Title: FUELS PELLETS, THEIR PREPARATION AND USE

Abstract: The invention pertains to a process for manufacturing compressed or compacted solid fuel bodies, said process comprising mixing (a) plant origin materials with (b) 0.1–10 wt% of a starch-based binding agent, based on the total weight of the solid fuel body, and (c) a composition containing at least 60 wt% of one or more saturated long chain fatty acids having an aliphatic chain length of at least 12 C atoms, and/or analogues thereof, the weight percentage based on the total weight of said composition, wherein said fatty acids and/or analogues thereof having a melting point or melting range within the range of 40-95 °C, wherein the weight ratio of (c) to (b) ranges between 1:200 and 1:3, and wherein the mixing of (a), (b) and (c) is performed at a temperature below said melting point or melting range, and the mixture of (a), (b) and (c) is subsequently subjected to compression or compaction at a temperature above said melting point or melting range. Stearic and palmitic fatty acids or analogues are particularly preferred.
FUELS PELLETS, THEIR PREPARATION AND USE

FIELD OF THE INVENTION

The present invention pertains to fuel pellets having improved binding properties, and to an improved process for manufacturing such fuel pellets at higher throughput and lower energy costs.

BACKGROUND OF THE INVENTION

Due to diminishing quantities of coal, petroleum, and natural gas products, attention is being directed to other energy sources. One source which is receiving considerable attention is biomass materials such as wood, bagasse, their byproducts, and agricultural residues, compressed wood waste, pellitized being the best examples. A problem however is in the frailty of compressed wood which leads to special handling to avoid crumbling, the creation of fines and dust, and the avoidance of weathering. To overcome the crumbling and weathering problems, inorganic binders, such as cement and silicate of soda, and organic binders, such as tar, pitch, rosin, glues, waxes and fibers, have been included in the pellets in the past. Attempts have also been made to use the self-binding characteristics produced from lignin in various species of wood to avoid the crumbling problem. All however with unsatisfactory results.

At present, purified and even food-grade starches are applied [see e.g. Conference book Interpellets 2007, Stuttgart]. These starches reduce processing energy, increase wear, ease production and, above all, reduce the amount of fines. However, purified grades of starches are expensive. Therefore, it has been attempted to switch to lesser, technical grades or even maize grits and rye meal for a binding material, all abundantly present and inexpensive. However, these products have often shown discouraging results in terms of slagging, caking and flowability.

Fuel pelleting requires the use of binding or pressing aids. Without these, pressing would simply not be possible or needs high energy methods. US 4,236,897, US 4,308,033 and US 2008/0171297 mention the use of paraffin, slack wax, carnauba wax, beeswax, hydrogenated triacylglyceride, tallow, thermoplastic polymers and certain lignosulfonates. Oil seeds and their products have a fatty acid content that can reduce wear in the pelleting die. Examples of such materials include coconut husks,
soy beans, peanuts, sunflower seeds, corn cake, pressing residuals and ethanol plant stillage. These waxes or lignosulphonates are added in a soft or liquid state. US 2008/0171297 discloses Super Lube (Uniscope), Lube Aid (Ag Research), Pelltech (BorregaardLigno Tech) as non-limiting examples of lubricants commercially available. US 4,308,033 describes a wax-in-water emulsion sold as Cascowax EW 4304, or a lignin-containing "black liquor" by the name of Lignisite. US 4,208,033 mentions that it is preferred to add the wax as an emulsion in water to facilitate the formation of a thin uniform flow of the wax on the pellet. US 4,529,407 discloses synthetic thermoplastic materials that are solid at injection molding temperature.

DE 20 2007 004 725 U1 discloses wood-based solid fuels to which palmitic acid, stearic acid, starch, rape seed oil, sunflower oil, soy oil, or coconut oil etc. can be added. In terms of manufacturing, the pressed wood body can either be immersed in a hot bath containing the additive in liquid form, or, alternatively, the additive can be sprayed onto the fuel body at these elevated temperatures.

However, it is found by the inventors that the soft or liquid binding and pressing processing aids disadvantageously affect mixing and subsequent pelletization. It is difficult to achieve mixing if involving liquid components, and aggregates and lumps are readily formed. On the other hand, it is essential that he processing aids are liquid during pelletization. Some of the liquid "fatty" components are volatile and thus increase the risk for fire and explosions during high temperature operations, high shearing and friction processing.

