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(54) HEATING DEVICE USING WOOD FUEL

(57) The patent application relates to thermal power engineering, particularly to heating devices in which wood fuel undergoes high-temperature gasification (pyrolysis). The problem which the claimed utility model addresses is that of the consistent and environmentally clean combustion of wood fuel possessing a natural (that is, high) moisture content. The technical result is achieved in that the device includes a vertically-oriented additional gas duct through which the moisture contained in the fuel is removed in the form of steam from the upper part of a fuel hopper to a flame in an afterburn chamber, wherein carbon monoxide mixed with steam is burned off and does not enter the atmosphere.

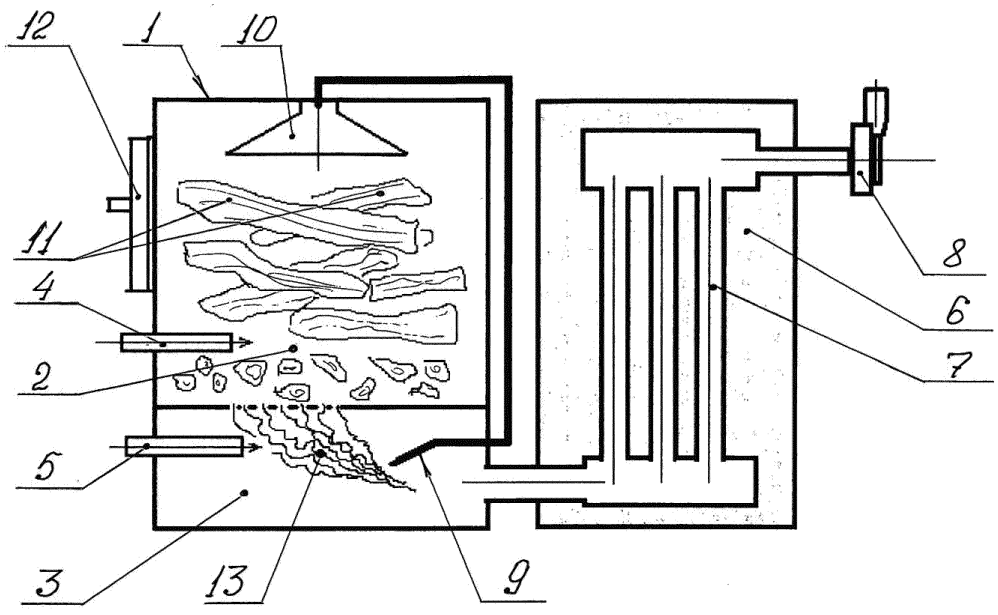

FIG 1

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Description

[0001] The utility model relates to heat power engineering, in particular to heating devices, in which solid fuel of plant origin (firewood, wood waste, chips, straw) is subjected to high-temperature gasification (pyrolysis) followed by combustion of pyrolysis gases and coal residue.

[0002] The prior art describes a heating device (boiler), which comprises a wood fuel hopper, a gasification chamber (primary combustion chamber) and an afterburner consisting of one or two compartments located below or to the side of the gasification chamber (primary combustion chamber), placed in a single vertically oriented housing. The majority of commercially available wood fuel boilers are made according to this scheme, for example, products manufactured by ARCA, Astra, Atmos, Attack, Buderus, Cichewic, Guntamatic, Kalvis, Heiztechnik, Kostrzewa, Orlan, Solarbayer, Viessmann.

[0003] In such a device, the products of wood fuel gasification, including water vapor released in the upper part of the fuel hopper, move downwards and enter the primary combustion chamber. Moreover, water vapor prevents the effective mixing of atmospheric oxygen with the combustible components of the pyrolysis gas, which makes the combustion process unstable or completely impossible. As a result, all the heating devices listed above can use only wood with a moisture content of not more than 15-20% as fuel.

[0004] This limitation significantly complicates the operation of the heating device and increases its cost, since wood with natural moisture (for example, freshly sawn firewood) has a moisture content of about 45-60%, and in order to use it as fuel, long-term drying is required. Some types of wood fuel, such as wood chips from freshly sawn trees, cannot be dried naturally (this is prevented by the development of decay on raw wood chips), and therefore cannot be used in a domestic heating device.

