, dried bio-solids from waste water plants, waste paper, waste card board, plastics and unusable silage and then formed into pellets or briquettes under pressure. The pellets or briquettes are formed by mixing the paste with the bio-mass filler and then by injecting the mixture into a mold and subjecting it to pressure such that the paste and biomass fillers is compressed into pellets or briquettes.

[0054] A significant issue with biomass pellets is the hydrophilic nature of biomass which results in a pellet or briquette that is capable of hydration or can absorbs water, reducing the production of energy due to the need to boil off the absorbed water entrapped in the bio-mass. This problem can be overcome by forming the paste of the invention with binders, grease or fats or other hydrophobic materials and then thoroughly mixing the resulting paste with the biomass material until all the biomass is uniformly coated with the paste. This results in encapsulating the biomass within the paste, which prevents the biomass from hydrating or absorbing additional water, and attaching the small particle size coal powder to the bio-mass so as to create a higher energy composite particle that is formed into the pellet or the briquette. By encapsulating the bio-mass with the paste the bio-mass will not hydrate the pellet by absorbing water either from the atmosphere or from weather such as rain. The benefit of the bio-mass not absorbing the water is that if the bio-mass absorbs water a significant amount of the energy contained in the bio-mass is used to boil off the entrapped water which reduces the overall BTU output of the pellets. An analogy would be the practice of drying wood prior to burning so that the maximum energy can be extracted from the wood; not letting the bio-mass absorb water improves the Btu output of the resulting pellets or briquettes.

[0055] The pellets or briquettes can be further enhanced by the addition of other waste, such as cellulose, waste foam or paper, into the mixture of coal, oil and waste material. This helps to remove and utilize combustible materials from household and industrial waste streams. This adds value to these waste products and reduces the carbon foot- print of the coal paste-derived products.

BRIEF DESCRIPTION OF THE DRAWINGS

[0056] The features of the invention believed to be novel and the elements characteristic of the invention are set forth with particularity in the appended claims. The figures are for illustration purposes only and are not drawn to scale. The invention itself, however, both as to organization and method of operation, may best be understood by reference to the detailed description which follows taken in conjunction with the accompanying drawings in which:

[0057] FIG. **1** is a schematic of the mixing the coal past with a flammable liquid carrier.

[0058] FIG. **2** is a schematic of the paste biomass formulation.

[0059] FIG. **3** is a chart showing shear testing results with the Frequency Sweep being 0.2% strain 0.008 radians/second sweep step.

[0060] FIG. **4** is a chart showing shear testing results with the Frequency Sweep being 4% strain 0.005 radians/second sweep step.

[0061] FIG. **5** is a chart showing shear testing results with the Frequency Sweep being 20% strain 0.006 radians/second sweep step.

[0062] FIG. **6** is a chart showing shear testing results with the Strain Sweep 0.001 being radians/second Strain sweep step.

[0063] FIG. **7** is a chart showing shear testing results with the Time Sweep 0.002 being radians/second Time sweep step.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0064] In describing the preferred embodiment of the present invention, reference will be made herein to FIGS. **1-7** of the drawings in which like numerals refer to like features of the invention.

[0065] The present invention is a coal energy fuel system in a paste composition comprising coal, which may be in the form of a dust, powder, granules, or the like, and may include at least one surfactant, at least one binder and at least one carrier fluid. The paste may include a bio-mass.

[0066] The invention is a coal energy fuel system that utilizes coal in the form of a dust, powder or granule formulated into a paste. The paste comprises anthracite or bituminous coal, dewatered sludge, bio-diesel fuel and a surfactant which may be mixed until a paste is formed. The paste may be a thick viscous fluid such as a semi-liquid colloidal suspension, emulsion, or aggregation which then can be loaded into a cartridge or directly into a screw pump to feed conventional oil furnaces. The paste may pass through a mixing valve where a secondary combustible liquid may be added as a carrier to allow the mixture of paste and combustible liquid to be injected into the burner of an oil furnace.

