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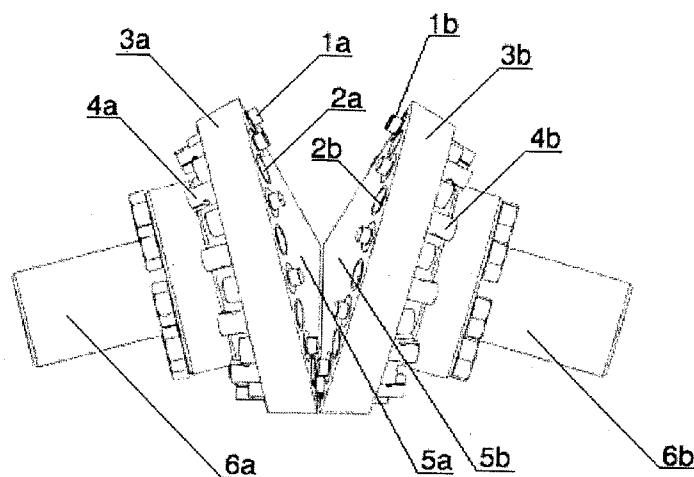


Fig. 1

(57) Abstract: Waste and biomass pellets are characterised in that the pellets size range from 15 to 40 mm, powdered calcium oxide CaO with the addition of castor oil and/or hydrated lime is used as the binding agent, whereby the pellet comprises: a) from 40 to 80% of biomass by volume with a moisture content of 35% by weight b) from 20 to 60% of dried organic waste, - c) 3 to 5% by weight, relative to the total weight of the biomass and organic waste, of hydrated lime mixed with castor oil. Furthermore, the object of the application is a method of manufacturing of the pellets and the pelletiser head used in the process.

Waste and biomass pellets, manufacturing process and the pelletiser head used in the process

The object of the invention are waste and biomass pellets, the process of their manufacturing and the pelletiser head used in the process.

The processes of pelletisation of fine-grained material that are waste products of energy fuels are known in the prior art. These processes generally require the suitable binding agent to hold the individual components of a pellet.

Polish patent PL165547 discloses briquettes which use asphalt and pitch as binding agents. Such binding agents are not preferred due to the environmental protection requirements. Polish patent PL 194593 describes pellets containing fine coal or coke or sawdust or peat or straw in which collagen obtained from animal hides was used as a binding agent.

Polish patents PL 174678 and PL 174972 describe starch and its derivatives modified with urea-formaldehyde resin as a binding agent for briquetting fragmented energy waste. Thermal energy market pays increasing attention to renewable energy sources, biomass in particular. Straw is currently the most interesting renewable fuel due to its availability and the abundance of supply. Recently, heat plants have been raising their expectations for the technologies of co-firing biomass with other organic or inorganic substances. The burning process in conventional systems is problematic since the physical and chemical properties of inorganic additives and biomass are different, which makes it necessary to significantly modify the design of a conventional boiler. Polish power plants find it difficult to finance the relevant investments (which require huge funds) and look forward to

the biomass fuel that is combustible in the existing system without causing damage to the boiler and simultaneously reducing the amount the combustion process leftovers (sulphur oxides, dust, ash). The new proposed biomass and waste fuel should make it possible to burn biomass and organic waste without the need to modify the boiler design. Simultaneous combustion of straw and organic waste without changing the boiler design damages it at a high rate due to the different physical and chemical properties of these substances. For this reason Projekt Karmelicka has decided to develop an innovative fuel that will be a combination of organic waste and biomass which, due to its properties, should not corrode conventional biomass boilers.

Polish patent PL201369 discloses the method of manufacturing of solid fuel by homogenisation and briquetting of the ingredients, whereby the key stage of the forming process takes place in a roller crusher.

Polish Patent Application P.390657 discloses a method of manufacturing fuel pellets or feed pellets characterised in that the shape-formed, vertical, sleeved slots in the horizontal fixed die are arranged at equal distances from one another in the same planes along the wheel circumference, and the convex, shape-formed, pressing elements are arranged perpendicular to the horizontal fixed die. Convex, shape-formed, pressing elements are fixed radially to the wheel rim in such a way that they sink into the vertical sleeved slots and work with each subsequent sleeved slot of the fixed horizontal die. At the same time, adequately fragmented combustible organic waste material is supplied to the entire surface of the fixed horizontal die. The patent application also describes the device that implements this method.

The practical operation of the device is hampered by a number of difficulties arising due to the use of a flat die with shape-forming slots, as even minute deviations in the arrangement of the shape-forming sleeves in the die or in the arrangement of the shape-forming punches in the rollers, as well as the wear of these parts resulted in inaccurate overlap of the shape-forming punches and the shape-forming sleeves. The device known in the prior art also encountered problems associated with unevenly distributed raw material. Excessive accumulation of the raw material mix was observed in some areas on the die, whereas in the others, the layer of raw material was insufficient, which resulted in lowered process efficiency. On the horizontal die there were also areas of accumulation of dense raw material which was unevenly directed to the die slots.

Waste and biomass pellets according to the invention are characterised in that the pellets size range from 15 to 40 mm, powdered calcium oxide CaO with the addition of castor oil and/or hydrated lime is used as the binding agent, whereby the pellet comprises:

- a) from 40 to 80% of biomass by volume with a moisture content of 35% by weight
- b) from 20 to 60% of dried organic waste, -
- c) 3 to 5% by weight, relative to the total weight of the biomass and organic waste, of hydrated lime mixed with castor oil.

Preferably, the pellet contains fragmented biomass and organic waste with grain size lower than 6 mm.

Preferably, the pellet contains 70% of biomass by volume.

Preferably, the biomass has a moisture content of 27 to 29% by weight.

Preferably, cereal straw, oilseed rape straw, miscanthus, dried corn cobs and/or stalks or coconut palm fibres are used as biomass.

Preferably, the pellet contains 30% of dried organic waste.

Preferably, the dried organic waste has a moisture content of 30 to 40% by weight, more preferably 35% by weight.

Preferably, the dried organic waste comprise beet pulp, coffee pulp, bran, baking yeast, dairy waste or dried sludge from biological wastewater treatment plants.

In another aspect, the invention relates to a method of manufacturing waste and biomass pellets characterised in that straw is fed via a feeding table to a chopper which reduces the granularity to about 10 cm, and subsequently transported, via a fan integrated with the primary impeller of the chopper, to the mixer which is also a buffer container and a conveyor, after which the fragmented straw in the dispensing buffer is transported by two screw conveyors to two initial pelletisers in which the process of final pelletisation occurs, accompanied by the mechanical degradation of the straw fibres, whereby in the course of this process the temperature of the raw material increases to approximately 100°C due to friction, as a result of which some of the moisture evaporates, whereby the initial pelletisers are equipped with a spraying system, which activates if the raw material is too dry, and then, when the moisture sensor indicates the value in the range of 14-18%, the raw material is transported via screw conveyors to the mixers located directly above the final pelletisers,

after which it is transported to the final pelletisers, where the semi-finished material is shaped into pellets.

In another aspect, the invention relates to the head of the pelletiser, which is characterised in that it has a conical working surface equipped with punches and/or sleeves, which extend into the die as tubes, whereby the sleeves and/or the punches are arranged on the working surface of the body of the head at least in one row located along the circumference of a circle whose centre is the centre of the head, and the head is mounted on a drive shaft which connects it to the drive unit, whereby the head comprises at least one row of concentrically arranged sleeves and/or punches.

Preferably, if both punches and sleeves are arranged on the surface of the working head, the punches alternate with the sleeves.