Also, many of the suggested compositions in the art are mixtures or waste products involving all kinds of components that may deteriorate the pellet quality, and worse, in an uncontrolled manner. Of some of the suggested materials such as coconut husks it is in fact questionable whether these contribute at all, and it puts restraints on the mixing process to render the oils present in the husks accessible. In view of environmental concerns, it is preferred to use non-renewable pelletization aids over e.g. synthetic thermoplastic materials, slack wax, paraffins and other petro-based (byproducts mentioned in the art. Tallow is a mixture of triglycerides again involving a significant amount of oils, with the aforementioned disadvantages associated therewith. Lignosulphonates, apart from being liquid, also undesirably introduces additional sulphur into the process.
Hence, in the art there is a need to further improve the pelletization process and the binding properties of the fuel pellets thus obtained.

Outside the field of biomass-based fuel pellets, there is prior art on solid fuel logs with improved burning times and improved heating values, which logs are formed from a mixture of a solid particulate, organic combustible material and stearic and/or palmitic acid. These logs are known firelighters. Large amounts of stearic acid and palmitic acid are applied. Examples are provided in WO 96/14372 and WO 2008/076456, disclosing minimum amounts of at least 40 wt% fatty acids. In each case, it concerns a completely different line of products, where binding properties and blending are simply not an issue. To increase heating value, these applications need at least 40% fatty acids. At these amounts the product becomes expensive.

SUMMARY OF THE INVENTION

The inventors have now found that the aforementioned problems for biomass-based solid fuel pellets or briquettes can be greatly reduced when making use of compression or compaction processing aids that contain significant amounts of saturated long-chain fatty acids, such as palmitic, myristic, stearic, and arachidic acids, or their analogues, for instance the fatty alcohols. The processing aids of the invention are solid at mixing conditions and readily molten when pelletization is due. Their melting point or range is significantly high to achieve easy blending without the aforementioned difficulties associated with soft or liquid materials, but at the same time reasonably low to ensure that these components are completely molten when the actual pelletization starts, typically at 95 °C. Hence, there is provided a dry mixture comprising one or more of the above processing aid(s) and the plant origin (waste) materials, which dry mixture is subsequently compounded or compacted. The pelletization or briquetting involves pressurized conditions inherently increasing temperatures, thus melting the processing aid(s) while compounding/compacting. However, the temperature increase due to internal friction may be helped externally, e.g. using steam.

It is found that the use of long chain saturated fatty acids or alcohols, preferably stearic acid, palmitic and arachidic acid and their alcohols, reduce frictional forces during pelletization and thus conveniently reduce energy consumption, or for that
matter, increase production rates. The effects are shown in the accompanying examples.

However, surprisingly, the advantages of the compression or compaction processing acids according to the invention are not limited to the compression or compaction process, but reach as far as the fuel pellets thus produced. It is found that these lubricating aids also increase the binding properties and reduce the abrasion - in terms of fines content - of the pellet. Again, evidence is provided in the accompanying examples.

DETAILED DESCRIPTION OF THE INVENTION

In one aspect, the invention pertains to a process for manufacturing compressed or compacted solid fuel bodies, preferably pellets or briquettes, said process comprising mixing (a) plant origin (waste) materials with (c) a compression or compaction processing aid composition containing at least 60 wt% of one or more saturated long chain fatty acids having an aliphatic chain length of at least 12 C atoms, and/or analogues thereof, the weight percentage based on the total weight of the processing aid composition, said fatty acids and/or analogues thereof having a melting point or melting range within the range of 40 - 95 °C, wherein the mixing is performed at a temperature below said melting point or range, and the mixture of plant origin (waste) materials and processing aid composition is subsequently subjected to compression or compaction, such as a briquette extruder or compactor, more preferably pelletization, at a temperature above said melting point or range.

In other words, said compaction process comprises i) blending plant origin (waste) materials with one or more processing aid composition as described above, and ii) compacting the resulting blend, wherein temperature due to pressing increases above the melting point or range.

In a most preferred embodiment, (b) a starch-based binding agent, preferably starch, meal or flour, is added in the mixing step. The combination of such starch-based binding agent and the lubricating aid composition yields excellent binding properties
and reduced fines. The processing aid and the binder agent are preferably added simultaneously, thus advantageously making use of a single injection mode.