[0067] In an example, the present invention is a Coal Energy Fuel System that utilizes coal dust/powder/granular coal which is formulated into a paste. The paste of the invention can be formed by taking 454 grams of anthracite coal (or bituminous coal), 15 grams of waste water treatment dewatered sludge, 100 grams of bio-diesel, 5 grams of surfactant (Triton X-100), and thoroughly mixing until a paste is formed. The paste needs to be a thick viscous fluid such as a semi-liquid colloidal suspension, emulsion, or aggregation which then can be loaded into a cartridge or directly into a screw pump mechanism to feed conventional oil furnaces where it passes through a mixing valve where a secondary combustible liquid is added as a carrier to allow the mixture of paste and combustible liquid to be injected in the burner of an oil furnace. When tested in a bomb calorimeter the mixture produced 20,100 BTU's (British Thermal Unit) per pound which corresponds to the thermal output of burning home heating oil of 19200 BTU's per pound.

[0068] In another example, the paste of the invention can be formed by taking 454 grams of anthracite coal (or bituminous coal), 15 grams of waste water treatment dewatered sludge, 120 grams of bio-diesel, 5 grams of surfactant (ammonium C12-15 pareth sulfate), and thoroughly mixing until a paste is formed. The paste needs to be a thick viscous fluid such as a semi-liquid colloidal suspension, emulsion, or aggregation that can be loaded into a cartridge or directly into a screw pump mechanism to feed conventional diesel engine where it passes first through a mixing valve where a secondary combustible liquid such as conventional diesel fuel is added as a carrier to allow the mixture of paste and combustible liquid to be injected in the diesel engine cylinder. When tested in a bomb calorimeter the mixture produced 22,700 BTU's per pound which corresponds to the thermal output of diesel fuel of 19,300 BTU's per pound. The diesel engine would have to be appropriately modified to provide a delivery system for the paste and a mixing system to pre-mix the paste with diesel fuel prior to the injection into the diesel engine cylinder. The modified diesel could be used in heavy duty trucks, railroad diesel electric engines or diesel generators.

[0069] Alternatively, shredded waste paper may be added to the paste formed and mixed until the paste completely covers and is in communication with all the waste paper forming a film on the waste paper. The combined paste and waste paper must be mixed until all the waste paper is completely coated with the paste. The intent is to form a hydrophobic coating that surrounds all the waste paper to prevent the paper from hydrating by absorbing water from the air during manufacturing, shipping, storage and use. The waste paper can be replaced or mixed with other bio-mass materials which are shredded to produce biomass filler. The final mixture is then compressed under pressure and heated to form a pellet or briquette that is usable in traditional coal or pellet stoves. In an example, pellets were produced using 1400 grams of shredded waste paper added to the paste formula. When tested in a bomb calorimeter the pellet produced 12,700 BTU's per pound which corresponds to the thermal output of burning wood pellets of 8,800 BTU's per pound.

[0070] In another example, the paste can be made by taking 454 grams of anthracite coal (or bituminous coal), 15 grams of dewatered waste water treatment sludge, 100 grams of bio-diesel, 5 grams of surfactant (ammonium C12-15 pareth sulfate), and thoroughly mixing until a paste is formed. The paste needs to be a thick viscous fluid such as a semi-liquid colloidal suspension, emulsion, or aggregation. Then add 1400 grams of waste paper, which has been shredded, to the paste and mix until the paste completely covers and is in communication with all the waste paper forming a film on the waste paper. The combined paste and waste paper must be mixed until all the waste paper is completely coated with the paste. The intent is to form a hydrophobic coating that surrounds all the waste paper to prevent the paper from hydrating by absorbing water from the air during manufacturing, shipping, storage and use. The waste paper can be replaced or mixed with other bio-mass materials which are shredded to produce biomass filler. The final mixture is then compressed under pressure and heated to form a pellet or briquette that is usable in traditional coal or pellet stoves. When tested in a bomb calorimeter the pellet produced 12,200 BTU's per pound which corresponds to the thermal output of burning wood pellets of 8,800 BTU's per pound.

[0071] Alternatively a paste can be formed by taking 454 grams of anthracite coal or bituminous coal, 100 grams of bio-diesel, 5 grams of surfactant (i.e. ammonium C12-15 pareth sulfate) 10 grams of vegetable shortening and thoroughly mixing until a smooth paste is formed. Then add 1400 grams of waste paper, which has been shredded, and mix until the paste completely covers all the waste paper forming a film on the waste paper. The combined paste and waste paper must be mixed until all the waste paper is completely coated with the paste so that the paste is in communication with the waste paper. The intent is to form a hydrophobic coating that surrounds all the waste paper to prevent the paper from hydrating by absorbing water from the air during manufacturing, shipping, storage and use. The waste paper can be replaced or mixed with other biomass materials which are shredded to produce bio-mass filler. The final mixture is then compressed under pressure to form a pellet or briquette that is usable in traditional coal or pellet stoves. When tested in a bomb calorimeter the pellet produced 11,200 BTU's per pound which corresponds to the thermal output of burning wood pellets of 8,800 BTU's per pound.