The objects of the inventions are described below in the embodiment designs, and are shown as figures, whereby fig. 1 and 2 show two co-operating heads, whereby each head is equipped with alternating shape-forming sleeves and punches, fig. 3 shows a single head from fig. 1 and fig. 2, fig. 4 shows a head equipped only with punches, fig. 5 shows a head provided only with slots.

The development of a biopellet manufacturing technology aims to create a new type of fuel, whose combustion would significantly reduce the emission of sulphur oxides (SO_x) into the atmosphere. This issue is particularly important due to the fact that from 2015 all power plants will be required to significantly reduce the emission of sulphur oxides into the atmosphere from its current level of 1200 mg/m³ to 400mg/m³, to comply with the Directive of the European Parliament and Council Regulation (EC) No 2001/80/EC of 23 October 2001 on

the limitation of emissions of certain pollutants from large combustion plants.

To meet this objective, conceptual studies were carried out which set out the basic units necessary for the proper operation of a production line, as well as works (related to structure and technology) to design the respective devices involved in the "method of manufacturing" of waste and biomass pellets.

It was established that the line for production of waste and biomass pellets should consist of four main units.

1. Biomass (straw) fragmentation unit with a system for feeding bales
2. Drying unit integrated with the fine-milling system
3. Pelletiser unit connected with the buffer container
4. Unit for cooling and packaging the finished product

It was assumed that the new designed line should be operated by at most two workers; therefore, special attention was paid to the design of the control and automation system.

Due to the fact that the moisture of the raw material is critical in the pelletisation process, the control and automation system was equipped with a system for constant measurement of biomass moisture.

The key task for the invention involving the development of the optimal formulation of waste and biomass pellets was carried out by first determining the percentage of each material in the fuel. On the basis of the usage samples, the optimal ratio, in terms of technology, of biomass and organic waste by weight was determined.

For this ratio, the load of the pelletiser proved to be most stable over time and the yield of the pelletisation process was the highest.

For comparative purposes, one batch of waste and biomass pellets was manufactured with 1% addition of calcium oxide CaO, and one batch was manufactured without this addition.

Thus prepared fuel samples were combusted in several types of boilers. The aim of this study was to determine the physical and chemical properties of the fuel and to test their combustion under operating conditions in retort burner boilers of different capacities, ranging from 15-20 kW to 60-75 kW of thermal output. The problem of the waste generated in the process of combustion of waste and biomass fuel was also addressed by carrying out internal analysis of the samples of residue ash after combustion of the fuel. The aim of this study was to determine the possible impact of the ash on the environment.

As a result of the research and development work, a prototype line for the production of waste and biomass pellets was tested.

The parameters of the main components of the pelletiser for waste and biomass pellets were determined. The main differences involve the geometry of the compaction area, which needs to be adjusted to the type of the raw material used. It was determined that for the production of waste and biomass pellets the demand for power is about 30% greater compared to the production of pure biomass, mainly due to the impact on the product of the use of organic waste of different consistency.

Straw drying tests using fluid bed dryer revealed that this method makes it difficult to transport the fragmented biomass, therefore a

tunnel dryer was used, which doubles as a conveyor transporting the straw to a hammer mill. This configuration also had disadvantages due to eventual clogging of the device by waste and biomass pellets. Optimum moisture categories for straw, which is the raw material for the manufacture of waste and biomass pellets, were determined.

On the basis of the tests and observation of the pelletisation process, we suggest three possible types of pelletisers to be used for the new method. These are pelletisers with flat, drum or ring die.

The waste and biomass fuel was subjected to the following internal tests:

- Physical and chemical tests
 - Elemental composition of the fuel
 - Elemental composition of the ash
 - Moisture content
 - Ash content
- Energy tests
 - Calorific value
 - Combustion heat
- Emission tests
 - Dusts
 - SO_x
 - OGC

- CO

The values of energy parameters and emission were measured under operating conditions for boilers with retort burner of different capacity. The combustion test for 15-20 kW boilers involved waste and biomass pellets with 1% addition of calcium oxide CaO and without this addition. In both cases, a positive effect of calcium oxide was observed on the content of SO_x in the flue gas. The addition of CaO also contributed to the stability of the combustion process (there were no sinters that would obstruct the flow of air to the fuel). The object of the tests was also to determine the elemental composition of the ash, including the elements of agricultural value (potassium, phosphorus, calcium, magnesium) and the content of heavy metals. The tests shown that the ash obtained from the combustion of waste and biomass pellets can be used as fertiliser or as a so-called soil improver to be used in the amount of 3-4 t/ha.

Waste and biomass pellets were developed to combine the advantages of the commonly used carbon fuel "ekogroszek" and of biomass pellets, and to eliminate the disadvantages of these fuels, as well as to take advantage of a number of the available waste organic material that are currently not recycled or recycled to a limited extent.

"Ekogroszek" coal was introduced to the market in the 1990's and was received very well due to a number of its advantages:

- it was suitable for combustion in automatic boilers
- it had high calorific value
- it had low sinterability (did not cause slag to form)
- it had good emission properties (low sulphur content)

About 150 000 boilers were installed in Poland with this fuel in mind; its annual consumption amounted to 1.5 million tonnes. "Ekogroszek" characterised by good calorific value and low emission was obtained from several deposits in Polish coal mines. However, these deposits were exhausted at the end of the first decade of the twenty-first century. As of today, a variety of coal types are sold under the name "ekogroszek" with the "pea" particle size ranging from 6 to 32 mm, which, unfortunately, do not have all the advantages of "ekogroszek".

Wood pellets are environmentally friendly fuel that can be burned in retort burner boilers. On the other hand, this type of fuel is expensive and is produced mostly from full-value timber. Pellets made from raw materials of agricultural origin are an alternative to wood pellets. The source of raw material for this type of fuel is cereal, rape or corn straw, meadow hay and biomass from mown idle land.

Pellets made of agricultural biomass have, however, several drawbacks, which make it difficult or impossible to use this fuel in low-output boilers. These drawbacks include in particular:

- tendency to slag due to the low softening and flowing temperature of the ash;
- high amounts of chlorine, i.e. the element corroding the heat transfer systems in a boiler;
- lower calorific value;

The following table presents the selected parameters of waste and biomass pellets manufactured from various types of biomass:

Parameter	Cereal straw	Hay pellets	Fruit pomace	Waste and
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	pellets		pellets	biomass pellets
Combustion heat MJ/kg	16.1	15.998	17.816	18.1
Moisture %	7.4	7.2	5	7.6
Calorific value MJ/kg	14.4	14.1	16.216	17.566
Ash content %	11.8	11.4	11	10.5
Carbon content %	41.9	41.8	46.1	44.3
Chlorine content %	0.248	0.354	0.142	0.112
Total sulphur content %	0.19	0.15	0.23	0.20
Ash sulphur content %	0.1	0.11	0.12	0.1
Pellets density kg/dm ³	1.25	1.3	1.4	1.35
Pellets bulk density kg/m ³	520	550	760	775

Source: own research

Combining carefully selected organic waste and agricultural biomass with the addition of CaO or Ca(OH)₂ resulted in unexpectedly high quality fuel, free from the drawbacks of the raw materials.