[0005] The prior art describes several technical solutions that allow using wood with high moisture content as fuel for a household heating device of small power (20-100 kW). The fundamental basis of the technical solution is to create and maintain a high temperature (700-800 °C or more) in the gasification chamber (primary combustion chamber) at which water vapor in contact with hot coal turns into two combustible gases: hydrogen and carbon monoxide. To achieve this temperature, the pyrolysis gas afterburner is placed inside the gasification chamber (see EP 2 821 698 A1), or the pyrolysis gas afterburner is made in the form of a ring concentrically surrounding the gasification chamber (see DE 3411822 A1 and RU 2578550 C1), or a stream of hot combustion products leaving the pyrolysis gas afterburner rises and at the same time washes and heats the side walls of the gasification chamber (see CZ 2008191 A3). The prior art also describes a heating device in which the above-mentioned heating methods are supplemented by blowing very hot primary air into the gasification chamber at high speed (see RU 164691 U1).

[0006] The disadvantage of such designs is the inevitable use of expensive materials, in this case: heat-resistant steel and special heat-resistant ceramics. In addition, numerous tests have shown that even using all the above-mentioned methods of heating the gasification zone (primary combustion zone) does not provide the sustainable burning of particularly complex types of wood fuel, such as freshly chopped wood chips or raw sawdust.

[0007] The closest to the claimed heating device is the so-called "Pomerantsev high-speed combustion chamber" (see V.V. Pomerantsev, "Топки скоростного горения для древесного топлива", M., Mashgiz, 1948; USSR copyright certificate No. 50503, filed May 19, 1936). In the upper part of the fuel hopper (Pomerantsev called it "fuel mine" or "fuel hose"), an opening was made through which "wet gas" was sucked out of the fuel hopper under the influence of rarefaction in the outlet chimney and was discharged into the atmosphere together with flue gases through a special gas duct.

[0008] The operability of this design is based on the fact that water vapor is the lightest component in the gas environment of the fuel hopper: it is 2.4 times lighter than carbon dioxide, 1.6 times lighter than nitrogen, 1.5 times lighter than carbon monoxide, and therefore accumulates in the upper part of the fuel hopper. Direct mechanical removal of water vapor is the most radical and at the same time a simple and inexpensive way to solve the problem of burning damp fuel, and this is a significant advantage of the "Pomerantsev furnace".

[0009] A permanent design flaw is that small doses of wood pyrolysis products, including carbon monoxide, which are inevitably present in a mixture with water vapor, are also emitted into the atmosphere. In the 30-40s this did not hold any significance, but since then, the requirements for the ecological cleanliness of heating devices have been significantly stricter. So, the Soviet standard from the 80s for wood stoves (GOST 9817-82)
limited the permissible carbon monoxide emissions to 4%, but the modern European standard EN 303-5 for class 5 requires a reduction in carbon monoxide emissions to 0.04%. It is not always possible to reduce carbon monoxide emissions to such a level even with the use of complex after-combustion chambers; all the more it is impossible to meet the strict modern standards by discharging the contents of the gas environment of the fuel hopper directly into the atmosphere.

[0010] The technical result for achieving the claimed utility model is the sustainable and environmentally friendly burning of wood fuel with a natural (i.e. high) moisture content.

[0011] The specified technical result is achieved by a **heating device using wood fuel** comprising placed in a single vertically oriented housing a hopper for solid fuel and a gasification chamber below it, an afterburner, as well as primary and secondary air supply ducts, an exhaust chimney and a water tank, inside which a fire tube heat exchanger is placed, which has at least one vertically oriented additional gas duct, the upper opening of which is located at the upper point of the internal volume of the fuel hopper, and the lower opening is located in the area of the afterburner, where the combustion of the flame ends.

[0012] At least one gas collection funnel can be installed in the upper part of the fuel hopper, the upper point of which is connected to the upper opening of the additional gas duct.

[0013] A shut-off and control valve may be inserted into the additional duct. The additional gas duct can be at least partially placed inside the water tank, while a container for collecting condensate with a device for draining condensate out of the heating device is placed at the bottom of the part of the additional gas duct that is placed in water.

[0014] These design solutions ensure the achievement of the claimed technical result and cannot be found in their totality in any of the known heating devices using wood fuel, therefore, the claimed utility model meets the criterion of novelty.

[0015] The claimed device can be manufactured with standard equipment using known and traditional heating devices, technological processes and materials. Thus, the claimed utility model meets the criterion of industrial applicability.

[0016] The design of the claimed heating device is illustrated by the sketch on FIG. 1, which shows a vertical section of the version having a gas collection funnel but no condensate collecting tank.

[0017] The heating device comprises a solid fuel hopper 1 with a loading hatch 12, gasification zone (chamber) 2 located in the lower part of the hopper, afterburner 3, primary air supply ducts 4, secondary air supply ducts 5, water tank 6 housing a fire-tube heat exchanger 7 connected to the smoke exhauster 8 via the outlet chimney. The additional gas duct 9, connected in its upper part to the gas collection funnel 10, passes downwards to the afterburner, and its lower opening is located at the end of the flame (along the direction of movement of combustible gases).