[0072] Alternatively a paste can be formed by taking 900 grams of anthracite coal or bituminous coal, 200 grams of bio-diesel, 10 grams of surfactant (i.e. ammonium C12-15 pareth sulfate) 50 grams of vegetable shortening and thoroughly mixing until a smooth paste is formed. Then add 1400 grams of waste paper, which has been shredded, and mix until the paste is in communication with the waste paper and completely covers all the waste paper forming a film on the waste paper. The combined paste and waste paper must be mixed until all the waste paper is completely coated with the paste. The intent is to form a hydrophobic coating that surrounds all the waste paper to prevent the paper from hydrating by absorbing water from the air during manufacturing, shipping, storage and use. The waste paper can be replaced or mixed with other biomass materials which are shredded to produce bio-mass filler. Then additional 500 grams sludge from brewing operations which is a waste carbon bearing materials is added to the mixture and thoroughly mixed to insure that the paste is in communication with all the biomass and Bio-Solids from waste water treatment plants. The waste carbon can be selected from one or more of the following, Bio-Solids from waste water treatment plants, sludge from paper manufacturing, sludge from brewing, wine making or distilling operations, manures and other agricultural waste.

[0073] When the paste is utilized to form a pellet or briquette it forms a replacement fuel for traditional the pellets

and briquettes used in home pellet heating systems as well as pellet boilers for home or commercial building heating systems.

[0074] The paste of the invention can be used as a fuel or as the feeder stock of the pellets or briquettes. The paste is mixed with binders, greases or fats and then the resulting paste is mixed with the biomass material until all the bio-mass is uniformly coated with the paste. This encapsulates the biomass with the paste which prevents the biomass from absorbing additional water and by attaching the small particle size coal powder to the bio-mass to create a higher energy composite particle that is formed into the pellet or the briquette.

[0075] The paste system when used as a fuel directly uses a liquid carrier which utilizes the existing fuel oil storage and pumping system. The system uses a supplemental screw pump that stores and dispenses the coal slurry and provides the high pressures needed to promote efficient combustion.

[0076] This invention relates to the use of coal as a part of a paste to form a fuel which can be used to replace oil, gasoline, and diesel biofuel such as biodiesel or ethanol. These liquid fuels are added with the necessary surfactants to form the paste so that it may be used in an application or device that normally uses a liquid fuel. The use of coal would partially offset the use of liquid fuels, such as those based on petroleum, as an energy source thus lowering the cost of the energy and reducing the demand for foreign energy supplies.

[0077] When used to form pellets or briquettes, the paste is formed by taking pulverized coal and mixing it with a liquid fuel, such as bio diesel made from greases and fats, and then adding a binder, grease or fat and one or more bio-mass components such as waste cellulose from a commercial or residential waste stream, corn stocks, grass, wood pulp or other bio-mass and thoroughly mixing the mixture such that the paste completely covers the biomass to seal out the ability to absorb water from the surrounding atmosphere. Then, a solid pellet or briquette can be formed from the mixture by feeding the mixture through a die to form the pellet or briquette. The formulation by weight of the paste is approximately 50% pulverized coal, 5% vegetable shortening 5% bio diesel and 40% chopped waste paper. The mixture is then placed in a standard pellet mill such as a Buskirk Engineering Dual PM1230 Densification System and compressed to form the pellets or briquettes. The mixture can vary depending on the desired results but it has been found that mixtures containing by weight 20-80% pulverized coal, 1-10% fats, greases or binders, 1-30% bio diesel and 5-80% chopped waste paper or bio-mass material make the best pellets or briquettes. Using the paste of the invention as the precursor material for the pellets and briquettes makes economic sense for the consumer and is cleaner and easier to handle than traditional coal or wood pellets. The bio-mass can be selected from fillers such as paper, wood, corn stocks, grass, unusable short fiber pulp from paper manufacturing, dried biosolids from waste water plants, waste paper, waste card board, plastics and unusable silage and then formed into pellets or briquettes under pressure. Additional waste carbon can be added to the mixture so that it contributes 2-60% of the mixture weight. The waste carbon can be selected from one or more of the following: Bio-Solids from waste water treatment plants, sludge from paper manufacturing, sludge from brewing, wine making or distilling operations, manures and other agricultural waste.