The fatty acid-containing processing aid composition and the starch-based binding agent are preferably mixed outside the pelletizing or briquetting plant, and the mixture of those two is then mixed with the plant origin materials. The starch-based binding agent advantageously prevents the fatty acid or analogues from sticking and melting in higher temperature environments (above RT) which are typical for such plants. If both compositions (b) and (c) would be added separately, sticking of the processing aid composition could easily occur. It is thus advantageous to provide (b) and (c) to the mixing step with the plant origin materials already as a mixture or blend, processing the lubricating aid in the amounts suited for the purpose of the invention.

In the preferred embodiment, the total weight of the mixture of (b) the starch-based binding agent and (c) the processing aid composition (containing the fatty acids or analogues) is between 0.1 and 10 wt%, more preferably between 0.1 and 5 wt%, most preferably 0.1 - 3 wt%, based on the total weight of the solid fuel obtained by the compaction process. It is preferred that the relative weight ratio of said composition containing the saturated long chain fatty acids (and analogues) to said starch-based binding agent ranges between 0.5:99.5 - 25:75 (1:200 - 1:3), more preferably 1:99 - 25:75, more preferably 1:99 - 20:80 (1:99 - 1:4); more preferably 1:99 - 1:5, most preferably up to 1:10, especially ranging between 1:99 and 5:95 (1:20). In one embodiment, the ratio is preferably about 2.5:97.5. The weight ratio calculations in this paragraph are preferably based on the total weight of fatty acids (and analogues) vs. total weight of the starch-based binding agent. Most preferably, the above numbers apply to the total weight of palmitic acid and stearic acid (and their analogues) vs. total weight of the starch-based binding agent, preferably meal or flour.

The compression or compaction step involves conventional pressing aids and machinery, and preferably involves temperatures ranging between 80 - 100 °C, more preferably at least 90 °C, most preferably at least 95 °C.

Throughout the description, the long chain fatty acids (and their analogues) are encompassed by the terms "compression or compaction processing aid" and "lubricating aid", thus functionally describing (at least part of) their benefits to the
compression or compaction process. As mentioned above, the same compounds also
have been found to improve binding and reduce fines.

Although solid fuel bodies are typically formed and shaped - by pelletization - to
pellets, the invention is not considered limited to this form. The term "solid fuel body"
icorporates both pellets and briquettes, where pellets are most preferred. Hence, in the
remainder of the text, where "pellet" is mentioned, it also comprises other shapes.
However, solid fuel pellets are considered the best mode.

Compaction processing aid (c)

The compression or compaction processing aid preferably has a melting point (or
range) within the range of 40 - 95 °C, more preferably 45 - 90 °C, most preferably 50
- 85 °C. It is preferred that the compression or compaction processing aid is of natural
(i.e. non-oil renewable) origin. It is preferred that the composition contains no or little
amount of volatile liquids, preferably less than 5 wt%, more preferably less than 2 wt%
of the composition ("volatile" meaning that the compound(s) evaporate or vaporize
readily under atmospheric conditions). It is preferred that less than 30 %, more
preferably less than 20 %, most preferably less than 10 % of the composition shows
liquid or fluid behavior at mixing conditions, preferably at 40 °C.

The compression or compaction processing aid composition preferably contains
at least 60 wt%, more preferably at least, 70, 80, 90 wt% of one or more of saturated
long chain fatty acids and/or their analogues, of which alcohols or esters (preferably
mono-esters) are most preferred, particularly the fatty alcohols. In the context of the
invention, instead of "analogues" the term "derivatives" may also be used.

"Saturated long chain fatty acids" is construed as those fatty acids having a C12:0
or more (i.e. having a saturated aliphatic chain of at least 12 C atoms). Long chain fatty
acids having > C14:0 are even more preferred. It is preferred that the composition
contains less than 5 %, more preferably less than 1 %, most preferably no detectable
amounts of unsaturated long chain fatty acids (or their analogues). It is preferred that
the composition contains less than 20%, more preferably less than 10% lauric acid or
its analogues, and/or of fatty acids having a saturated aliphatic chain of less than 12 C
atoms. The weight calculations are based on the actual weight contribution of the fatty
acid chain to the total weight of the processing aid composition.
Non-limiting examples of the C12:0 and longer aliphatic saturated chain fatty acids and analogues are stearic alcohol, cetyl alcohol, cetostearyl alcohol, arachidyl alcohol, clutyl alcohol, melissyl or myricyl alcohol, sorbitan monostearate (Span60), sorbitan monopalmitate (Span40), glycerol monostearate. Purified non-lauric fat based on hydrogenated palm oil glyceride, like DYNASON® P 60 (F) Sasol, is also included. These fatty acids and analogues are encompassed within the definition of a compaction or compression processing aid provided that they satisfy the above requirements regarding the melting behavior.

