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(54) **METHOD AND DEVICE FOR
HIGH-TEMPERATURE COMBUSTION
USING FUEL AND AQUEOUS SOLUTION OF
ORGANIC COMPOUND**

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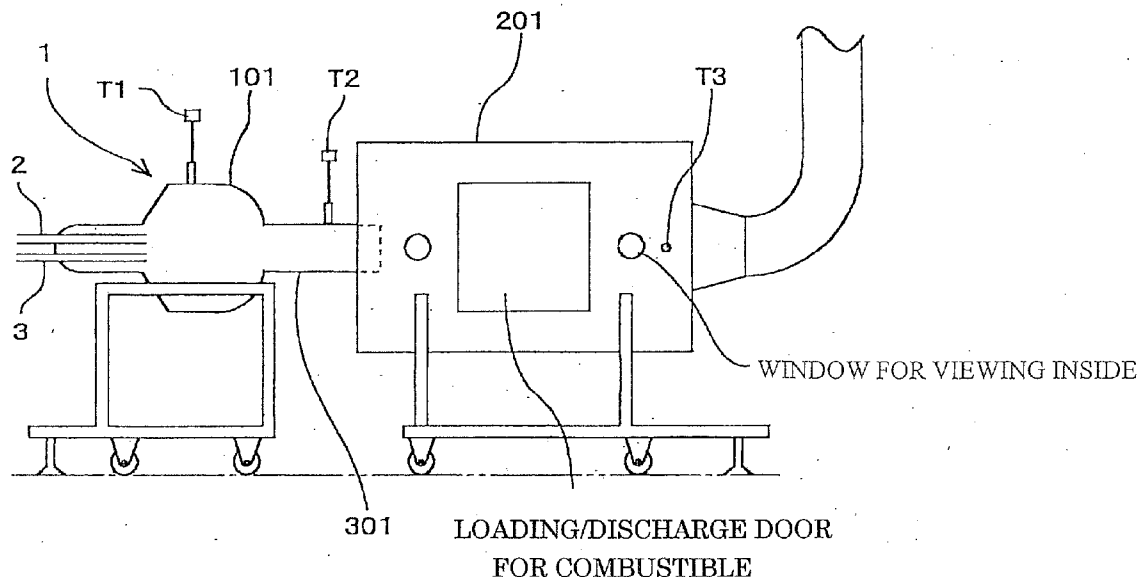
(52) **U.S. Cl.** **431/4; 431/253**(57) **ABSTRACT**

A method and a device are disclosed with which high-temperature combustion is attained using a fuel and an aqueous solution of an organic compound, e.g., an aqueous alcohol solution. In a combustion chamber, a fuel is sprayed and burned with a first burner to elevate the interior temperature of the combustion chamber (and/or a heat-resistant reflector disposed inside the combustion chamber) to a high temperature of 700° C. or above, and an aqueous solution of an organic compound (e.g., an alcohol-water mixture) is subsequently sprayed with a second burner into the high-temperature combustion gas obtained with the first burner, thereby causing microexplosion of water vapor and further elevating the interior temperature. As such, the fuels and organic compounds (e.g., Alcoholic aqueous solution) are fully burned, and thus the fuel cost can be reduced. Thus, high-temperature superheated steam containing a large amount of water vapor is yielded.