[0078] Testing the pellets formed with the paste of the invention for the ability to resist hydration by absorbing water was conducted. First a paste was formed by taking 454 grams of anthracite coal or bituminous coal, 100 grams of biodiesel, 5 grams of surfactant (i.e. ammonium C12-15 pareth sulfate) 10 grams of vegetable shortening and thoroughly mixing until a smooth paste is formed. Then 1400 grams of waste paper was added, which has been shredded, and mixed until the paste completely covers all the waste paper forming a film on the waste paper. The combined paste and waste paper was mixed until all the waste paper was completely coated with the paste so that the paste is in communication with the waste paper. The final mixture was then compressed under pressure using a Buskirk Engineering Dual PM1230 Densification System to form a pellet that is usable in traditional pellet stoves. Two lots of pellets were created each weighing 150 grams.

[0079] The first lot was placed on a polyethylene sheet and placed in an ESPEC SH-241 SH Series bench top humidity chamber and the relative humidity was set at 95% and the temperature was set to 95 degrees. The pellets were left for 14 days in these conditions. At the end of 14 days the pellets were removed and re-weighed and the weight after 14 days of hydration was 153 grams which was a 2% increase in weight due to water absorption. When tested in a bomb calorimeter the first lot of pellets produced 11,000 BTU's per pound.

[0080] The second lot of 150 grams of pellets was placed in a polyethylene bag and heat sealed using a Mighty Mutt heat sealer and placed in an ESPEC SH-241 SH Series bench top humidity chamber and the relative humidity was set at 95% and the temperature was set to 95 degrees. The pellets were left for 14 days in these conditions. At the end of 14 days the pellets were removed and re-weighted and the weight after 14 days of hydration was 151 grams which was less than 1% increase in weight due to water absorption. When tested in a bomb calorimeter the second lot of pellets produced 11,200 BTU's per pound

[0081] A second test similar to the first test was performed, the second test using premium wood pellets purchased from Agway. Three lots of 150 grams each were created. The first lot which was the control was tested in a bomb calorimeter. The first lot produced 10,800 BTU's per pound.

[0082] The second lot of premium wood pellets was placed on a polyethylene sheet and placed in a ESPEC SH-241 SH Series bench top humidity chamber and the relative humidity was set at 95% and the temperature was set to 95 degrees. The pellets were left for 14 days in these conditions. At the end of 14 days the pellets were removed and re-weighed and the weight after 14 days of hydration was 162 grams which was an 8% increase in weight due to water absorption. When tested in a bomb calorimeter the second lot of pellets produced 9,700 BTU's per pound.

[0083] The third lot of premium wood pellets was placed in a polyethylene bag and heat sealed using a Mighty Mutt heat sealer and placed in an ESPEC SH-241 SH Series bench top humidity chamber. The relative humidity was set at 95% and the temperature was set to 95 degrees. The pellets were left for 14 days in these conditions. At the end of 14 days the pellets were removed and re-weighed and the weight after 14 days of hydration was 158 grams which was a 5% increase in weight due to water absorption. When tested in a bomb calorimeter the third lot of pellets produced 10,200 BTU's per pound.

[0084] When comparing the hydration results the pellets made with a paste of the invention absorbed significantly less water and produced more Btu's than the premium wood pellets subjected to similar environmental conditions.

[0085] Wood pellets usually require the harvesting of up to 1.9 tons of wood to form one ton of wood pellets and the wood requires extensive drying to minimize the entrapped water in the base wood, all of which requires substantial amounts of fossil fuel to harvest and manufacture. The paste of the invention, when formed into solid briquettes or pellets, provide the consumer increased ease of use, while still providing a cleaner alternative to lump coal. These pellets and briquettes formed from the coal, bio-waste, waste carbon, surfactant and combustible carrier fluid, such as bio-diesel, burn well and do not require a starter material to ignite. By forming the coal into a paste and then mixing with bio-waste, grease or fat and forming this into a briquette or pellet, the handling issues while creating a stable and safer fuel is solved. The fuel from this technology can be formed from the "waste" tailings from inactive coal mines and could aid in cleaning up old sites limiting environmental impact even further.