[0018] The heating device operates as follows. Wood fuel 11 (for example, firewood or wood chips with a natural moisture content) is loaded into the hopper 1 through the loading hatch 12 on the side wall of the hopper. Due to gravity, the wood fuel falls down, successively passing through the drying zone (upper part of the hopper), the dry distillation zone (lower part of the hopper) and enters the gasification zone (chamber) 2. In this zone, the fuel is ignited from an external source (not shown) and burns in the atmosphere of primary air supplied to the gasification and primary combustion zones through duct 4.

[0019] Combustible gases (hydrogen, methane, carbon monoxide), formed as a result of primary pyrolysis of wood and chemical reduction after contact with hot coal, enter the afterburner 3, where they are mixed with secondary air entering through duct 5 and burned in the flame 13. The hot combustion products from the afterburner enter the fire tube 7, where they transfer their heat to the water in tank 6 and are then discharged into the exhaust pipe with a smoke exhauster 8 , from there into the chimney (not shown) and then to the atmosphere.

[0020] Moisture evaporating from raw wood in the form of water vapor with a temperature of 100-120 °C rises ("floats") to the upper part of the fuel hopper 1 and enters the additional gas duct 9 through a gas collection funnel 10. The movement of water vapor from the top of the additional gas duct 9 to the bottom occurs under the influence of rarefaction (differential pressure) created by the smoke exhauster 8 in the afterburner 3; furthermore, the difference in the specific gravity of the steam having a temperature of 100-120 °C and the combustion products in the afterburner having a temperature of more than 800-900 °C contributes to the movement of steam from the top of the additional gas duct 9 to the bottom. The removal of or at least a significant reduction in the amount of water vapor in the primary combustion zone, contributes to the sustainable burning of wood fuel.

[0021] Water vapor through the additional gas duct 9 is supplied to the end point of the torch 13 (in the direction of movement of the combustible gases). In this zone, the mixing of combustible gases and the secondary air has already been completed, and therefore the appearance of water vapor will not interfere with the combustion process. Carbon monoxide, a certain amount of which will inevitably be present in the stream of water vapor, caught in the zone of high temperatures (more than 900 °C) in the most heated part of the torch 13 burns in the secondary air.

[0022] The complete afterburning of carbon monoxide is also promoted by water vapor, which reacts with carbon monoxide at high temperatures according to the formula: $H_2O + CO = H_2 + CO_2$. As a result of the reaction, two gases harmless to human health are formed (hydrogen and carbon dioxide). This reaction is accompanied by heat, and thus does not interfere with the main combustion process in the afterburner. In addition, at high temperatures, water vapor reacts with the smallest particles of unburned coal (soot) and burns them according to the formula: $H_2O + C = H_2 + CO$, and an insignificant amount of carbon monoxide resulting from the reaction is burned according to the reactions described above. The possibility for destroying (afterburning) the smallest particles of coal (soot) is very important, because according to modern data, these particles are a strong carcinogen, and their content in flue gases should be strictly limited.

Claims

1. A heating device using wood fuel, comprising placed in a single vertically oriented housing a fuel hopper and a gasification chamber below it, an afterburner, as well as primary and secondary air supply ducts, a water tank, inside which there is a fire-tube heat exchanger connected to the outlet chimney, **wherein** it contains at least one vertically oriented additional gas duct, the upper opening of which is located at the upper point of the internal volume of the fuel hopper, and the lower opening is located in the area of the afterburner, where the combustion of the flame ends.

2. The heating device using wood fuel according to claim 1, wherein at least one gas collection funnel is installed in the upper part of the fuel hopper, the upper point of which is connected to the upper opening of the additional gas duct.

3. The heating device using wood fuel according to claim 1, wherein a shut-off and control valve is embedded in the additional gas duct.

4. The heating device using wood fuel according to claim 1, wherein the additional gas duct is at least partially located inside the water tank, while a container for collecting condensate with a device for draining condensate out of the heating device is located at the bottom of the part of the additional gas duct that is placed in water.