Waste and biomass pellets share some of the advantages of "ekogroszek" coal, such as:

- high calorific value,
- low moisture content from 2 to 8%
- no crumbling
- no moisture absorption

- can be combusted in all pellet boilers;

and some advantages of biomass pellets:

- reduced carbon emissions,
- calcium oxide binds the sulphur present in the ash, which substantially reduces the emission of SO_x in the flue gas
- easily transported by a screw feeder
- no dust generation
- no slag generation

The following table presents the main parameters of waste and biomass pellets:

Parameter	Symbo l	Value	Unit of measur e	Notes
Dimensions	Øx l	18x40	mm	
Calorific value	Q	18123	kJ/kg	mean value
Total moisture content %	W _{tr}	9.2	%	
Moisture content	W _a	7.2	%	
Ash content	A _r	10.5	%	
Volatile compounds content	V _a	49.76	%	
Total sulphur content	S _{ta}	0.8	%	
Ash sulphur content	S _{Aa}	0.5	%	
Combustible sulphur content	S _{Ca}	0.3	%	
Carbon content	C _{ta}	53.9	%	
Hydrogen content	H _{ta}	4.75	%	

Nitrogen content	Na	0.78	%	
Chlorine content	Cl _a	0.088	%	
Fluorine content	F _a	0.005	%	
Ash sintering point	t _s (Or)	1000	°C	
Ash softening point	t _A (Or)	1290	°C	
Ash melting point	t _B (Or)	1330	°C	
Ash flowing point	t _C (Or)	1340	°C	

Source: own research

In the course of the studies, the optimal composition of the raw materials used to manufacture waste and biomass pellets was determined allowing to produce the fuel with optimal calorific and environmental properties.

The following conclusions were drawn on the basis of the studies:

- energy and emission tests carried out using a central heating boiler with automatic fuel loading, equipped with a screw fuel feeding system and a 2nd generation retort furnace, with a nominal capacity of 15-20 kW demonstrated that:
- SO₂ emission values for waste and biomass pellets, determined to be at the level of 657 and 750 mg/nm³, are much lower than the value of 1100 mg/nm³ required for environmentally friendly fuels.
- nitrogen oxides emission values determined to amount to 350 g/Nm³ are lower than the value of 400 mg/nm³ required for environmentally friendly fuels.

It should be added that the emission values were impacted, in addition to the type of fuel, also by the type of installation in which the fuel is burned and the boiler load.

Performance tests carried out using a Heiztechnik QEKO DUO 60 boiler with a nominal output of 58.5 kW resulted in the sulphur oxides emission values in the range from 143 to 159 mg/nm³ at 92% boiler load.

The analysis of the results of the combustion tests using the Heiztechnik Duo boiler and waste and biomass pellets clearly shows that that addition of calcium oxide in the fuel decreased the sulphur dioxide content in the flue gas by 15%, compared to the same fuel without the addition of CaO. Therefore, it may be concluded that the addition of 1-2% of calcium compounds is the cheapest and relatively efficient method of "desulphurisation" of the flue gas

Method of manufacturing of waste and biomass pellets

A key issue in the process of pelletisation of waste and biomass is the use of an appropriate pelletisation head for the production of fuel or feed pellets. The method of operation of these devices involves compacting organic material and pressing it through dies. The material, depending on the purpose of the pellets, may be agricultural biomass, sawmill biomass, cereals, rape or corn straws, vegetable pomace, bran, sawdust and other waste material or their mixtures originating from agriculture or industry. The material for the production of fuel pellets may be combined with additives such as organic waste and may contain other additives, such as fillers and binding agents.

The head and the device used to perform the production tests of waste and biomass pellets allow to carry out the process in an even

manner and with high efficiency. The device heads work in pairs, so that their working surfaces, that is the surfaces equipped with sleeves and punches, are always in motion. As a result, the raw material mixture is additionally mixed and, on the one hand, it is naturally pulled down, while on the other, it is grabbed by the moving heads.

Fig. 1 and 2 show the head in the first embodiment design, working with the second similarly shaped head (a system of two heads). The head according to the invention has a conical working surface (5a) equipped with punches (1a) and sleeves (2a), which extend into the die as tubes 4a. The sleeves 2a and punches 1a are arranged on the working surface 5a of the body 3a of the head alternately in rows on the circumference of the conical working surface 5a. The head is mounted on the drive shaft 6a, which connects it to the drive unit. The head may comprise one, two, three or more concentrically arranged rows of sleeves and/or punches. On the other head, working with the first head, the arrangement of punches 1b and sleeves 2b (which include tubes 4b) on the conical working surface 5b of the body 3b represents the arrangement of the punches and sleeves on the first head. The second head is also mounted on the drive shaft 6b, which connects it to the drive unit. During their operation, the heads are arranged so that each punch 1a and 1b meets the sleeve 2a and 2b. The easiest way to accomplish this is to arrange the sleeves and punches in regular, equal distances, so that one head is a mirror reflection of the other, i.e. that punches 1 and sleeves 2 are located opposite each other during operation.

Fig. 3 shows a single head from the system of working heads, described above. The conical working surface 5 of this body 3 of the head is equipped with punches 1 and sleeves 2.

It is, however, possible to configure the production of waste and biomass pellets so that the conical working surface 5 of the body 3 of the head is equipped only with punches 1 or only with sleeves 2. Heads with this arrangement are shown in fig. 4 and 5. In this arrangement, the head with sleeves works with the head with punches.

The punches located in the heads, as the elements whose purpose is to effectively press the material, are made to always match the shape of the sleeves. Fig. 2 shows an example configuration of the heads in a device forming pellets or briquettes. The S arrow shows the direction of raw material feed, which is gravitationally fed from the top.

The device for the manufacture of fuel or feed pellets may consist of basically any number of systems of heads arranged in working pairs, i.e. of working head pairs. At least one head of the system of two heads working together is connected through a drive shaft to the drive unit.

The movement of the two working heads allows to grab the raw material, press it through the slots and crush it. If only one head is connected to the drive unit, it is necessary to transmit the drive through the engagement of the punches of one head and the slots of the opposite head, which is mounted in a bearing seat so as to allow its free movement. If, however, both cooperating heads are connected to drive units and driven independently, which is a variant of the invention, their speeds are adjusted by using the appropriate transmission ratio, so that the working elements do not rub against each other during operation. This solution significantly increases the service life by eliminating metal-metal friction.

The shape of the tube sleeves and punches located on the head is preferably cylindrical, but may also be of oval, square or triangular cross-section. The cylindrical shape is most convenient for a number of reasons. The diameter of the slots forming the fuel, and thus the diameter of the obtained briquettes or pellets can be relatively freely chosen – the size may vary from a few millimetres to a few centimetres, i.e. from 6 to 25 mm.

The heads can be arranged so that below their working surface the raw material is directly or indirectly fed back into the device.

The head of the device manufacturing fuel pellets or feed pellets equipped with shape-forming sleeves and/or shape-forming punches, characterised in that it is equipped with a conical working surface (5) provided with punches (1) and/or sleeves (2) passing through the body (3) of the head.

The head, through the drive shaft (6) located on the opposite side of the conical working surface (5) of the body (3), is connected to the drive unit or is mounted on the shaft (6) and is mounted in a bearing seat.

A system of heads, equipped with shape-forming sleeves and/or shape-forming punches, of a device manufacturing fuel pellets or feed pellets consists of two cooperating heads whose conical working surfaces (5) face each other, whereby each of the two heads is equipped with punches 1 and sleeves 2 or one of the heads is equipped with punches (1) and the other with sleeves (2).

The system of the heads in which the arrangement of the punches (1) and/or sleeves (2) on the working surfaces (5) of the

heads reflects the arrangement of the punches (1) and/or sleeves (2) on the opposite head cooperating with the first head.