[0086] The process developed is for creating a coal paste that is easy to handle and burns safely and is termed "Bio-Coal". This type of material is typically referred to as a coal-oil mixture or COM. However, Bio-Coal is more sustainable when formed from a mixture of biodiesel which is derived primarily from vegetable oil coupled with anthracite coal in the United States market because it burns cleanly, without much smoke or soot. In addition to the biodiesel benefits, the adoption of Bio-Coal can reduce the amount of wood burned for home heating and thus lessen deforestation effects on the environment which in turn improves the ability to mitigate greenhouse gas such as CO_2 and NOx compounds found in coal because of the substantial amount of non-coal materials in the Bio-Coal. Tailings from old mines can be utilized, which uses a previously thought of "waste product" to produce energy. Coal dust burns better than lump coal as it has more surface area, thus creating a hotter and cleaner burning product. Bio-Coal paste is relatively thick like a gel or a paste, which makes handling, a common problem with coal fuels, easy and safe, but still allows Bio-Coal to be pumped. Mild chemicals such as surfactants may be added to improve the storage and separation properties of the slurry, allowing the material to be stored without separating. Additionally, by using biodiesel for the oil portion of the mixture, emissions from burning coal and the problems associated with pulverized coal and coal dust have been reduced.

[0087] When used as liquid fuel replacement, the liquid fuel provides a consistency to the mixture that allows for the injection of the fuel into the combustion chamber that is the same as or similar to other liquid fuel injection methods. The liquid fuel also helps reduce explosion and inhalation hazards associated with coal dust as it helps trap the small particles preventing them from entering the air. The formulation by weight of the paste is approximately 20-80% pulverized coal, surfactants 1-10%, binders, fat or grease 1-20% and 1-30% bio diesel. The mixture can vary depending on the desired results.

[0088] This invention creates a mixture containing pulverized coal or coal dust and a combustible liquid fuel which may be oil, bio diesel, gasoline, diesel, or ethanol that may have varying degrees of viscosity and coal content. Additives or surfactants may be added to the liquid fuel to improve the consistency and suspension of the coal particles.

[0089] Surfactants that may be added are:

[0090] Triton X-100, Triton X-114, ammonium C12-15 pareth sulfate, Sodium dodecyl sulfate, CHAPS (3-[(3-cholamidopropyl)dimethylammonio]-1-propanesulfonate), Cholic acid, and NP-409 full name of NP-40 is Tergitol-type NP-40, which is nonyl phenoxypolyethoxylethanol), liquid Gantrez, soaps, Magnesium Isododecyl-Benzene-Sulfonate, Lauramido-Propylamine Oxide, Sodium Xylene Sulfonate or mixtures thereof and other surfactants that work with oils and alcohols.

[0091] The binders, fats or grease can be selected from vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any other oils which are available. When using the paste or slurry the container that holds the mixture containing the coal and liquid fuel may be a standard liquid container where the mixture may be drawn from the container by means of gravity, pump, or pressure. Alternatively, the container for the fuel mixture may be syringe-like or a flexible compressible tube such that the mixture is forced from the container by compression.

[0092] The coal-liquid fuel paste/slurry mixture may be used directly in a combustion chamber or may be added to one or more carrier fluids. As shown in the schematic of FIG. **1**, the fuel mixture **5** containing coal paste **1** may be mixed in varying ratios with the carrier fluid **2** by passing the coal paste **1** through a mixing venturi valve **3** which adds the required amount of carrier fluid **2** so that the burner **4** can adequately burn the mixture **5**. The carrier fluids **2** are preferably combustible liquids such as oil, gasoline, diesel fuel, and/or ethanol. The mixture **5** is then injected into the combustion chamber **7** where it is burned.

[0093] The data acquired during shear testing to validate the pumpability of the paste of the invention is shown in FIGS. **3**, **4**, **5**, **6** and **7**. It should be noted that strain is deformation or movement that occurs in a material. Expressed as the amount of movement that occurs in a given sample dimension this makes it dimensionless. The translation of this is: How much did I move the sample? The results show that the paste when tested demonstrates that there is very clear shear thinning, which means it is capable of being easily pumped. Additionally, this data also can be interpreted that in a properly designed mixer it will also mix well with additional liquid fuels.