Of the above, stearic and palmitic fatty acid (analogues) are most preferred, and of the analogues preferably the fatty alcohols. In order to avoid the introduction of components that may affect pellet quality negatively, it is preferred that the amounts of stearic and/or palmitic acid in the processing aid are high, preferably at least 90 wt%.

In a most preferred embodiment, the processing aid contains at least 80, more preferably at least 90 wt% of palmitic acid and/or stearic acid, and/or their alcohols or esters, most preferably at high purity (preferably making up for at least 95% of the processing aid). The processing aid preferably consists of palmitic acid, palmitic alcohol, stearic acid and/or stearic alcohol, at commercially acceptable purity grades.

The fuel pellets are based on plant origin materials or waste materials known in the art. Non-limiting examples are agricultural biomass, peat, wood, charcoal. In the context of the invention, the term "plant origin materials", or "plant material", includes plant (origin) waste materials. The term "wood" includes wood flour, chips or sawdust, wood shavings, Sander's dust, hog fuel, peat and bark. It may originate from hard and soft woods. Examples of soft wood are conifers such as spruces (picea), pines, cedars, douglas-firs, cypresses, firs, junipers, kauris, larches, redwoods, and yews, etc..

However, problems with pelletization are particularly encountered using hard woods, such as (fast-growing) eucalyptus and torrefied wood, and also "old" dry waste wood products. Torrefied wood has practically no (close to 0%) internal moisture and will not reabsorb moisture from the air or surface runoff since its hygroscopic properties are altered by the heating process. Therefore, in one embodiment the wood comprises hard and/or torrefied wood. Examples of hard woods are oak, beech, ash, maple, teak, mahogany and cherry.
Good results are also obtained with pyrolysed wood, peat, charcoal. The term agricultural biomass includes hay, straw, sunflower husk, cereal milling by-products such as bran, grasses, etc.. The plant-based waste materials preferably form at least 90 wt%, more preferably at least 95 wt% of the total solid fuel body, more preferably at least 98% of the solid fuel body.

**Starch-based binding agent (b)**

It is preferred to use the compression or compaction processing aids according to the invention in combination with starch-based binding agents. Although such binding agent may be (food-grade) starch, it is preferred to apply more economical starch-containing products, more preferably meal or flour. Hence, the starch-based binding agent is preferably selected from starch, flour and meal, more preferably from flour and meal.

In "flour" and "meal" starch and proteins originating from one and the same vegetable source coexist, because no attempts have been made to separate the protein-containing fraction and the starch-containing fraction from one another (yet). Other components originating from the vegetable source may be present likewise, such as cell wall or non-starch polysaccharides, fibres, lipids and ash. While meal may exhibit binding properties that are inferior to that of starch, it is found that the combination of meal or flour with the processing aid according to the invention shows improved binding and reduced abrasion. Abrasion is determined according to CEN/TS 15210-1. Reference is made to the examples.

It is noted that the terms "flour" and "meal" cannot be applied interchangeably. In terms of processing, flour differs in that it requires additional steps. Meal is simply milled grain, while flour requires additional sieving and/or a higher degree of bolting (cloth or drum sifting), refinement or extraction rate. Again, the skilled person is well capable of distinguishing meal from flour.

The flour or meal can be derived from seeds, tubers, roots, grains or grasses. More extensibly, flour or meal may be derived from seeds, legumes, nuts, and grains, such as beans, kidney beans, soybeans, lentils, (yellow, green, wrinkled) pea, chickpea, wheat, buckwheat, triticale, sorghum, amaranth grain, corn, sago, barley, oat and rice. Chemical modifications (e.g. phosphorylation) may be involved, although not preferred.
In one embodiment, rice meal is however excluded from the invention.

Although it may appear linguistically confusing, the skilled person is well aware that the term "flour" does not comprise "wood flour" as wood saw dust is sometimes expressed (precautionary, "flour" in the context of the invention may be called "non-wood originating flour"). Meal is sometimes confusingly referred to as "whole-grain flour,"; however flour distinguishes from meal in that it contains reduced amounts of ash, germ, bran and fiber.