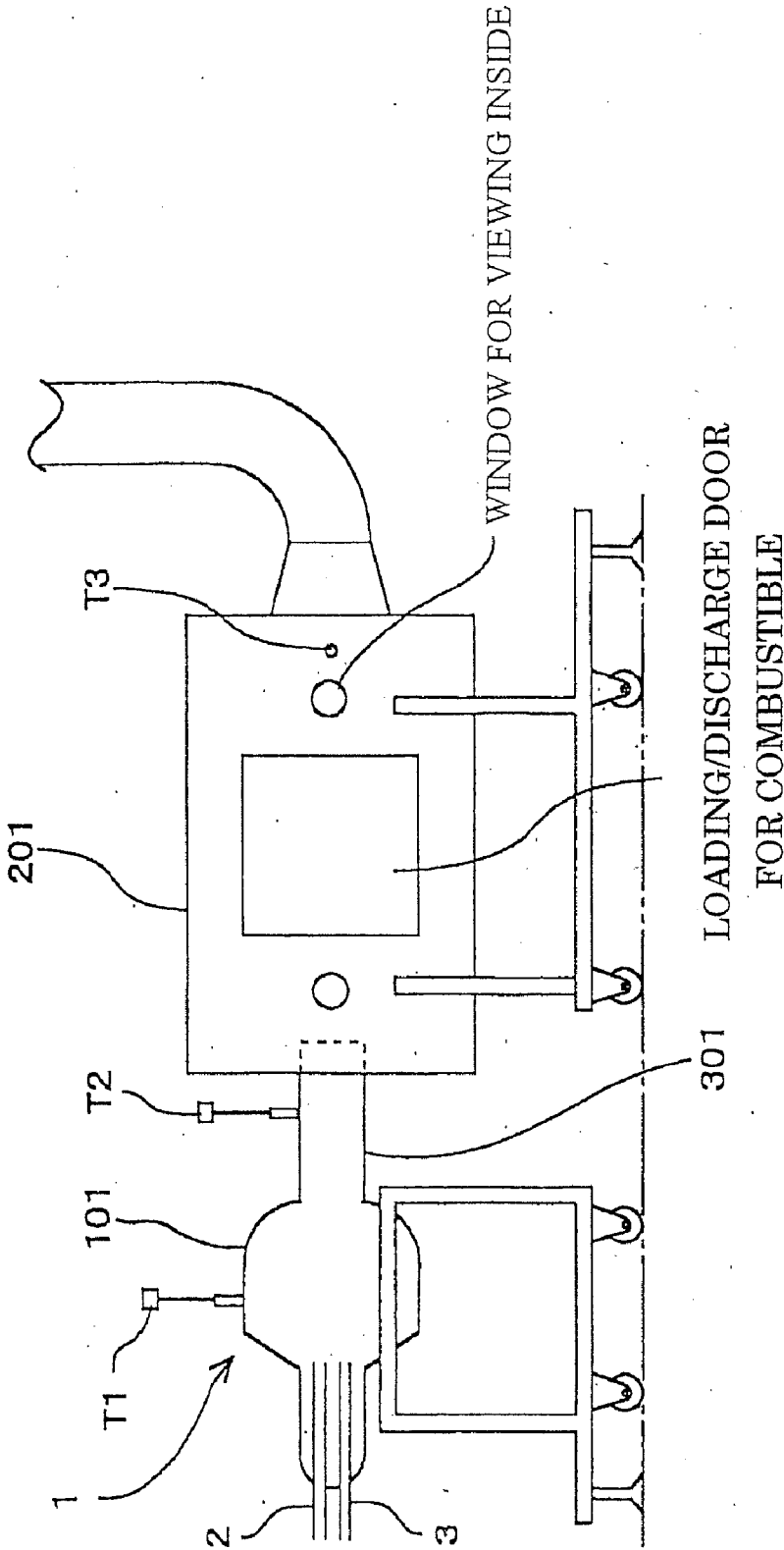
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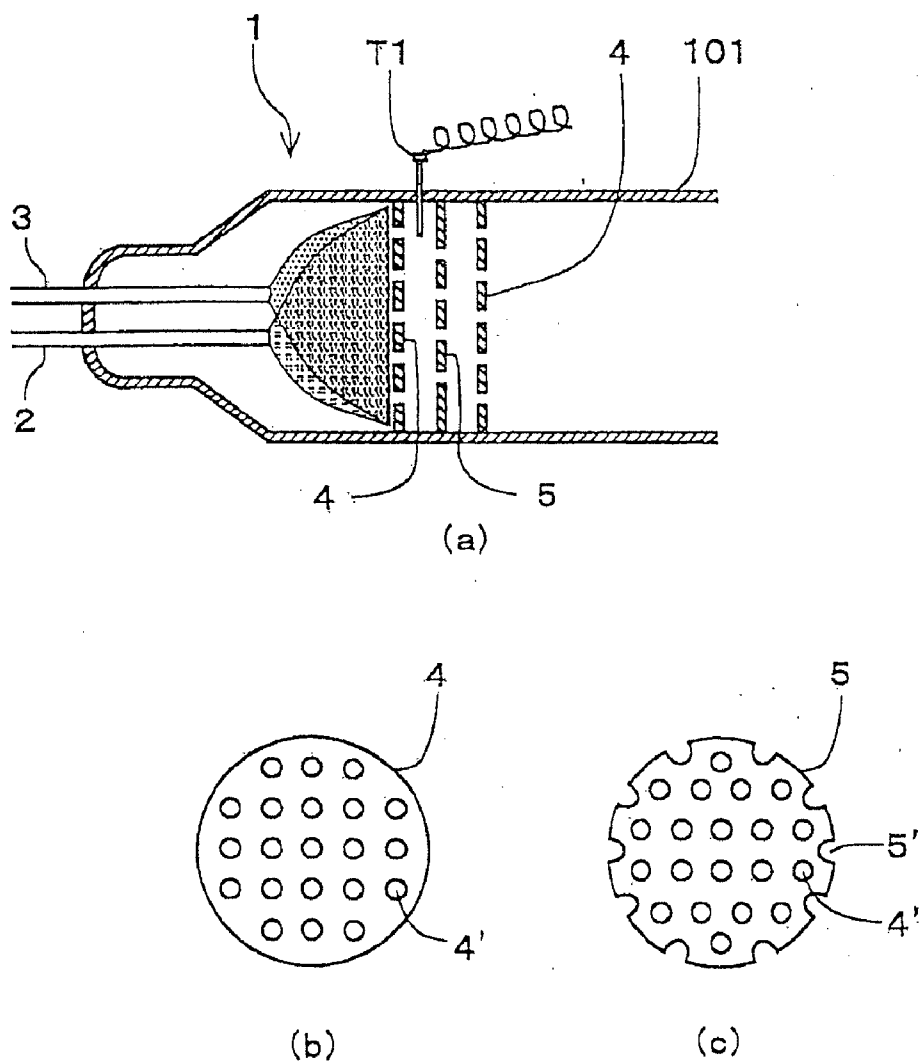
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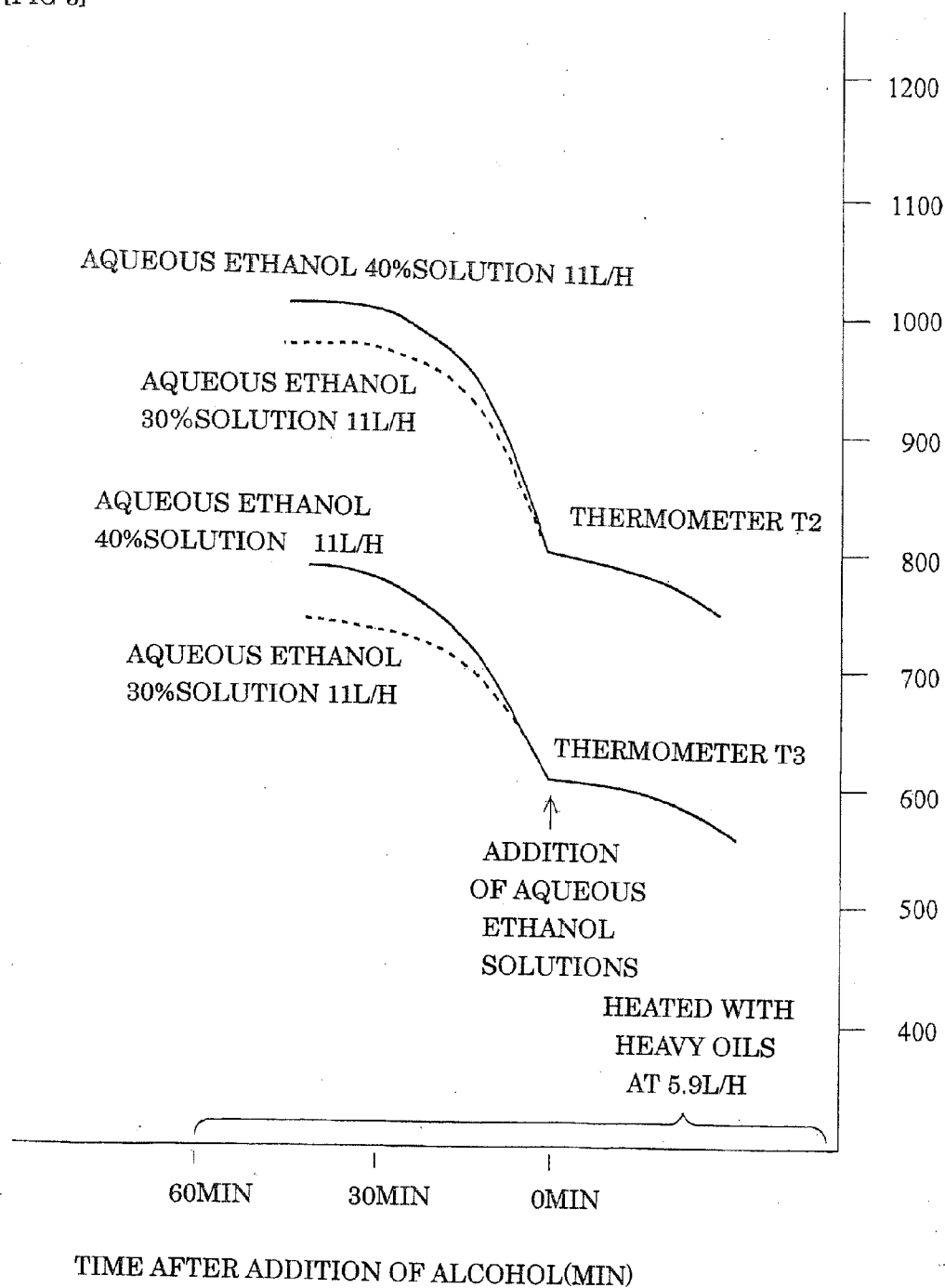
[FIG 1]