A line for the manufacture of the waste and biomass pellets under the invention

The attempts to manufacture waste and biomass pellets were made using a mobile pellets production line made by ZUK Staporków SA. It is a mobile technology line, installed on one or two semi-trailers or container platforms, whose purpose is production of waste and biomass pellets. It is a fully functional manufacturing facility which converts the raw material in the form of straw bales into a full-value product in the form of pellets.

The raw materials include cereal, rape or corn straw, hay and biomass from mown idle land. Energy crops, i.e. miscanthus or sida, as well as fruit pomace, dried fruits, and exotic plants (coconut palm, bamboo, etc.) are a very good source of raw materials.

Biomass as a product of photosynthesis is a form of accumulated solar energy. Biomass is considered renewable energy since plants can grow as long as there is sunlight and the soil is fertile.

The energy potential of biomass is a function of the fuel form (biological resource), type of material, moisture content, type, and the resulting calorific value. The positive role of biomass as a fuel is not only due to its renewability, but also its availability, quantity, chemical composition and the costs of acquisition. Biomass is generally recognised as "environmentally clean" fuel compared with fossil fuels. Biomass is environmentally friendly because of the fact that amount of CO₂ emitted during its combustion is equal to the amount of CO₂ absorbed by this renewable biofuel through photosynthesis.

Combustion of fuels pollute the atmosphere with large amounts of carbon and nitrogen oxides, sulphur dioxide and dusts.

The following materials were used in the study:

- 1) aronia pomace obtained from industrial trials,
- 2) black currant pomace obtained from industrial trials,
- 3) carrot pomace obtained from industrial trials
- 4) apple pomace
- 5) tomato pulp
- 6) coal W

Solid fuels quality.

The ash content was determined according to PN-G-04560:1998. The content of volatile compounds was determined according to PN-G-04516:1998; calorific value was determined according to PN-81/G-04513; total sulphur content and ash sulphur content were determined according to PN-G-04584:2001; the content of carbon, hydrogen and nitrogen (C, H, N) were determined according to PN-G-04571:1998.

Estimation of gas and dust emission

The emissions indicator method was used to determine the amount of emission of the respective gases and dust related to the use of non-conventional energy sources. The emissions were determined using the following formula:

$$Emissions = A * WE$$

where:

A - activity, Mg, WE - emission factor, kg/Mg.

The following assumptions were made when calculating the amount of emissions:

- combustion in a furnace boiler with a nominal capacity of 100 KW
- boiler efficiency is 85%.

The amount of fuel burned per hour was determined from the following relationship:

where:

fuel consumption,
B - kg/h,
nominal capacity of
M - the boiler, kW,
combustion
 η - efficiency,
Wd - calorific value, kJ/kg.

Due to the absence of literature data on the emission and release factors involving combustion of the studied biomass from fruit and vegetable waste, it was decided to determine these factors. The widely used IPCC/OECD methodology was the basis for the calculation.

The methodology used to estimate the emissions bases on the parameters of the fuel in its operating condition, as well as on the data

relating to the combustion methods and technologies. Therefore, Table 1 summarises the parameters of the operating condition of the analysed fuels useful for such determination.

The results of the analysis of the operating condition of the fuels listed in Table 1 confirmed the prevailing belief that biomass is a fuel that is characterised by: lower calorific value, lower sulphur content and lower ash content when compared to coal.

The estimated amounts of emission are based on the emission factors of EMEP/CORINAIR Atmospheric Emission Inventory Guidebook and the factors developed by the Ministry of Environmental Protection, Natural Resources and Forestry. This analysis applied both methods of estimating emission factors, using unit emission factors for coal, as determined on an experimental basis in relation to the specific type of boiler.

The calculated values of unit emissions of WE expressed in kg/GJ and presented in the table below confirm the argument made by a number of experts and researchers, who claim that a particular advantage of biomass energy sources is the lower resulting emission of CO₂ and SO₂ during their burning due to the elementary composition of this fuel. According to the researchers, the advantages also include lower rates of emissions of most of other gases as a result of combustion of biomass, as compared with conventional fuels, primarily with coal. In the case of the analysed biomass sources, the increase of the emissions level was noted only for nitrogen oxides.

The emission of CO for biomass combustion depends on the process conditions, the type and age of boiler and the type and properties of the burned material. For the purposes of this study

WECO was adopted for a furnace boiler with a fixed grate.

The WECO values for BZBO presented in the table proved to be lower than those for coal; about 12-14% lower for apple and carrot pomace, about 17-22% lower for aronia and black currant pomace, and about 24% lower for tomato pulp.

In contrast, clean sources of waste biomass, in particular tomato pulp and currant pomace (average WECO = about 2.9 kg/GJ), result in much lower CO emission into the atmosphere compared to coal. The value of BZBO emission factors for apples, carrots and aronia was determined to be in the range of 3.1-3.4 kg/GJ. Similar values (approximately 3.4 kg/GJ) for beet pulp biomass are cited in the literature. For traditional biomass, the literature cites the following WECO values: straw 0.038-1.15 kg/GJ, wood approx. 0.04 kg/GJ. The wide span of data indicates that the parameter depends on the applied technology and method of combustion and attests to the difficulties in the calculation method.

Table: Main statistical measures of energy properties and elemental composition of fuel expressed as the operating condition. Biomass sources:

BJ – apple

BM – carrot

BP – currant

BA – aronia

B. POM – tomato

Fuel	Ash	Calorific value	Total sulphur	Ash sulphur	Combustible sulphur	Carbon	Nitrogen
	$\pm S_x$						
	%	KJ/kg	%	%	%	%	%
BJ	1.24 $\pm$		0.06 $\pm$	0.01 $\pm$	0.06 $\pm$	43. $\pm$ 0.5	0.78 $\pm$
	0.03	15937.8 $\pm$ 62.3	0.01	0.01	0.01	73 0	0.10
BM	3.40 $\pm$	16231.6	0.08 $\pm$	0.00 $\pm$	0.08 $\pm$	43. $\pm$ 0.2	1.59 $\pm$
	0.21	7 $\pm$ 75.83	0.01	0.00	0.00	61 0	0.06
BP	2.90 $\pm$	20863.0	0.30 $\pm$	0.02 $\pm$	0.28 $\pm$	50. $\pm$ 0.3	2.61 $\pm$
	0.21	0 $\pm$ 46.86	0.02	0.00	0.02	27 9	0.11
BA	1.65 $\pm$		0.08 $\pm$	0.02 $\pm$	0.00 $\pm$	50. $\pm$ 0.4	0.75 $\pm$
	0.02	19641.3 $\pm$ 75.0	0.01	0.01	0.00	73 1	0.10

B	-2.65 ±		0.30 ±	0.01 ±	0.30 ±	54. ±0.3	3.24 ±
POM	0.07	23275.3 ±69.0	0.03	0.01	0.04	90 5	0.06
W	18.66 ±		0.46 ±	0.2 ±	0.26 ±	66.	1.16 ±
	3.32	26103 ±1195.2	0.14	0.02	0.17	57 ±2.8	0.09

Table: Emissions of gas and dust for biomass and coal

Fuel	WECO	WENox	WESO2	WE _{dust}
	kg/GJ			
BJ	3.38	80.90	0.17	0.10
BM	3.31	64.61	0.35	0.26
BP	2.97	58.88	0.44	0.18
BA	3.18	63.13	0.13	0.11
B - POM	2.91	57.03	0.49	0.14
W	3.83	70.87	0.04	1.14

The CO₂ emission values presented in the table show a wide variation for biomass sources. They are approximately 9-19.5% lower than for coal; only in the case of lower energy BJ the level is higher. The following sequence can be established (not including BJ):

BM > BA > BP > BPOM. It is worth noting that this sequence almost entirely corresponds to the sequence of carbon content in the biomass sources.