Flour preferably comprises cereal flour, more preferably rye flour and/or wheat flour, preferably in predominant amounts of all starch-providing materials present in the fuel pellet. More preferably, the flour source of the flour-based composition consists of rye flour and/or wheat flour. It is preferred that flour contains less than 1.2 wt% of ash, preferably less than 1.0 wt% of ash, more preferably at most 0.85 wt% of ash, based on the total weight of flour. It is preferred that flour contains less than 0.5 wt% of germ, based on the total weight of flour. It is preferred that flour contains less than 1 wt% of bran, based on the total weight of flour. It is preferred that flour contains less than 1 wt% of fibre, based on the total weight of flour, more preferably less than 0.75 wt% fibre. In one embodiment, it is preferred to use a flour rich in pentosans and/or hemicellulose. It is especially preferred to use a flour, or meal, rich in pentosans. The amount of pentosans present in the flour is preferably 0.1 - 10%, preferably 0.5 - 5%, based on the total weight of flour present in the composition. The amount of pentosans in the additive and in the fuel pellet can be calculated there from.

The solid fuel body, e.g. pellet, preferably contains 0.1 - 3 wt% of the starch-based binding agent, based on the total weight of the solid fuel. The fuel body may also include anti-slagging metal salts. In one embodiment, the starch-based binder is preferably present in amounts of 0.2 - 2%, more preferably in the range of 0.3 - 1.2 wt%, preferably 0.4 - 1 wt%, based on the total weight of the solid fuel body.

In one embodiment, the mixture of (b) and (c) is preferably applied in amounts of 0.1 - 5 %, more preferably 0.5 - 4 %, most preferably 0.5 - 3 %, based on the total blend.

The same numbers also apply to the fuel pellet thus formed.

In one aspect, the invention pertains to a kit-of-parts containing (i) a starch-based binding agent and (ii) a lubricating aid composition containing at least 60 wt%
saturated long chain fatty acids or analogues (preferably alcohols and/or esters) thereof, wherein the weight is based on the total weight of the lubricating aid composition (ii). All of the above restrictions concerning either (i) or (ii) also apply here.

In another aspect, the invention pertains to a composition containing a starch-based binding agent and one or more saturated long chain fatty acids or analogues (preferably alcohols and/or esters) thereof, said composition being suitable for use in the compression or compaction process to obtain solid fuel bodies. As said above, the mixture of binder and lubricating aid renders a single injection possible. Also, in the composition the lubricating fatty acids are prevented from melting and sticking at the atmospheric conditions in the processing plant, which is usually characterized by increased temperatures (due to heat production by machines). The composition renders it more convenient to work with the stearic acid and palmitic acid (and analogues), which otherwise would require more care in order to avoid their melting behavior to affect processing.

In the composition, it is preferred that the relative weight ratio of the saturated long-chain fatty acids (and analogues) to the starch-based binding agent ranges between 0.5:99.5 - 25:75 (1:200 - 1:3), more preferably 1:99 - 25:75, more preferably 1:99 - 20:80 (1:99 -1:4);, more preferably 1:99 —1:5, most preferably up to 1:10, especially ranging between 1:99 and 5:95 (1:20). In one embodiment, the ratio is preferably about 2.5:97.5. The weight ratio calculations in this paragraph preferably apply to the total weight of palmitic acid and stearic acid (and their analogues) vs. total weight of the starch-based binding agent, preferably meal or flour.

The preferred starch-based binder is flour or meal, and the (preferred) lubricating aid contains at the saturated fatty acids and/or analogues as described above. All preferred embodiments mentioned with respect to the lubricating aid used in the method of manufacturing solid fuel bodies equally apply here. It is preferred that the saturated long chain fatty acids/analogues (e.g. alcohols) are present in the composition (c) in amounts of at least 60, 70, 80, 90, 95 wt% of the weight of all fatty acids/alkals present in the composition (c).

The composition may further contain conventional anti-slag additives. Slagging-related problems have more than occasionally been observed in pellet burners and stoves over the last years. Slag is formed by the reaction of alkali metals (released
during the pyrolysis and combustion process) with silicon. Sticky silicate melts are formed and further particles can adhere.

In the above kit or composition, the starch-based binder and the lubricating aid preferably make up for at least 90%, more preferably at least 95 wt% of the total dry weight of the parts or composition, respectively. The parts comprised in the kit and the composition are preferably in dry form, as a powder. The powder(s) preferably has a water content of less than 15% (on the basis of dry solids). The kit components or composition are preferably a free-flowing powder. It preferably contains less than 15 wt% of water, or more preferably less then 13.5wt% water, based on total weight.