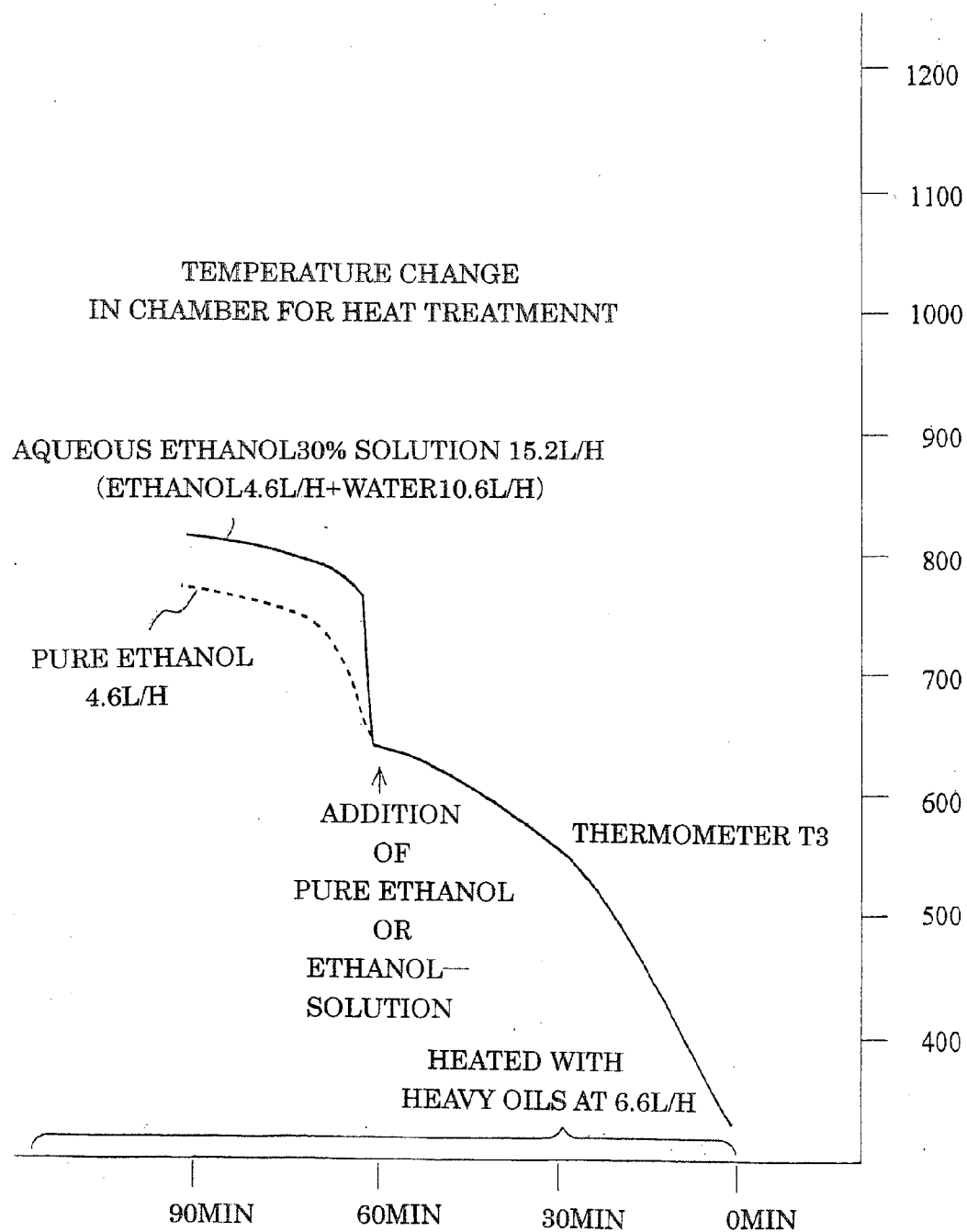
[FIG 2]



[FIG 3]