A comparison of CO₂ emission values expressed per a unit of energy reveals that the values are noticeably lower (57-65 kg/GJ) than the factors for coal (71 kg/GJ), which applies to the majority of the analysed biomass sources. Only relatively low-energy apple pomace shows a higher value (at 81 kg/GJ), which corresponds to the value for beet pulp (83 kg/GJ). The emission factor of carbon dioxide adopted for coal proved to be significantly lower than cited in the literature (94-100 kg/GJ), which can be attributed to, on the one hand, the lack of clear methods of data estimation and, on the other hand, the differences between the theory and the measurement data. In relation to the value of this factor for wood and bagasse (approx. 102 kg/GJ), the studied sources of biomass proved to be fuel much less demanding on the environment.

The results of combustion tests of BZBO biomass sources confirm that biomass, as compared to coal, is characterised by a high content of volatiles, although this value varies between the respective sources of biomass.

It is worth noting that some literature sources cite that during degassing fuel, nitrogen is divided between the released volatiles and the obtained coke breeze, the proportion depending on the type of fuel. The studies described in these literature sources demonstrate that the nitrogen content is comparable to that of volatiles. This theory shows that the emissions of NO_x as a result of the combustion of biomass sources can be higher than that for coal.

It should also be noted that the biomass sources analysed in this research vary in terms of nitrogen content, whereas vegetable waste, mainly tomato pulp, are characterised by the levels of this element significantly higher than that of coal. The calculated emission factor

values presented in the table and expressed in kg/GJ for each biomass source are higher than those for coal [respectively: apple pomace – tomato pulp: 0.17 – 0.49 kg/GJ, coal: 0.04 kg/GJ], and the compositions can emit significantly more nitrogen oxides. This data is in line with the results of the tests carried out by Kubik [19] involving unit emission of NO_x calculated for the combustion of beet pulp (WE NO_x = 0.36 kg/GJ).

It should be emphasised that these values depend on the quality and composition of the burned fuel, and on the methods and technology of combustion. Therefore, the available literature cites a large spread of results for similarly specified fuels.

The obtained results confirmed the hypothesis that the sulphur content in the fuel correlates with the amount of sulphur oxides produced during the combustion. As shown in the table, biomass sources are characterised by a lower, albeit diverse total sulphur content, thus the determined emission values for their combustion, shown in Table 3, also vary, but are lower than the values for coal. They can be arranged in the following sequence: ESO_{2w} kg/GJ: BJ = BA - 0.06 < BM - 0.10 < BPOM - 0.25 < BP - 0.27 < W - 0.28. This means that SO₂ emission necessary to obtain a unit of energy from apple and aronia pomace is lower than that of coal by about 80%, whereas for tomato pulp this value is lower by only 11%. It is worth reminding that similar relationships were observed by analysing the elemental composition of these fuels – the highest total sulphur content was observed for currant and tomato waste, significantly lower for carrot and aronia pomace, and the lowest for apple pomace. The results of thus estimated emission factors correspond with those described in the literature for beet pulp (at the level of 0.11 kg/GJ) and for straw (0.1-

0.17 kg/GJ). They are, however, significantly higher than for wood (at the level of 0.01-0.03 kg/GJ). This means that in relation to conventional straw biomass, the value of SO₂ emission for apple, aronia and carrot pomace is similar, and is significantly higher compared to wood biomass.

It should be noted that some researchers indicate higher values of the emission factor of sulphur dioxide for coal, in the range of 0.4-0.5 kg/GJ, which can be most likely attributed to the quality of the fuel used.

The potential to generate dust is considered to be related to the "environmental friendliness" of a fuel type. It depends, among others, on the ash content in the fuel, furnace type and combustion conditions. The results of the chemical composition analysis of the tested biomass sources confirmed the hypothesis made by many researchers that biomass is characterised by much lower ash content than coal. Therefore, in theory, the dust release rate for OZE biomass, as compared to coal, should reflect such relation. The data presented in the table relating to dust indicate its amount which is lifted from the furnace along with the volatile compounds constituting the flue gas stream, therefore indicating the value of the release. They do not account for the ratio of reduction of dust in the flue gas resulting from the operation of a dust collector. The results for the determined release factors for the burned biomass sources are more than 77% (up to 90%) lower than those for the analysed coal. This phenomenon is also confirmed by the reports available in the literature, involving comparative analyses of actual combustion processes for wood, straw and coal in terms of emission differences. Similar results were obtained for beet pulp, for which the dust release rate was

approximately 40% lower compared to the value for the analysed coal.

As mentioned above, the volume of pollutants emitted into the environment during the combustion of fuels depends on their reactivity, parameters of the combustion process and conditions in the combustion chamber. Large-scale combustion of biomass is carried out in low capacity furnace boilers, which can be installed in municipal facilities and in distributed individual heating systems.

An attempt was made to use the previously calculated emission factors to determine the gas and dust emission values for biomass sources and their combinations with coal in model heat facility conditions. The emissions analysed in this work were estimated for a low capacity (nominal output of 100KW) grate furnace boiler, commonly used to burn biomass.

The calculated CO (ECO) emissions, as summarised in the table, are lower than the emissions from coal. ECO decrease for biomass in relation to coal in the range of 15-20%.

Similarly, on the basis of the results shown in this table, it was concluded that the emissions of CO₂ (ECO₂) from biomass sources (with the exception of lower-energy apple pomace) are lower than the emissions from coal.

Table: Estimated gas and dust emissions for a furnace boiler with a nominal output of 100KW and efficiency of 85%

Fuel	Max fuel	Gas emissions	Dust emission
------	-------------	------------------	------------------

	con- sum- ption					
	B	EC O	EC O ₂	ENO x	ESO 2	Edust
	Mg/h	kg/h				
BJ	0.026 6	1.4 3	34.3 0	0.0 7	0.0 3	0.04
BM	0.026 1	1.4 0	27.3 7	0.1 5	0.0 4	0.11
BP	0.020 3	1.2 6	24.9 4	0.1 9	0.1 1	0.07
BA	0.021 6	1.3 5	26.7 8	0.0 6	0.0 3	0.05
B - POM2	0.018	1.2 3	24.1 6	0.2 1	0.1 1	0.06
W	0.016 3	1.6 3	30.1 6	0.0 2	0.1 2	0.49

There is no legal obligation to pay for the emission of CO₂ from pure biomass (as human contribution to the amount of this gas in the

natural circulation cycle), which is the case for biomass-coal combinations. Consequently, the emissions statements for biomass combustion process often provide no data on the amounts of emitted CO₂, which makes it difficult to discuss test results.

The emission of nitrogen oxides is not a simple function of the elemental composition of the fuel, but is associated to a greater extent with the methods and technology of combustion. In the case of NO_x emissions, biomass sources proved to be less environmentally friendly fuel than coal. This refers in particular to tomato pulp, black currant pomace and carrot pomace.

Emissions of sulphur dioxide and volatile dust are commonly accepted indicators of "environmental friendliness" of fuel. The calculated emissions of sulphur dioxide and total dust confirmed that all biomass sources show significantly lower emission of these substances compared to coal.

The calculated emissions of gas and dust therefore confirm, in most cases, the hypothesis of "environmental friendliness" of fuels from waste biomass.

An analysis of the ecological values of the tested biomass revealed that WECO for biomass sources are about 12-24% lower than for coal.