The invention also pertains to the use of the above composition or kit in manufacturing solid fuel bodies, preferably through compaction or compression, e.g. pelletization and briquetization.

In yet another aspect, the invention pertains to a solid fuel body obtained or obtainable by the above process, said fuel body comprising one or more of the aforementioned compression or compaction processing aid(s) and a starch-based binding agent, preferably flour and/or meal.

**EXAMPLES**

**Comparative example 1**

Wood pellets were prepared from dried and conditioned saw dust derived from soft wood (spruce). Pellets were made from a constant feed of saw dust, with 3 different processing aids at 1% dosing levels, and compared with a control pellet containing no processing aids at all. The press was a CPM type CL5 with a maximum production of 12 kg/h using 6 mm die with two series of holes. The temperature at the die was about 79 ºC. Pellets were cooled using a small band drier equipped with adjustable cooling speed.

Every composition was pressed in 4-5 test batches, results were averaged and standard deviation calculated. The results are summarized in table 1. Abrasion - in terms of percentage fines - was tested according to CEN/TS 15210-1. The pellet
density in all cases was 1.26 g/cm³, water content about 8.1% (using CEN/TS 15774-2 and 15150). The energy input I was measured as amperage (A) of the press.

Table 1 - Comparison in terms of amperage, efficiency, abrasion and pellet length

<table>
<thead>
<tr>
<th></th>
<th>I (Amperage)</th>
<th>Efficiency (% pellet)</th>
<th>Abrasion %Fines</th>
<th>Pellet length median (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>4.23</td>
<td>36</td>
<td>4.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Corn starch</td>
<td>4.21</td>
<td>38</td>
<td>3.8</td>
<td>10.9</td>
</tr>
<tr>
<td>FlourBond*</td>
<td>4.18</td>
<td>34</td>
<td>3.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Cereal rye meal + 2.5% stearic acid</td>
<td>4.12</td>
<td>30</td>
<td>2.7</td>
<td>10.1</td>
</tr>
</tbody>
</table>

*Commercially available with Meneba BV (Rotterdam, the Netherlands); containing cereal flour

The results show that the use of stearic acid gives good quality process and pellets. These results are particularly surprising, since different experiments comparing meal with flour (but without processing aids) had shown that flour provides improved binding properties. The combination of the processing aid with meal in the above table thus shows surprising behavior. In particular taking into account that the applied pressure during pelleting (lower amperage) is also lower in the example. Referral is made to example 1A below.

The stearic acid-containing product gives the highest lubrication of the press compared to the blank due to the additional effect of the right combination in carrier-binder and lubrication. The power is significantly better than the blank but also as two commercially used binders in the wood pelleting industry. Due to the lower amperage the pellet production is slight lower. There is less force in the press and therefore less compaction of the saw dust. This is reflected in a decreased pellet length. It was observed that the temperature of the stearic acid-containing pellet was lower than in other cases (74 vs. 77-78 °C), due to the lower forces in the die exerted on the pellets.
Further improvements would be observed if the press would be run at constant throughput. Due to the lower amperages it is possible to increase throughput with the processing aid of the invention. As a result, efficiency will increase. Increased density pellets could thus be obtained.

However, perhaps most striking is the effect of the processing aid according to the invention in terms of fines. Undoubtedly, the processing aid according to the invention adds to the pellet quality over the binders commercially available.

1A - Effect of flour vs. meal

To underline the surprising results obtained with the processing aid of the invention, the results of a comparison study between flour and meal are copied here. These results are obtained without any processing aid. The example demonstrates that, without any processing aid, flour is clearly the better binder of the two. However, it has been shown in table 1 that the addition of the processing aid of the invention make up for the disadvantages observed for meal otherwise. With the processing aid of the invention, results obtained with meal are as good as with flour.

1A - Energy usage for rye meal and rye flour

An industrial press (with 12 mm die) was fed with hard wood based saw dust at constant pellet production. The energy input was measured as amperage of the press. The initial amperage without additive dropped by more than 10% after addition of rye flour (Meneba Rotterdam, the Netherlands). The energy input was also much more constant after the addition.

When changing rye flour for rye meal ("roggemeel fijn", Meneba Rotterdam, the Netherlands), the energy input increased again to higher levels. It was clearly observed that the press ran much better and smoother with rye flour than with rye meal. It was also found that the pellet quality was much better with flour (harder, smooth and less fines).