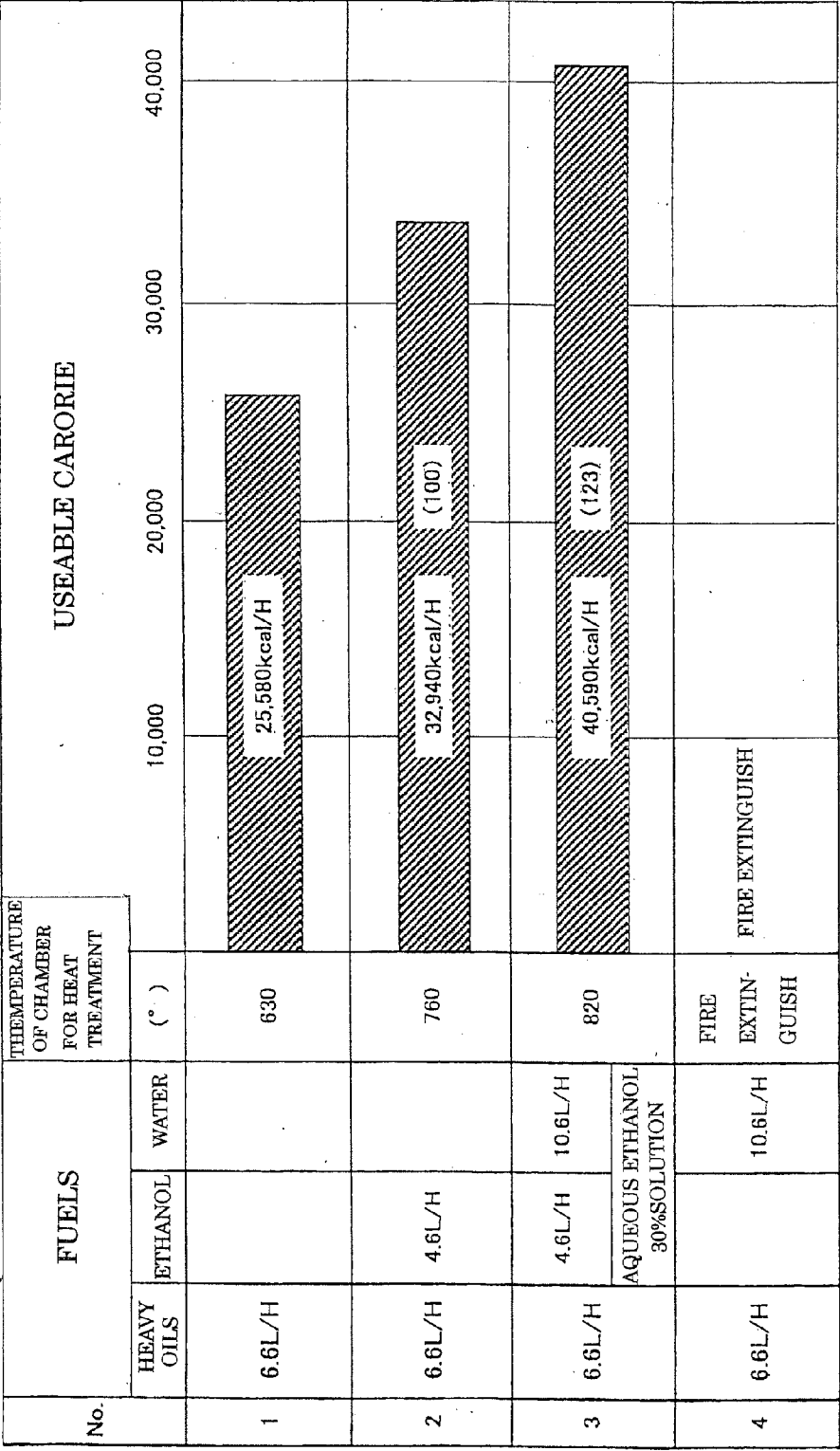


[FIG 4]

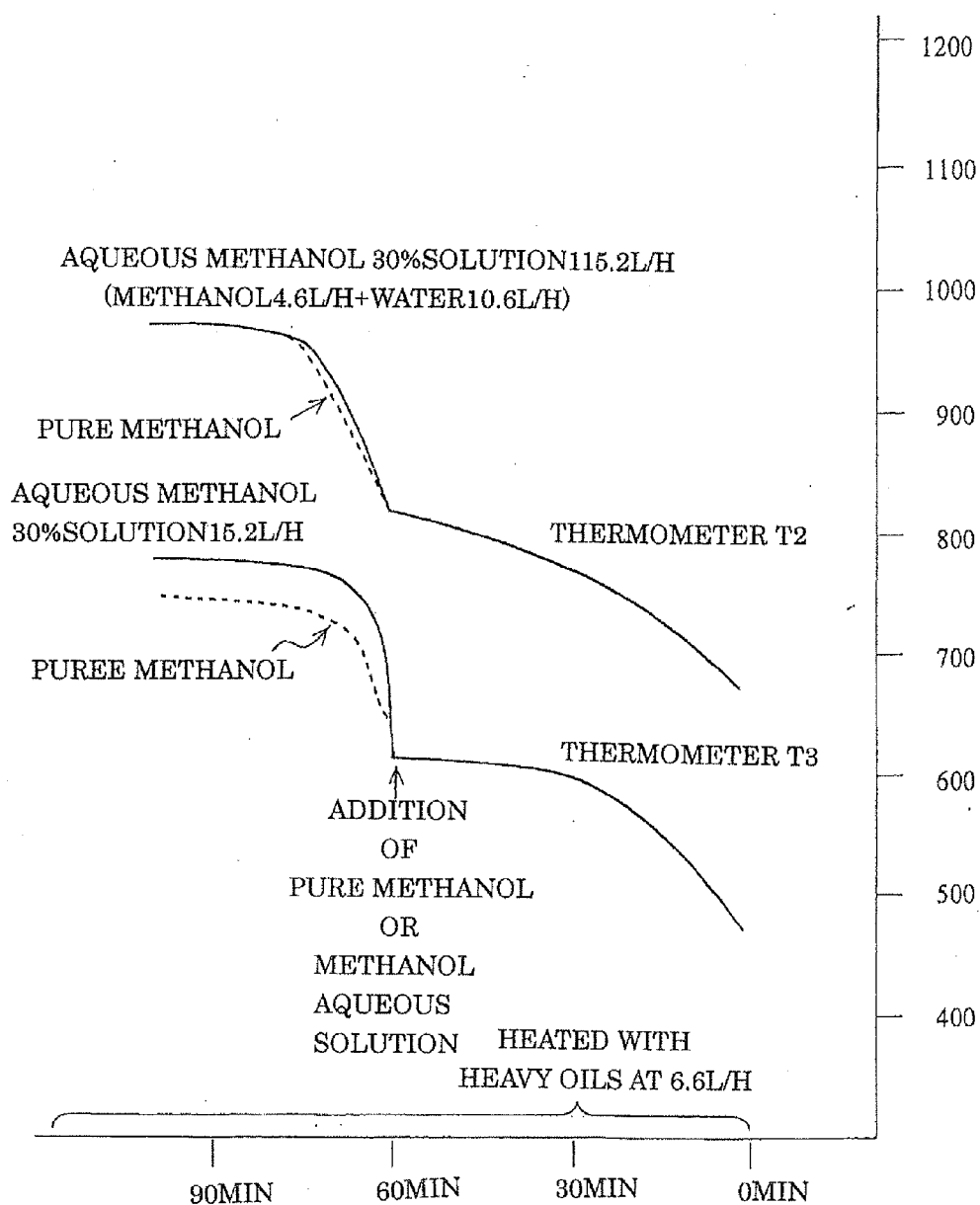


[FIG 5]