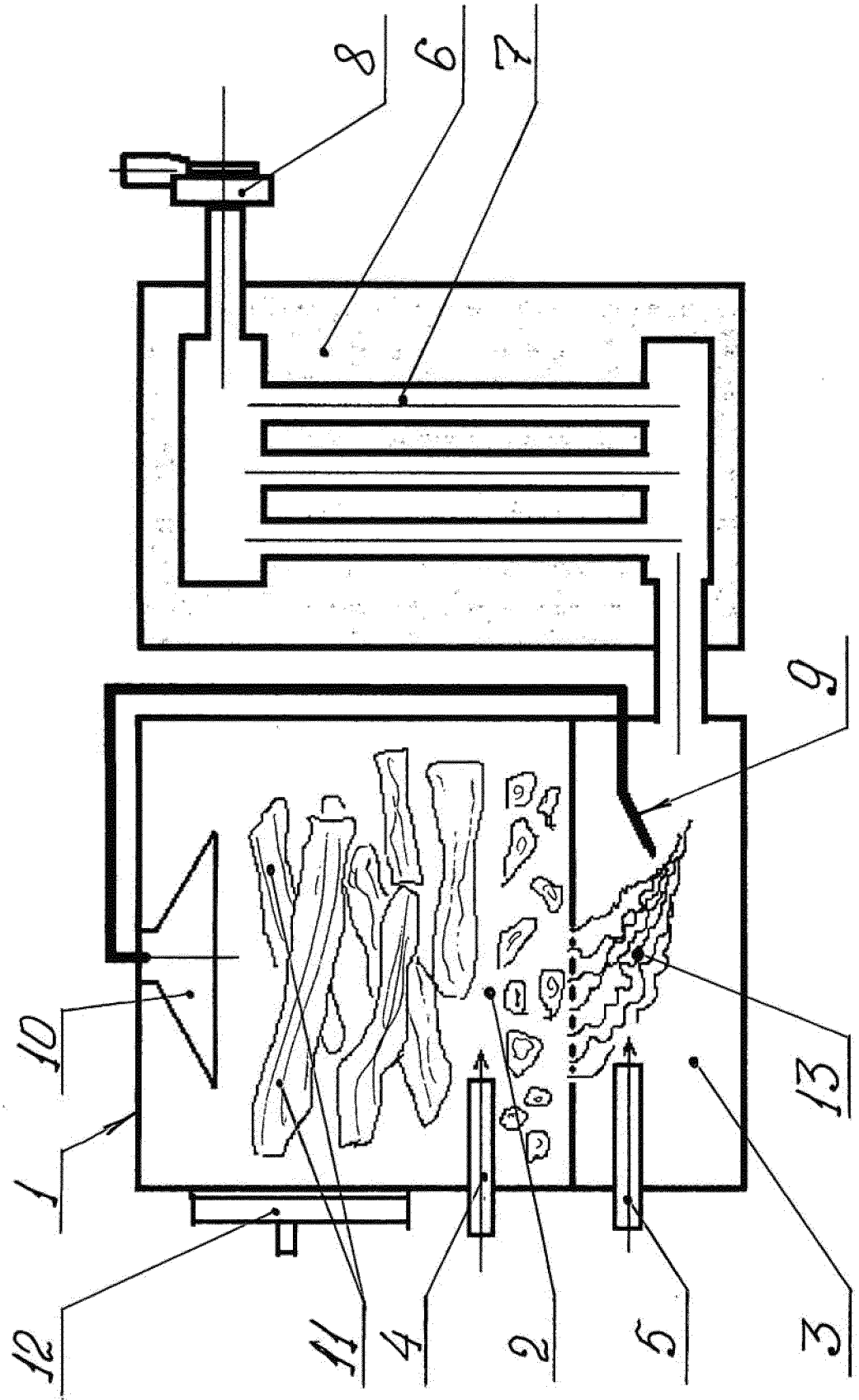

FIG 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2018/000287

A. CLASSIFICATION OF SUBJECT MATTER

F23B 10/00 (2011.01); F23B 50/06 (2006.01); F23L 7/00 (2006.01)

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)

F 23 B 10/00, 50/00 –50/12, 60/00, 60/02; F 23 C 6/00 –6/04; F 23 G 7/00, 7/10; F 23 L 7/00

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 19531821 A1 (HERLT, CHRISTIAN) 20.02.1997	1-4
A	FR 2589988 A (HS KEDLER -TARM A/S) 15.05.1987	1-4
A	US 6336415 B1 (ALSTOM (SWITZERLAND) LTD) 08.01.2002	1-4
A	RU 2450207 C1 (UCHREZHDENIE ROSSIISKOI AKADEMII NAUK INSTITUT TEPLOFIZIKI IM. S.S. KUTATELADZE SIBIRSKOGO OTDELENIYA RAN) 10.05.2012	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"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	Date of mailing of the international search report
25 September 2018 (25.09.2018)	27 September 2018 (27.09.2018)
Name and mailing address of the ISA/ RU	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2821698 A1 **[0005]**
- DE 3411822 A1 **[0005]**
- RU 2578550 C1 **[0005]**
- CZ 2008191 A3 **[0005]**
- RU 164691 U1 **[0005]**