1A - Ash content

An industrial press was run at 75% of its maximum capacity of 3.5 tons/h of wood saw dust (spruce). As additives rye meal and rye flour (Meneba, Rotterdam) were used at various dosage levels. The dosage levels were controlled by feeder speed (rpm).
The results are listed in table 2 below. It shows that the dosage of additive can be reduced significantly by using rye flour instead of rye meal, while maintaining low fines and good pellet quality. Ash content was not negatively affected by using flour.

<table>
<thead>
<tr>
<th>Additive material</th>
<th>Feeder speed (rpm)</th>
<th>Ash (%)</th>
<th>Fines (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meal</td>
<td>12</td>
<td>0.27</td>
<td>0.3</td>
</tr>
<tr>
<td>Meal</td>
<td>8</td>
<td>0.25</td>
<td>0.4</td>
</tr>
<tr>
<td>Flour</td>
<td>12</td>
<td>0.28</td>
<td>0.1</td>
</tr>
<tr>
<td>Flour</td>
<td>8</td>
<td>0.26</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 2: Results tests meal versus flour

Summarizing: Without processing aid, the skilled person would find that flour acts as a better pelletization binding agent than meal.

Comparative example 2

Wood pellets based on dried saw dust were pressed with two industrial processing lines number 1 and 2 (with 2 presses each, Andritz Sprout Matador type). At line 2 no additive was added, and at line 1 a mixture of a wheat flour (Meneba BV, Weert (The Netherlands)) with 2.5% stearic acid (Interland Chemie) was applied prior to pressing.

Both lines were fed with the same wood saw dust at similar dosing speed run at an amperage as close as possible to the optimal power of 350 Ampere. Mixing was achieved batch-wise (per batch 750 kg with 5 minutes mixing periods). At start of the experiment the saw dust feed at the presses of line 1 was about 2.7 ton/h per press which means 1.4% processing aid was fed. Ash content of the pellets was between 0.35-0.45% for all cases. The fines measured by an abrasion tester slightly decreased during the test by adding the processing aid with on average about 2-3%.

The saw dust feed (wet material) was followed in time after starting the dosing of the processing aid mixture. The results clearly show a significant higher increase in throughput in line 1 compared to line 2 as shown in Table 3. As a result of higher throughput and decreased fines also the total pellet production per press (both lines together) increased from 2.8 ± 0.2 ton/h/press.
Table 3: Throughput in ton/h/line during total test

<table>
<thead>
<tr>
<th>Time(min)</th>
<th>0 (start)</th>
<th>60</th>
<th>170</th>
<th>250</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 1</td>
<td>6.05</td>
<td>6.00</td>
<td>7.85</td>
<td>7.94</td>
<td>1.89</td>
</tr>
<tr>
<td>Line 2</td>
<td>6.25</td>
<td>5.97</td>
<td>6.76</td>
<td>6.65</td>
<td>0.40</td>
</tr>
<tr>
<td>Total 1+2</td>
<td>12.3</td>
<td>12.3</td>
<td>14.6</td>
<td>14.6</td>
<td>2.29</td>
</tr>
</tbody>
</table>

Comparative example 3

Wood pellets based on dried saw dust based on very dry old mixed waste wood with high ash content (1.8 - 2.2%) were pressed on an industrial line using one press (van Aarsen type, 12 mm die), with an optimal power at 350-360 A. In this experiment it was found that it is not possible to run this type of saw dust without the compression or compaction processing aid according to the invention unless unduly complicating the mixing procedure.

Similar to Comparative example 2, two runs were performed using a binding agent [FlourBond-O, Meneba, Weert] alone and in combination with 2.5% stearic acid.

It was shown that without the addition of the processing aid a low quality pellet was obtained with 10-16% fines (abrasion test). With addition of the processing aid the fines were lowered to 4-6%.

It was not possible to run pure saw dust: The throughput had to be lowered below 60% of the optimal throughput to stay below maximal amperage of 350-360%. At this low throughput the press is not filled enough to obtained pellets. However, using the processing aid it was possible to run the press at 100% throughput without any problem.
CLAIMS

1. A process for manufacturing compressed or compacted solid fuel bodies, said process comprising mixing (a) plant origin materials with (b) 0.1 - 10 wt%, preferably 0.1 - 3 wt%, of a starch-based binding agent, based on the total weight of the solid fuel body, and (c) a composition containing at least 60 wt% of one or more saturated long chain fatty acids having an aliphatic chain length of at least 12 C atoms, and/or analogues thereof, the weight percentage based on the total weight of said composition, wherein said fatty acids and/or analogues thereof having a melting point or melting range within the range of 40 - 95 °C, wherein the weight ratio of (c) to (b) ranges between 1:200 and 1:3, and wherein the mixing of (a), (b) and (c) is performed at a temperature below said melting point or melting range, and the mixture of (a), (b) and (c) is subsequently subjected to compression or compaction at a temperature above said melting point or melting range.