CARORIE CHANGE ACCORDING TO ADDITION OF
ETHANOL OR AQUEOUS ETHANOL SOLUTION

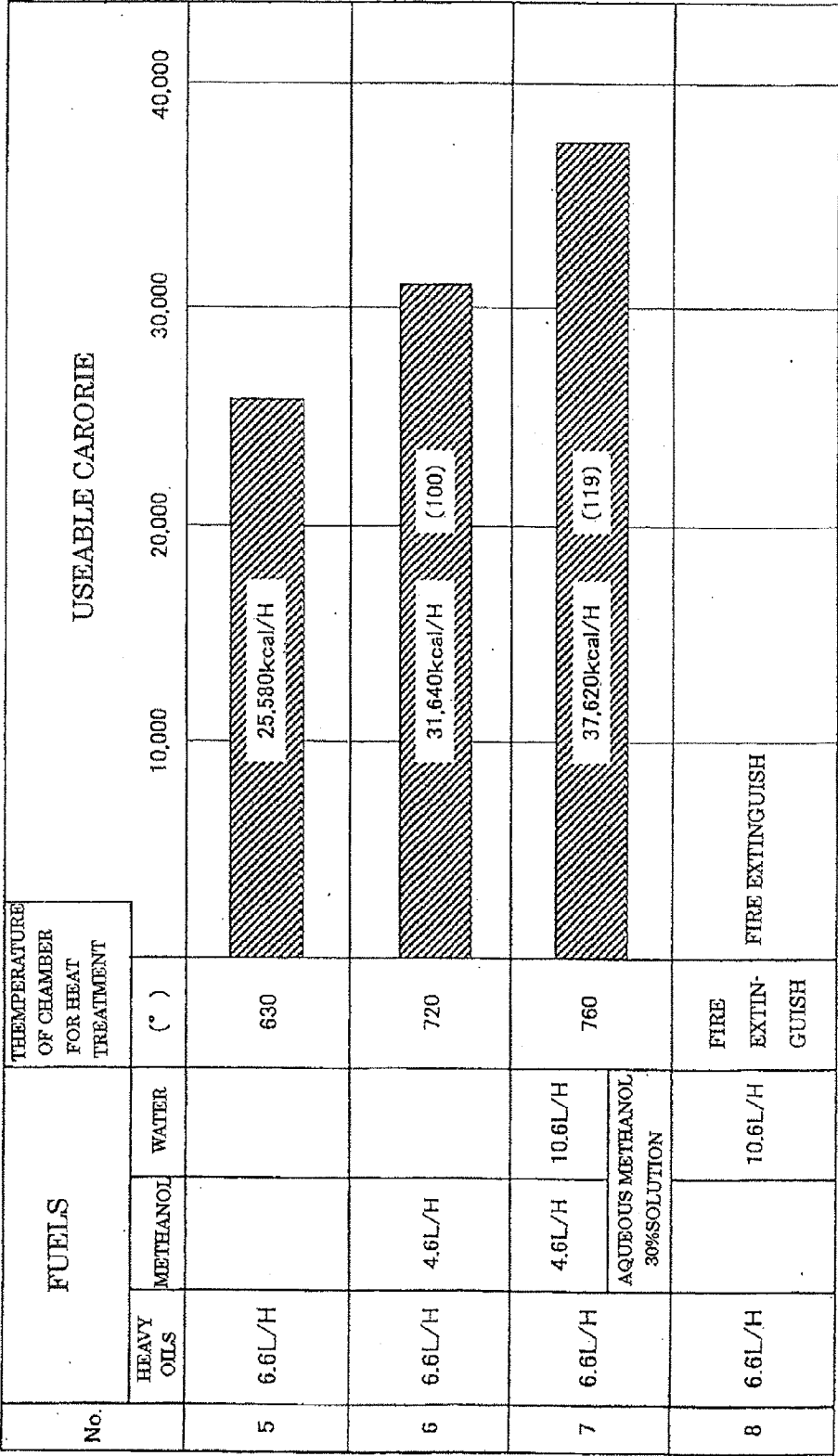


[FIG 6]

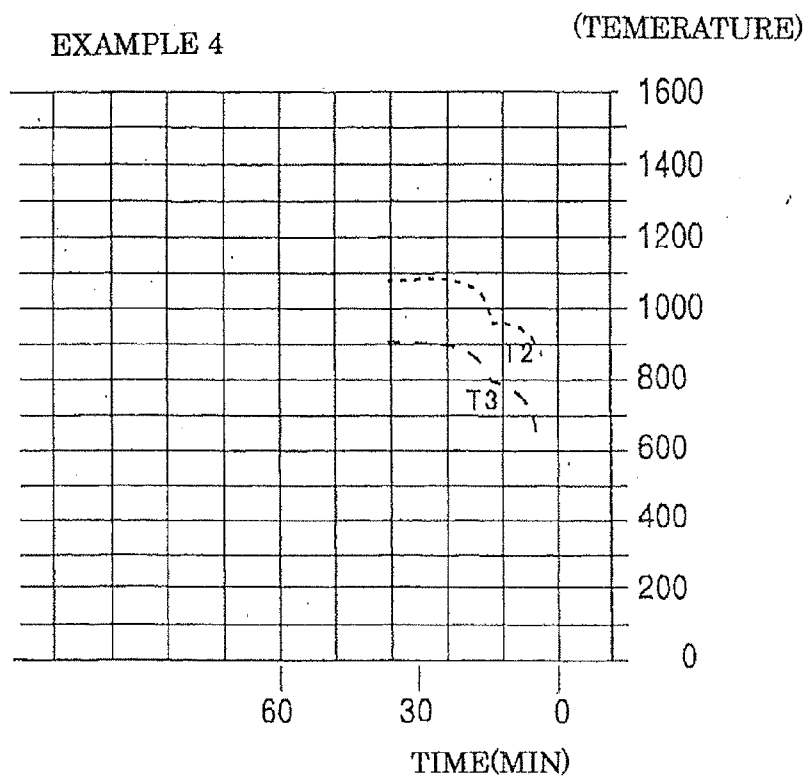


[FIG 7]

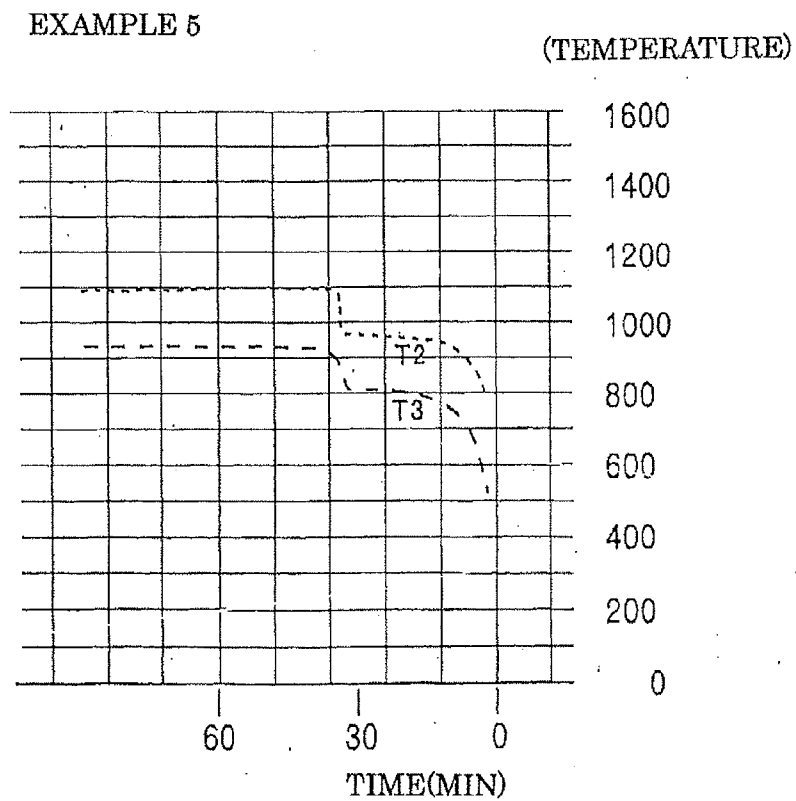
CARORIE CHANGE ACCORDING TO ADDITION OF
METHANOL OR AQUEOUS METHANOL SOLUTION



[FIG 8]