Also the calculated emissions (for furnace grate boiler with low capacity) of CO for biomass sources are lower than the emissions from coal ECO.

Additionally, the CO₂ emission values for sources of biomass are approximately 9-19.5% lower than for coal, although the values vary,

and in the case of lower energy BJ – the level is even higher. Similarly, lower emission of CO₂ from biomass sources were observed (with the exception of lower-energy apple pomace).

In the case of NO_x emissions, biomass sources unexpectedly proved to be less environmentally friendly fuel than coal.

The determined values of SO₂ emission for the combustion of biomass vary, but are lower than the emission values for carbon: SO₂ emission necessary to obtain a unit of energy, in the case of apple and aronia pomace, is lower than that of coal by about 80%, whereas for tomato pulp this value is lower by only 11%.

The results for the determined release factors for the burned biomass sources are significantly lower (80÷90%) than those for the analysed coal.

It can be therefore concluded that the calculated total sulphur dioxide and dust emissions [kg/h], as indicators of the environmental friendliness of fuel, confirmed that all biomass sources are characterised by lower emission level, relative to carbon, of these substances and therefore can be called “environmentally clean” biomass energy sources.

The output of a system with two pelletisers depends largely on the type and parameters of the raw material (moisture content and degree of fragmentation). In the conducted tests it ranged from 0.5 to 0.7 t/h.

Modules of the line used to manufacture waste and biomass pellets.

1. Fragmentation module together with the feeding table (scraper conveyor), which prepares the raw material by cutting it into pieces about 10 cm in size.
2. Mixing and pelletisation module, which thoroughly mixes of the raw material until its consistency is homogenous, then compacts it into pellet with a diameter of 18 mm.

Both modules are installed on separate container platforms or semi-trailers and are connected to each other with flexible pneumatic transport tubes which allows to freely arrange them.

Control system

There are two possible modes of operation in the production of waste and biomass pellets:

1. manual mode
2. automatic mode

In manual mode, it is possible to individually enable and disable each receiver in both directions, and to control the speed of the motors equipped with frequency converters (inverters).

In automatic mode, the two systems are controlled automatically.

1. Biomass fragmentation system

The rotational speed of the chopper drum and the feed rate of the feeding table are adjusted on the basis of the current of the main chopper motor. The value of the current of the main chopper motor should be around the rated current value.

In case of a prolonged overload of the main chopper motor, the system shuts off all power consuming devices of the section.

2. Biomass pelletisation system

The raw material feed rate is adjusted on the basis of the load current of the pelletiser. In case of a prolonged overload of the pelletiser motor, the drive of the feeder and pelletiser is shut down. If mixer motors are overloaded, they are shut down together with the entire chopper module and the fan.

The control system in the automatic mode also makes it possible to disable the chopper section if the mixer is overflowing.

Emergency stops (mushroom head type) located on the control cabinet, by the pelletisers and near the chopper, allow the staff to turn all these devices at once in case of an emergency.

Sequence of turning on the power consumers in the automatic cycle

1. Mixer
2. Chopper main drive
3. Chopper drum rotation drive
4. Feeding table drive
5. Pellet coolers drives
6. Pelletisers drives (in sequence)
7. Dispensers drives

Waste and biomass pellets manufacturing process:

A front end loader provides straw bales onto the chain scraper feeder, which transports them to the drum chopper. Straw is fragmented in the drum into 5-10 cm long sections. The chopper is a new, proprietary design which sequentially unrolls the bales, pulls the straw and cuts it into chaff.

From the preliminary chopper, via a fan integrated with the chopper shaft, the straw is transferred to the mixer which serves as a homogeniser and a buffer container. The volume of the mixer is adjusted to ensure the operation of the pelletiser for about 2 hours, even if the straw chopper is not running. Due to the use of a mixer, additional drying of the raw material is not necessary, which lowers the amount of energy consumed by the system. Screw feeders of special design, installed above the system of pelletisers, continuously feed the fragmented material into the work area of the pelletisers. After pelletisation, the final product is transported to the pellet cooler, where it is cooled and evaporated. Moisture content of the pellets after cooling is 10-14%.

The control system ensures stable feeding of the raw material, so that the pelletisers drive motors operate within the rated loads. The system of pelletisers of new design operates effectively for moisture content up to 25%. Optimal moisture content of straw used to manufacture the product of highest quality is 14-18%.

Mobile pellet production facility can be powered from the mains or via an electric generator, with a capacity of about 180 kVA.

The pelletiser uses punches compacting the pressed material, which significantly improves the efficiency of the process and reduces its energy consumption.

The components prone to rapid wear (pressing punches and shape-forming sleeves) are designed in a way that allows their easy replacement.

The new type of pelletiser efficiently presses the pre-fragmented material to the size of 10-15 cm and with moisture content of 25%. Conventional designs require fragmentation of material to the size of 1-3 mm and moisture content not higher than 18%.

Use of the mixer-homogeniser

The mixer also serves as a buffer container, allowing for consistent and stable operation of the system.

The mixer is equipped with feed connections, which allow other components to be added to the basic material, e.g. coal dust, lime or binding agents.

At the stage of the mixing, adequately prepared organic waste can be successfully added.

In particular, from 20 to 60%, preferably 30%, of adequately prepared and dried organic waste can be added, wherein the preferable moisture content is 30-40% (most preferably 35%). The organic waste may comprise, in particular, beet pulp, coffee pulp, bran, baking yeast, dairy waste or adequately dried sludge from biological wastewater treatment plants. They should be sorted out. The organic waste can be added to the mixer or directly to the pelletiser. Adding it

at the mixer stage results in better quality and homogeneity of the pellets.

- mobility of the line – if there is no raw material, the facility can be moved to the source of the raw material. Power supply via a generator allows the facility to operate in all conditions, independent of the power grid.
- parallel operation of two pelletisers allows to carry out any maintenance works without shutting down the entire facility.
- eliminating the need to dry the raw material and replacing it with thorough mixing significantly contributed to the reduction of energy consumption of the pelletisation process.
- in the new biomass pelletisation process, the raw material does not have to be finely fragmented (as required by all conventional technologies). This substantially lowers the manufacturing costs.
- low energy consumption – approximately 80kWh per tonne of the product. Conventional pellet production technologies, which require additional milling and drying of the raw material, require more than 200 kWh/tonne of the product.
- very low operating costs. The use of replaceable pressing punches and shape-forming sleeve lowers the cost of the replacement of components subject to wear and tear.
- powered from the mains or by a generator.
- complete automation of the production process allows to reduce staff workload for loading raw material to the feeding table and receiving the finished product.
- low sensitivity to impurity of the raw material.
- effective separation of impurities (rocks and metal elements).

The use the stone catcher, magnetic separator and pneumatic transport effectively protects the pelletisers against damage.

- possible pelletisation of different kinds of raw materials and various mixtures thereof.
- no need to obtain building permits and other documents required in case of investing in the construction of a stationary facility.
- two main modules connected by flexible tubes of pneumatic transport allows to freely arrange the modules for optimal adjustment to the ground conditions.
- modular structure enables easy and inexpensive upgrades of the Facility to increase the production capacity

Description of the technological process of manufacturing waste and biomass pellets

In the first production step, the feeding table feeds the straw into the chopper which fragments it to a size of about 10 cm. The straw is transported via a fan integrated with the primary impeller of the chopper to the mixer, which also serves as a buffer container and a conveyor. The fragmented straw in the dispensing buffer is transported by two screw conveyors to two initial pelletisers in which the process of final pelletisation occurs accompanied by the mechanical degradation of the straw fibres. In the course of this process, the temperature of the raw material increases to approximately 100°C due to friction, as a result of which some of the moisture evaporates. The initial pelletisers are equipped with a spraying system, which activates if the raw material is too dry.