2. The process according to claim 1, wherein said composition containing fatty acids and/or analogues is of non-oil renewable origin.

3. The process according to claim 1 or 2, wherein said saturated fatty acids are selected from palmitic acid and stearic acid, and/or their alcohols or esters.

4. The process according to any one of the preceding claims, wherein said starch-based binding agent is selected from the group consisting of starch, meal and flour, or mixtures thereof.

5. The process according to any one of the preceding claims, wherein said plant origin materials comprise agricultural biomass, peat, wood and/or charcoal.

6. The process according to claim 5, wherein said wood comprises hard and/or torrefied wood, wherein said hard wood is preferably selected from the group consisting of oak, beech, ash, maple, teak, mahogany and cherry.
7. The process according to claim 5, wherein said agricultural biomass comprise straw or hay, cereal milling byproducts, husks.

8. The process according to any one of the preceding claims, wherein said composition contains at least 80 wt% of palmitic acid and/or stearic acid, and/or their alcohols or esters.

9. The process according to any one of the preceding claims, wherein (b) and (c) are provided to the mixing step already as a mixture or blend.

10. A solid fuel body obtainable by process according to one of the preceding claims, said fuel body comprising one or more of the saturated long chain fatty acids according to the preceding claims, and a starch-based binding agent, preferably selected from the group consisting of starch, flour and meal, or mixtures thereof.

11. A kit-of-parts containing (b) a starch-based binding agent and (c) a composition containing at least 60 wt% of one or more saturated long chain fatty acids having an aliphatic chain length of at least 12 C atoms, and/or their analogues, the weight percentage based on the total weight of said composition, wherein the weight ratio of (b) to (c) in said kit ranges between 1:200 and 1:3.

12. A composition containing a starch-based binding agent and one or more saturated long chain fatty acids having an aliphatic chain length of at least 12 C atoms, or analogues thereof, said composition being suitable for use in the compression or compaction process to obtain solid fuel bodies, wherein the ratio of said starch-based binding agent to said one or more saturated long chain fatty acids ranges between 1:200 and 1:3.

13. The composition according to claim 12, being a free-flowing powder.
14. The kit according to claim 11 or the composition according to claim 12 or 13, wherein the starch-based binding agent is selected from the group consisting of starch, meal and flour.

15. Use of the kit according to claim 11 or 14 or the composition according to claim 12, 13 or 14 in manufacturing solid fuel bodies.
# INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. C10L5/44

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>page 1 - page 2; claims 1, 2, 3, 5, 9, 15; example 1</td>
<td>6, 9, 11-15</td>
</tr>
</tbody>
</table>

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" document member of the same patent family

**Date of the actual completion of the international search**

1 February 2011

**Date of mailing of the international search report**

16/02/2011

**Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk**

**Authorized officer**

Pol Imann, Kl aus
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>DE 199 55 844 Al (PELLETSVERBAND VERTRIEBS&lt;br&gt;UND B [AT]) 25 May 2000 (2000-05-25)&lt;br&gt;col umn 1 - col umn 2; claims 1,2</td>
<td>1-15</td>
</tr>
<tr>
<td>A</td>
<td>WD 96/14372 Al (HARDY MICHAEL JOHN [GB];&lt;br&gt;BARFORD ERIC DENNIS [GB])&lt;br&gt;17 May 1996 (1996-05-17)&lt;br&gt;pellets briquets made of wood chips,&lt;br&gt;stearic acid and starch as processing aid;&lt;br&gt;page 1 - page 5; claims 1,3,6,7; examples 1-4</td>
<td>1-15</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>DE 202007004725 U1</td>
<td>31-05-2007</td>
<td>NONE</td>
</tr>
<tr>
<td>JP 2001139726 A</td>
<td>22-05-2001</td>
<td>NONE</td>
</tr>
<tr>
<td>CA 2236546 A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DE 789740 T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EP Q789740 A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ES 2104527 T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GB 2310670 A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US 5858032 A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>