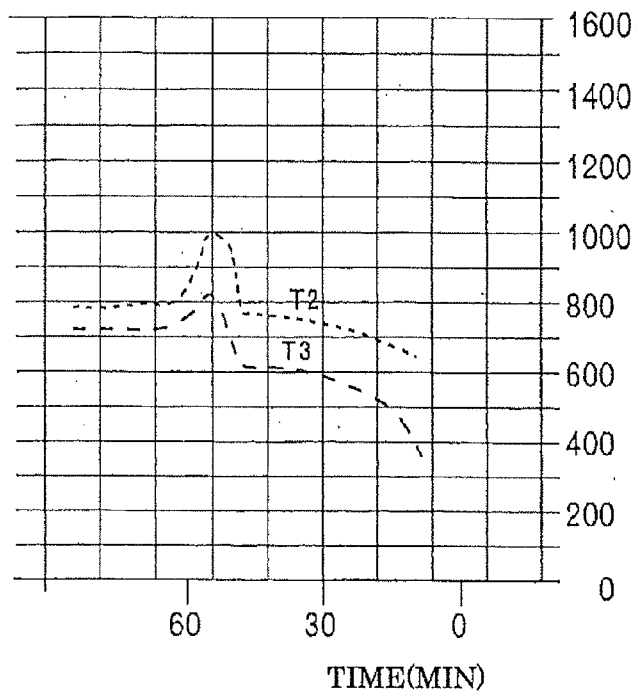
[FIG 9]



[FIG 10]

EXAMPLE 6

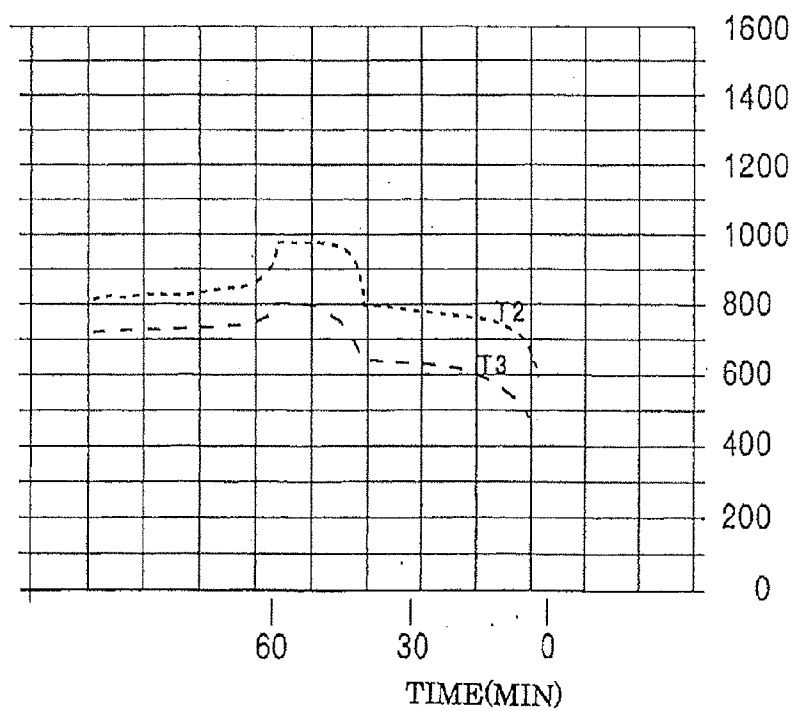
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[FIG 11]

EXAMPLE 7

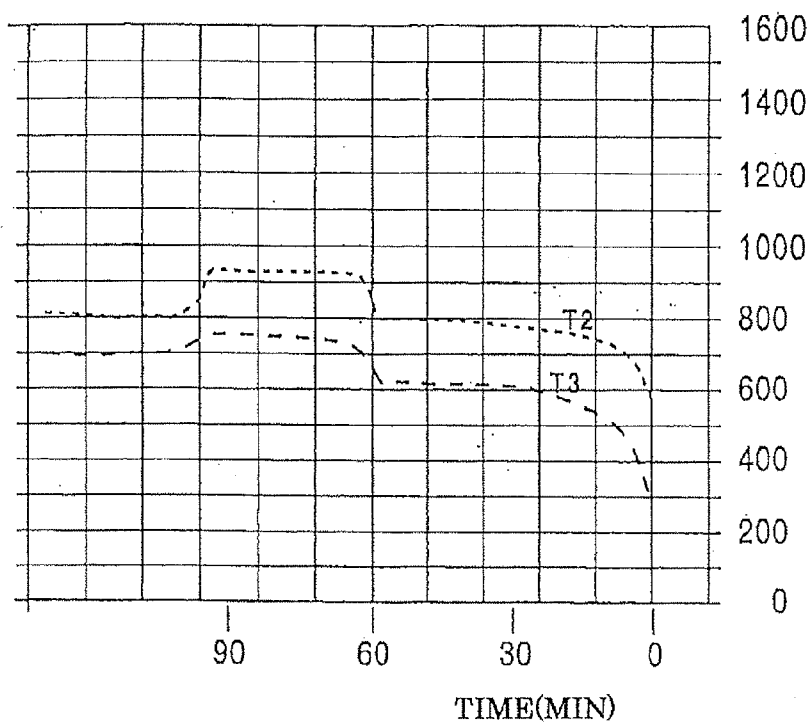
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[FIG 12]

EXAMPLE 8

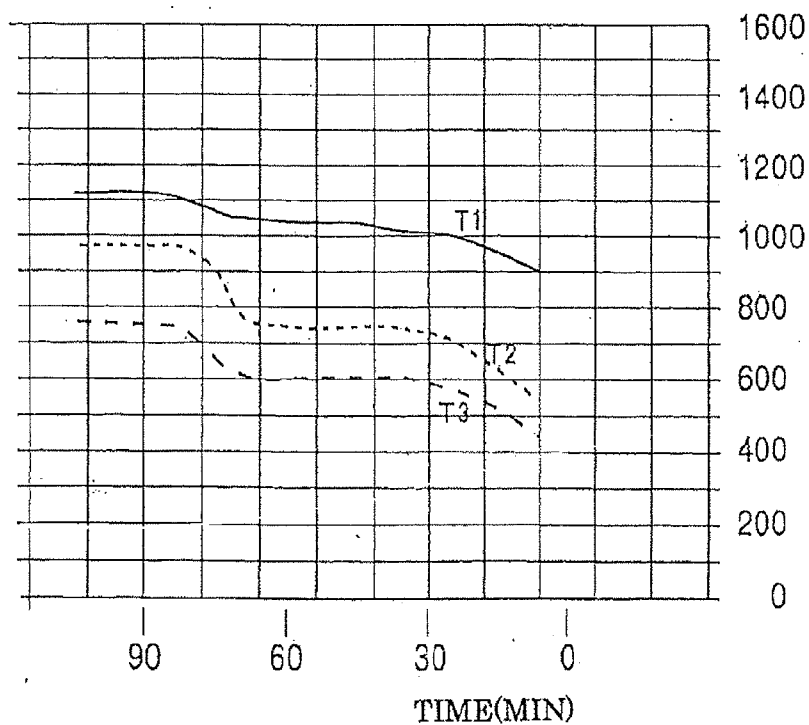
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[FIG 13]

EXAMPLE 9

(TEMPERATURE)



**METHOD AND DEVICE FOR
HIGH-TEMPERATURE COMBUSTION
USING FUEL AND AQUEOUS SOLUTION OF
ORGANIC COMPOUND**

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method and a device for combustion of an aqueous solution of an organic compound. In particular, it relates to a method and a device for high-temperature combustion in which an aqueous solution of an organic compound like an aqueous alcohol solution and fuel are used.