[0094] The Coal Energy Fuel paste system utilization in the existing fuel oil burner would require the following modifications: 1) The formulation by weight of the paste is approximately 20-80% pulverized coal, 1-30% bio diesel and can include binders that make up between 1 and 10% of the total weight of the final paste. The paste can be formed by substituting the biodiesel with ether ethanol, gasoline, alcohol or other combustible carrier fluid. When doing this, the percentage of coal may have to be adjusted to provide the proper combustion of the paste. 2) Alternatively 2-40% by weight of water can be added to facilitate the formation of pellets or briquettes when using rotary die systems to form the pellets or briquettes. The mixture can vary depending on the desired results but it has been found that mixtures containing various percentages of pulverized coal and bio diesel make the best paste. This creates a suitable paste after complete mixing. When used as a number 2 heating oil replacement fuel, the oil delivery company would fill both the screw pump and the existing fuel oil tank. A new controller would be added which takes the existing signal for the fuel pump and converts it to insure the correct fuel ratio is injected into the existing burner nozzle. 3) A cabinet containing a screw pump, new controller and piping would be installed. A tee is placed in the furnace fuel supply, and electrical connections are added to the exist-

ing fuel pump. In systems without a fuel pump, a restrictor valve is added which allows for adjustable flow from the tank to the input of the burner. 4) A new burner may have to be installed in some installations.

[0095] FIG. **2** shows a schematic of the paste biomass formulation. 454 grams of coal dust of powder **10** is placed in a vat **11** and then 100 grams of bio-diesel **12** is add to vat **11**, which was determined by experimentation based on the coal dust porosity is added to the vat. Next 2 grams of surfactant ammonium C12-15 pareth sulfate **13** is added to the vat and then 10 grams of dewatered sewage sludge **14** and the combination is mixed completely until a paste is formed. Then add 1000 grams of waste paper 15 which has been shredded and 400 grams of sludge **16** from brewing operation and mix until the paste completely covers all the waste paper and sludge from the brewing operation forming a film on the waste paper and sludge.

[0096] When used to form pellets or briquettes, the paste is formed by taking pulverized coal and mixing it with a liquid fuel such as bio diesel made from greases and fats and then adding waste cellulose from a commercial or residential waste stream. The formulation by weight of the paste is approximately 20-80% pulverized coal, 1-30% bio diesel and 5-80% chopped waste paper or bio-mass material, additional waste carbon can be added to the mixture so that it contributes 2-60% of the mixture weight. The waste carbon can be selected from one or more of the following Bio-Solids from waste water treatment plants, sludge from paper manufacturing, sludge from brewing, wine making or distilling operations, manures and other agricultural waste.

[0097] The mixture is then placed in a mold and compressed to form the pellets or briquettes. The pellets or briquettes are then formed by injecting the mixture into a mold and compressing with pressure. The pellets or briquettes can then be used in existing pellet, wood or coal stoves as a substitute for wood, wood pellets.

[0098] It will be appreciated that the present invention enables the formation of a coal paste that where the coal will not separate from the carrier material used to form the paste. In addition, the present invention provides a paste which includes a coal product for use as an energy source. The invention also provides a paste which includes a coal product and which can be mixed with a flammable carrier liquid.

[0099] The object of providing a coal paste wherein the coal remains in suspension within the paste has been met. In addition, the object of providing a paste which can be mixed with a bio-mass fiber to make the bio-mass hydrophobic has been met.

[0100] The present invention also provides a coal paste which may be mixed with bio-mass to form a pellet when compressed with heat and pressure. The present invention also provides a method to form a paste which is formed from coal particles entrapped in a carrier that can be pumped.

[0101] The object of the present invention is to provide a paste formed from coal particles that are mixed with fats or grease and can be mixed with bio-mass to form a pellet when compressed with heat and pressure has been met.

[0102] The bio-mass used to mix with the paste to make the pellet or briquette may be a paper product such as waste paper or recycled paper, cardboard or recycled cardboard and short fiber pulp from paper manufacturing process, preferably unusable for any other purpose. Any other paper product may also be used. The bio-mass may also consist of wood, corn stocks, grass, solid waste, and silage. Solid waste would preferably be the solid waste recovered from waste water plants. Silage would preferably be silage which is otherwise unusable for any other purpose.

[0103] The binder in the paste or pellets may be fats such as those derived from animals or plants, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, motor lubricant which may be used or reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil. The binder may be any oil such as those containing a high carbon and hydrogen content.