The intermediate product in the form of ground biomass is transported via a belt conveyor to the buffer container, which also

serves as a mixer (homogeniser). The moisture content is measured in the container. If the moisture sensor indicates the value of 14-18%, the raw material is transported via screw conveyors to the mixers located directly above the final pelletisers.

The following devices are used in the production process.

SP4000 feeding table with a capacity of 0.37 kW

Chain conveyor for feeding of straw bales to the preliminary chopper. The control system automatically adjusts the raw material feed rate to the current output of the chopper. In the version built on a container platform, the feeding table length is 4 m. In the stationary version, the table can be extended using two-meter modules

SP straw chopper with a capacity of 30-37kW and output up to 1200-1500 kg/h.

The chopper is designed to fragment straw into pieces of about 10 cm in size.

Straw bales are unrolled in the device and the straw is pulled and finally milled. The chopper is a unique design in which beating hammers cooperate with matching counterblades, so that the machine achieves high performance with low electricity consumption. The chopper shaft is integrated with a fan impeller, which effectively transports the fragmented biomass into the buffer container.

SG 55 pelletiser with a capacity of 37 kW and output of at least 800-1200 kg/h.

Modern pelletiser which takes advantage of an innovative method of concentrating biomass.

The use of replaceable pressing punches and shape-forming sleeves significantly reduces the cost of operation of the device. The working head is equipped with four pressing rollers. The combination of two pelletising units in one line allows to carry out any maintenance work without shutting down the entire line.

The machine is designed in a way to reduce maintenance operations and servicing to a minimum,

SM 18 mixer with a capacity of 7.4 kW and a volume of 18 m³.

The device in which, due to mixing raw materials of different moisture, a constant average moisture content not greater than 25% is achieved. The mixer also serves as a buffer container, allowing for continuous operation of the system. It is equipped with additional feed connectors for simultaneous adding of different ingredients. The mixer can supply two pelletisers. The device is provided with a continuous moisture measurement sensor and a dust collection system, whose purpose is to release the pressure in the mixer and to improve the ease of operation.

Pellet coolers

Pellet coolers are conveyors with rod belts, where, as result of forced circulation of air, the temperature of the pellets is lowered to the ambient temperature and its moisture content is reduced to 8-12%.

Patent claims

1. The waste and biomass pellets is characterised in that the pellets size ranges from 15 to 40 mm, powdered calcium oxide CaO with the addition of castor oil and/or hydrated lime is used as the binding agent, whereby the pellet comprises:
 - a) from 40 to 80% of biomass by volume with a moisture content of 35% by weight
 - b) from 20 to 60% of dried organic waste, -
 - c) 3 to 5% by weight, relative to the total weight of the biomass and organic waste, of hydrated lime mixed with castor oil.
2. The waste and biomass pellet Waste and biomass pellets, manufacturing process and the pelletiser head used in the process, according to claim 1, **is characterised in that** it contains fragmented biomass and organic waste with grain size lower than 6 mm.
3. The waste and biomass pellets, according to claim 1-2, **is characterised in that** it contains 70% of biomass by volume.
4. The waste and biomass pellets, according to claim 1-3, **characterised in that** the biomass has a moisture content of 27 to 29% by weight.
5. The waste and biomass pellets, according to claim 1-4, **characterised in that** cereal straw, oilseed rape straw, miscanthus, dried corn cobs and/or stalks or coconut palm fibres are used as biomass.
6. The waste and biomass pellets, according to claim 1-5, **characterised in that** it contains 30% of dried organic waste.

7. The waste and biomass pellets, according to claim 1-6, **characterised in that** the dried organic waste has moisture content of 30 to 40% by weight.
8. The waste and biomass pellets, according to claim 7, **characterised in that** the dried organic waste has moisture content of 35% by weight.
9. The waste and biomass pellets, according to claim 1-8 **characterised in that** the dried organic waste comprise beet pulp, coffee pulp, bran, baking yeast, dairy waste or dried sludge from biological wastewater treatment plants.
10. A method of manufacturing waste and biomass pellets **characterised in that** straw is fed via a feeding table to a chopper which reduces the granularity to about 10 cm, and subsequently transported, via a fan integrated with the primary impeller of the chopper, to the mixer which also serves as a buffer container and a conveyor, after which the fragmented straw in the dispensing buffer is transported by two screw conveyors to two initial pelletisers, in which the process of final pelletisation occurs accompanied by the mechanical degradation of the straw fibres, whereby in the course of this process the temperature of the raw material increases to approximately 100°C due to friction, as a result of which some of the moisture evaporates, whereby the initial pelletisers are equipped with a spraying system, which activates if the raw material is too dry, and, when the moisture sensor indicates the value in the range of 14-18%, the raw material is transported via screw conveyors to the mixers located directly above the final pelletisers, after which it is transported to the final pelletisers, where the semi-finished material is shaped into pellets.
11. Pelletiser head, **characterised in that** it has a conical working surface (5;5a;5b) equipped with punches (1;1a;5b) and/or sleeves

(2;2a,2b), which extend into the die as tubes (4;4a;4b), whereby the sleeves (2;2a;2b) and/or the punches (1;1a;1b) are arranged on the working surface (5;5a;5b) of the body (3;3a3b) of the head at least in one row located along the circumference of a circle whose centre is the centre of the head, and the head is mounted on a drive shaft (6;6a;6b) which connects it to the drive unit, whereby the head comprises at least one row of concentrically arranged sleeves and/or punches.

12. Pelletiser head, **characterised in that** if both punches (1a;1b) and sleeves (2a;2b) are arranged on the surface of the working head, the punches (1a;1b) alternate with the sleeves (2a;2b).

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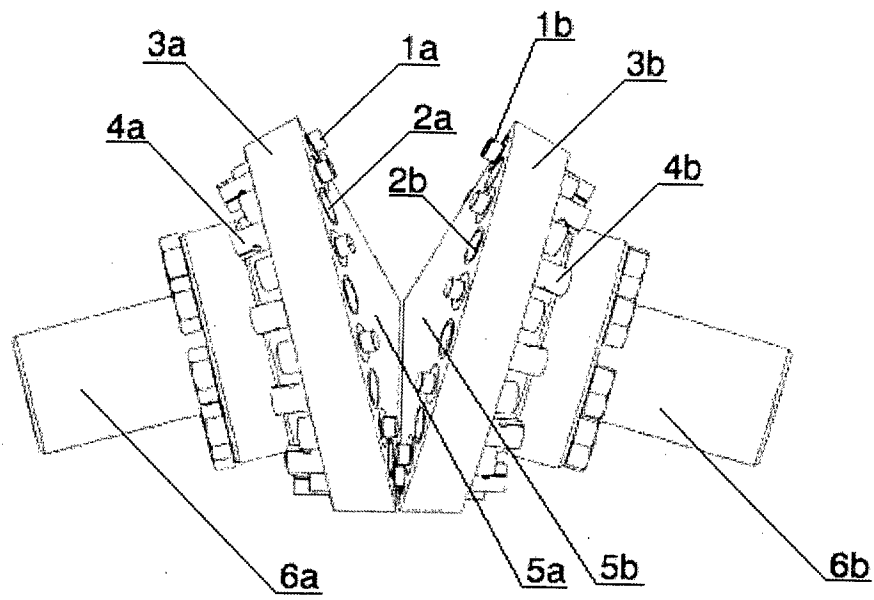