[0003] 2. Description of the Related Art

[0004] With regard to a conventional method for combustion by using liquid fuel and adding hydrous fuel containing an organic compound, examples of the organic compound for an aqueous solution of an organic compound (hereinafter, referred to as an "organic aqueous solution") include alcohols, organic acids, and aldehyde ketones. Examples of the organic aqueous solution include organic waste water, which is an industrial waste.

[0005] For combustion of an organic aqueous solution, a common practice includes that an organic aqueous solution is slowly added thereto for combustion while heavy oil or the like is burned with a burner. According to this method, the organic compounds contained in an organic waste water are oxidized while water contained in the organic waste water is vaporized by burning heavy oil, and as it has almost no contribution in terms of energy, it is just practiced as a simple way of processing waste water.

[0006] There is also a method including adding and mixing heavy oil or the like to an organic aqueous solution to give a water-in-oil (W/O) type emulsion and processing it as fuel. However, according to this method, although the organic compounds contained in an organic aqueous solution can be utilized as fuel, it does not provide any particularly efficient combustion.

[0007] In a case in which an emulsion type hydrous fuel is burned, the fuels used for an incinerator or an internal combustion engine is mostly a water-in-oil (W/O) type emulsion. According to this type, oils in water-in-oil (W/O) type are exposed to surface, and therefore there is a merit that it is easily combustible. On the other hand, according to an oil droplet in water (O/W) type, oils are included as microparticles in water, and therefore there is a problem that it is much less combustible.

[0008] However, with regard to thermal conductivity of petroleum oils and water, water has a thermal conductivity of 0.674 W/mk at 360° K (87° C.) while decane (C₁₀H₂₂), which is one type of oils included in petroleum oils, has a thermal conductivity of 0.119 W/mk at the same temperature. As such, it is known that water has a thermal conductivity which is 5.6 times larger than that of decane (see, Handbook of Chemistry, Basics II (Maruzen Company, Limited, published on Jun. 25, 1984, page 73).

[0009] Meanwhile, with regard to a condition for water vapor explosion, the water vapor explosion does not occur when extremely rapid heat transfer is not allowed. Thus, under the exactly same condition, the heat transfer occurs about 5 times faster in an O/W type than a W/O type, and therefore it has greater chance to have water vapor explosion.

[0010] Further, it is also described that the water vapor explosion may occur when molten iron is dropped into a

water bath or underground water is in contact with magma (see, Science of Vapor Explosion (written by TAKASHIMA Takeo and IIDA Yoshihiro, SHOKABO Publishing Co., Ltd. published on Jan. 25, 1998, pages 28 to 57).

[0011] Even when a W/O type emulsion is sprayed, surface of the emulsion is covered with oils, and therefore thermal conductivity is small. Further, as the surface of oils is covered with oil vapor film (in general, thermal conductivity of a gas is only 1/10 or less than that of a liquid), a possibility of having water vapor explosion is extremely low.

SUMMARY OF THE INVENTION

[0012] In view of the knowledge described above, an object of the invention is to accomplish improvement of combustion efficiency by having a condition at which water vapor explosion (i.e., microexplosion of sprayed particles or the like) is guaranteed to occur, decomposing organic compounds contained in water by utilizing the energy of microexplosion of water vapor, and promoting an aqueous gas reaction with water molecules and an oxidation reaction with air.

[0013] First, with regard to the condition at which water vapor microexplosion occurs, it involves instantaneous temperature increase of an organic aqueous solution to high temperature, and for example, water vapor microexplosion is caused by collision on surface of a solid at high temperature.

[0014] If no water vapor microexplosion occurs, only a simple aqueous gas reaction of water vapor and organic compounds contained in an organic aqueous solution and an oxidation reaction of air will occur, and therefore it is difficult to expect a significant increase in combustion efficiency. According to the invention, droplets of sprayed organic aqueous solution are sprayed into a high temperature environment to cause microexplosion of water vapor, and according to decomposition of an organic compound contained in the organic aqueous solution, an aqueous gas reaction and an oxidation reaction occur to reduce an endothermic reaction of an aqueous gas reaction (i.e., an endothermic reaction is reduced when chemical bonds are broken or the like), and consequently combustion efficiency increases. In fact, when a 40% by volume aqueous alcohol solution is sprayed on a heat resistant iron reflector with holes, which is heated to 850° C., the heat resistant iron reflector is melted to give a molten mass. Thus, it is believed that water vapor microexplosion, an aqueous gas reaction, and an oxidation reaction occur simultaneously to cause instantaneous temperature increase.

[0015] Under the circumstances described above, inventors of the present invention conducted intensive studies, and as a result, were able to solve the problems with the means given below.

[1] A high-temperature combustion method using fuels and an aqueous solution of an organic compound, including: in a combustion chamber, (1) spraying and burning a fuel with a first burner to heat the interior temperature of a combustion chamber to a high temperature of 700° C. or above; and (2) spraying subsequently an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature.

[2] A high-temperature combustion method using fuels and an aqueous solution of an organic compound, including: (1) spraying and burning in a combustion chamber a fuel with a first burner to heat the interior temperature of the combustion chamber to a high temperature of 700° C. or above; (2) spray-

ing subsequently in the combustion chamber an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature; and (3) burning completely in a chamber for heat treatment, which is installed to be connected to the combustion chamber, the combustion gas introduced from the combustion chamber for elevating the temperature to a high temperature.

[3] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to the item [1] or [2], including: (1) spraying and burning in a combustion chamber a fuel with a first burner to heat a heat resistant reflector installed within the combustion chamber to 700° C. or above; and (2) spraying subsequently in the combustion chamber an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning, and further elevating the interior temperature to higher temperature by colliding with the surface of the heat resistant reflector being heated.

[4] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to the item [3], wherein the heat resistant reflector is a heat resistant metal or ceramic reflector including several holes.

[5] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to any one of the items [1] to [4], wherein the organic compound of the aqueous solution of an organic compound has boiling point of 100° C. or less and is soluble in water.

[6] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to any one of the items [1] to [5], wherein the organic compound of the aqueous solution of an organic compound is one or more types that are selected from water-soluble alcohols, organic acids, aldehydes, and ketones.

[7] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to any one of the items [1] to [6], wherein the aqueous solution of an organic compound is an aqueous alcohol solution including 10 to 50% by volume of ethanol or methanol.

[8] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to any one of the items [1] to [7], wherein the fuel sprayed with the first burner is any one or more types that are selected from petroleum oils like kerosene oil and light oil, organic solvents like alcohols, city gas, LPG, natural gas, hydrogen gas, and brown gas.