[0104] Although the present invention has been described in connection with preferred embodiments thereof, it will be appreciated by those skilled in the art that additions, modifications, substitutions and deletions not specifically described may be made without departing from the spirit and scope of the invention as defined in the appended claims.

[0105] While the present invention has been particularly described, in conjunction with a specific preferred embodiment, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. It is therefore contemplated that the appended claims will embrace any such alternatives, modifications and variations as falling within the true scope and spirit of the present invention.

Thus, having described the invention, what is claimed is:

1. A paste comprising:

coal;

a surfactant;

a combustible carrier fluid; and

a binder.

2. The paste of claim **1** wherein the coal is a powder.

3. The paste of claim **1** wherein the surfactant is selected from the group consisting of Triton X-100, Triton X-114, ammonium C12-15 pareth sulfate, Sodium dodecyl sulfate, CHAPS (3-[(3-cholamidopropyl)dimethylammonio]-1-propanesulfonate), Cholic acid, Tergitol-type NP-40, liquid Gantrez, soaps, Magnesium Isododecyl-Benzene-Sulfonate, Lauramido-Propylamine Oxide, Sodium Xylene Sulfonate or any combination of the foregoing.

4. The paste of claim **1** wherein the binder is selected from the group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, used/reclaimed motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any combination of the foregoing.

5. The paste of claim **1** including a bio-mass wherein the paste is dispersed evenly and is in communication with all the surfaces of the biomass to prevent hydration of the biomass from atmospheric water.

6. The paste of claim **5** wherein the bio-mass is selected from the group consisting of paper, wood, plastic, corn stocks, grass, unusable short fiber pulp from paper manufacturing process, solid waste, waste paper, waste card board and silage.

7. The paste of claim **5** wherein the binder is selected from the group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any combination of the foregoing.

8. The paste of claim **1** including a mixture containing a bio-mass, a second binder and a waste carbon material wherein the paste is dispersed evenly and in communication with all the surfaces of the biomass to prevent hydration of the biomass from atmospheric water.

9. The paste of claim **8** wherein the bio-mass is selected from the group consisting of paper, wood, corn stocks, grass, short fiber pulp, solid waste, waste paper, waste card board and silage.

10. The paste of claim **1** wherein the binder is corn starch.

11. The paste of claim **8** wherein the waste carbon is selected from one or more of Bio-Solids from waste water treatment plants, sludge from paper manufacturing, sludge from brewing, wine making or distilling operations, manures and other agricultural waste.

12. The paste of claim **1** wherein the surfactant is ammonium C12-15 pareth sulfate.

13. A method for using a coal paste comprising:

providing a paste including a coal product, a surfactant, a combustible carrier fluid and a binder;

transferring the paste through a conduit wherein the transfer is initiated by a pump;

allowing the paste to enter a combustion chamber for conversion to heat energy.

14. The method of claim **13** wherein the surfactant is selected from a group consisting of Triton X-100, Triton X-114, ammonium C12-15 pareth sulfate, Sodium dodecyl sulfate, CHAPS (3-[(3-cholamidopropyl)dimethylammonio]-1-propanesulfonate), Cholic acid, Tergitol-type NP-40, liquid Gantrez, soaps, Magnesium Isododecyl-Benzene-Sulfonate, Lauramido-Propylamine Oxide, Sodium Xylene Sulfonate or any combination of the foregoing.

15. The method of claim **13** wherein the binder is selected from a group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any combination of the foregoing.

16. The method of claim **13** including a bio-mass wherein the paste is dispersed evenly and is in communication with all the surfaces of the biomass to prevent hydration of the biomass from atmospheric water.

17. The method of claim **16** wherein the bio-mass is selected from the group consisting of paper, wood, plastic, corn stocks, grass, unusable short fiber pulp from paper manufacturing process, solid waste from waste water plants, waste paper, waste card board and silage.

18. A pellet for use as a combustible fuel, the pellet including a coal powder, a surfactant, a combustible carrier fluid and a binder.

19. The pellet of claim **18** wherein the binder is selected from the group consisting of fats, grease, vegetable shortening, sewage sludge, corn starch, wall paper adhesive, motor lubricant, animal renderings, vegetable oils, eucalyptus oil, or any combination of the foregoing.

20. The pellet of claim **18** including a bio-mass selected from the group consisting of paper, wood, plastic, corn stocks, grass, short fiber pulp from paper manufacturing process, solid waste, waste paper, waste card board and silage.

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