Fig. 1

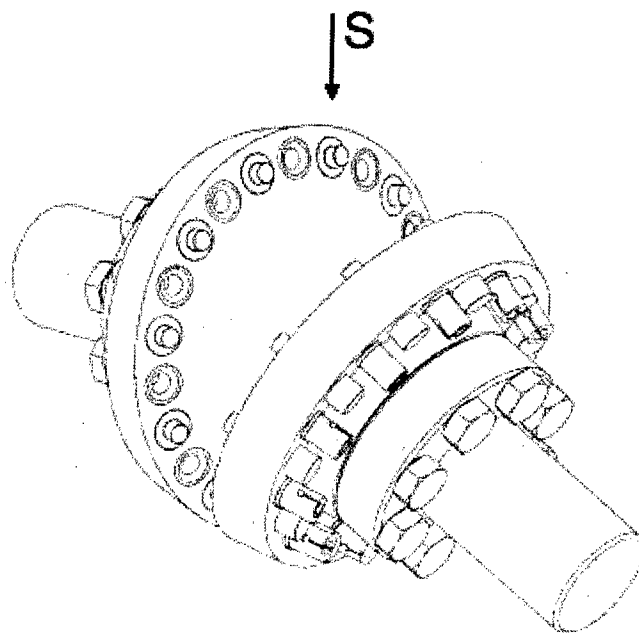


Fig. 2

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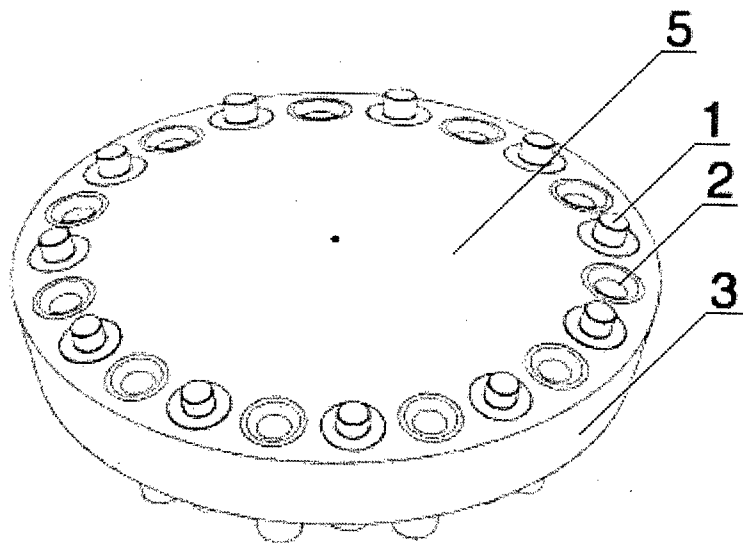


Fig. 3

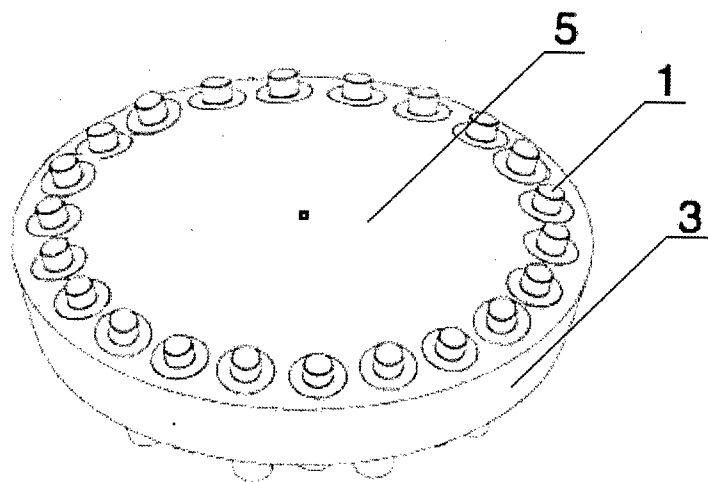


Fig. 4

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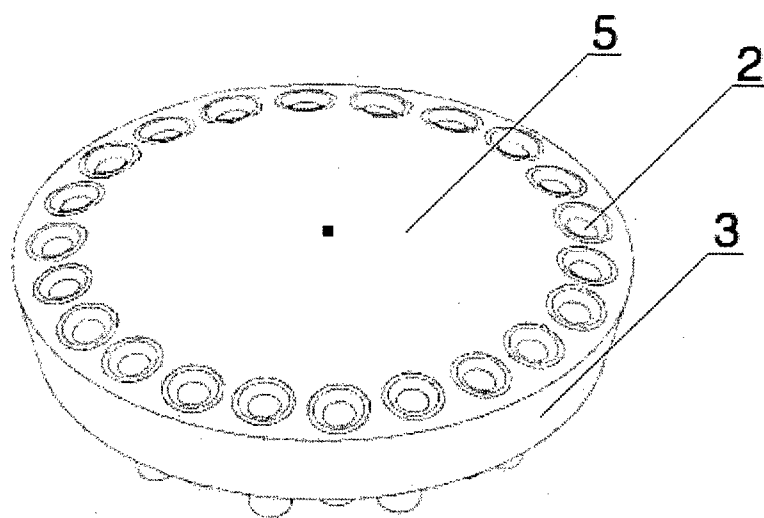


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/PL2013/000180

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C10L5/40
 ADD.

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 data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2 664 664 A1 (OLEOFINA GMBH [DE]) 20 November 2013 (2013-11-20) paragraphs [0013], [0079], [0101], [0109], [0112], [0124] - paragraph [0128]; claims 1,3,12,14 -----	1-9
Y	CN 102 127 480 A (TONGLIAO HETIAN LIVESTOCK TECHNOLOGY DEV CO LTD) 20 July 2011 (2011-07-20) abstract -----	1-9
Y	CA 2 670 530 A1 (9166 3260 QUEBEC INC GRANULES NEWTON PELLETS [CA]) 25 December 2010 (2010-12-25) paragraph [0006] - paragraphs [0012], [0049]; figure 1 paragraph [0051] - paragraph [0056]; claims 1-7,9,10,13 ----- -/-	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* 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 application or patent 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

"&" document member of the same patent family

Date of the actual completion of the international search

19 March 2014

Date of mailing of the international search report

19/08/2014

Name and mailing address of the ISA/

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Authorized officer

Pöllmann, Klaus

INTERNATIONAL SEARCH REPORT

International application No

PCT/PL2013/000180

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 352 252 A (TOLMIE RICHARD W [US]) 4 October 1994 (1994-10-04) column 2, line 4 - line 15 -----	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/PL2013/000180

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 2664664	A1	20-11-2013	DE 102012009799 A1	21-11-2013
			EP 2664664 A1	20-11-2013

CN 102127480	A	20-07-2011	NONE	

CA 2670530	A1	25-12-2010	NONE	

US 5352252	A	04-10-1994	NONE	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/PL2013/000180

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-9

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9

Waste and biomass pellets characterised by a size from 15-40 mm, comprising biomass, dried organic waste and hydrated lime mixed with castor oil

2. claim: 10

A method of manufacturing waste and biomass pellets characterised by processing straw via a chopper, fan , mixer, two screw conveyors, two pelletizer equipped with a spraying system and during which the temperature of the raw material increases to 100°C due to friction

3. claims: 11, 12

A pelletiser head characterised in that it has a conical working surface equipped with punches and/or sleeved extending into the die as tubes optionally with alternating punches and sleeves.