[9] The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to any one of the items [1] to [8], wherein the aqueous solution of an organic compound includes hardly-decomposable toxic materials including a benzene ring as a skeleton structure like dioxin and PCB and the benzene ring of the toxic materials are detoxified by decomposition in a combustion chamber.

[10] A method of producing high-temperature and superheated steam by using the method described in the items [1] to [9].

[11] A device for high-temperature combustion using fuels and an aqueous solution of an organic compound, including (1) a combustion chamber, (2) a first burner attached thereto to spray and burn a fuel in the inside of the combustion chamber so that the interior temperature of the combustion chamber is heated to a high temperature of 700° C. or above,

and (3) a second burner which is attached close to the first burner and used for spraying an aqueous solution of an organic compound into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature.

[12] A device for high-temperature combustion using fuels and an aqueous solution of an organic compound, including (1) a combustion chamber, (2) a first burner attached thereto to spray and burn a fuel in the inside of the combustion chamber so that the interior temperature of the combustion chamber is heated to a high temperature of 700° C. or above, (3) a second burner which is attached close to the first burner and used for spraying an aqueous solution of an organic compound into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature, and (4) a chamber for heat treatment which is installed to be connected to the combustion chamber.

[13] The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to the item [12], wherein a means for connecting the combustion chamber and the chamber for heat treatment is a pathway with reduced diameter, which is installed between an exit of the combustion chamber and an entrance of the chamber for heat treatment.

[14] The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to any one of the items [11] to [13], wherein a heat resistant reflector is disposed and installed in the combustion chamber.

[15] The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to the item [14], wherein the heat resistant reflector is a metal or ceramic reflector including several holes.

[16] The method for high-temperature combustion using fuels and an aqueous solution of an organic compound according to any one of the items [11] to [15], wherein the organic compound of the aqueous solution of an organic compound has boiling point of 100° C. or less and is soluble in water.

[17] The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to any one of the items [11] to [16], wherein the aqueous solution of an organic compound sprayed with the second burner is an aqueous alcohol solution including 10 to 50% by volume of ethanol or methanol.

[18] The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to any one of the items [11] to [17], wherein the fuel sprayed with the first burner is any one or more types that are selected from petroleum oils like kerosene oil and light oil, organic solvents like alcohols, city gas, LPG, natural gas, hydrogen gas, and brown gas.

[19] A device for producing superheated steam using the device described in any one of the items [11] to [18].

[0016] According to the invention, in a combustion chamber, a fuel is sprayed and burned with a first burner to elevate the interior temperature of the combustion chamber to a high temperature of 700° C. or above, and an aqueous solution of an organic compound is subsequently sprayed with a second burner into the high-temperature combustion gas obtained with the first burner, consequently causing mixing and burning. Thus, compared to a case in which combustion is carried out by using only fuels or an aqueous solution of an organic

compound, interior temperature of the combustion chamber and/or temperature of a chamber for heat treatment can be synergistically increased to high temperature. As such, the fuels and organic compounds are fully burned, and thus the fuel cost can be reduced.

[0017] Further, with a simple means, high-temperature and superheated steam can be produced in a large amount.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a frontal view for describing the device of Example 1 of the invention;

[0019] FIG. 2A is a cross-sectional view for illustrating the combustion chamber in the device of Example 1 and FIGS. 2B and 2C are plane views for illustrating a heat resistant reflector which is placed in the combustion chamber;

[0020] FIG. 3 is a graph for illustrating the temperature change in the device of Example 1;

[0021] FIG. 4 is a graph for illustrating the temperature change in the device of Example 2;

[0022] FIG. 5 is a graph for illustrating the heat calorie generated in the device of Example 2;

[0023] FIG. 6 is a graph for illustrating the temperature change in the device of Example 3;

[0024] FIG. 7 is a graph for illustrating the heat calorie generated in the device of Example 3;

[0025] FIG. 8 is a graph for illustrating the temperature change in the device of Example 4;

[0026] FIG. 9 is a graph for illustrating the temperature change in the device of Example 5;

[0027] FIG. 10 is a graph for illustrating the temperature change in the device of Example 6;

[0028] FIG. 11 is a graph for illustrating the temperature change in the device of Example 7;

[0029] FIG. 12 is a graph for illustrating the temperature change in the device of Example 8; and

[0030] FIG. 13 is a graph for illustrating the temperature change in the device of Example 9.

DETAILED DESCRIPTION OF EMBODIMENTS

[0031] Hereinbelow, the preferred embodiments of the invention are explained in greater detail in view of the drawings and the examples.

[0032] FIG. 1 is a frontal view for describing the high-temperature combustion device of the example of the invention. Specifically, reference numeral 1 indicates a combustion chamber, reference numeral 2 indicates a first burner, reference numeral 3 indicates a second burner, reference numeral 101 indicates a wall of a combustion chamber, reference numeral 201 indicates a chamber for heat treatment, reference numeral 301 indicates a pathway, and reference numerals T1 to T3 indicate a thermometer.

[0033] FIG. 2A is a cross-sectional view for illustrating the combustion chamber 1 of FIG. 1. Specifically, a ceramic heat resistant reflectors 4 and 5 (FIGS. 2B and 2C) having several holes 4' and notch parts 5' are vertically installed within the combustion chamber 1. Further, FIGS. 2B and 2C are plane views of the heat resistant reflectors 4 and 5.

[0034] First of all, fuel oils like heavy oil A, light oil, and kerosene oil are typically sprayed from the first burner (fuel burner) 2 into the combustion chamber 1 and burned therein. As to an amount of air, an amount suitable for complete combustion is supplied with the same fuels and the air ratio is generally in the range of from about 1.3 to 1.7.

[0035] Accordingly, the heat resistant reflectors (for example, silicon carbide based ceramic plate of which surface is coated with alumina) 4 and 5, which are disposed and installed inside the combustion chamber 1, are heated to a high temperature of 700° C. or above. As for the heat resistant reflector 4 or 5, one type or a combination of two or more types may be used.

[0036] Subsequently, an organic aqueous solution (water containing an organic compound) is sprayed from the second burner (burner for spraying an aqueous solution of an organic compound) 3 so that it can be mixed with fire flame of the first burner within the combustion chamber 1 and collided with the heat resistant reflectors 4 and 5 which are heated to high temperature, and as a result, the organic compounds are decomposed and oxidized accompanied with water vapor explosion on the surfaces of the heat resistant reflectors 4 and 5.

[0037] The aqueous solution of an organic compound is sprayed from the second burner 3 into the combustion chamber 1, and the composition ratio range is as follows; organic compounds:water=1:0.5 to 20 (that is, content of the organic compounds is 66.7 to 5.0% by volume). Further, the spray amount of the aqueous solution of an organic compound from the second burner 3 is preferably 1 to 5 parts by volume per one part by volume of the kerosene oil sprayed from the first burner 2.

[0038] Further, the interior temperature of the combustion chamber 1 is constantly monitored by a thermometer T1.

[0039] In such case, the high-temperature gas within a pathway 301 and a chamber for heat treatment 201 is also a high-temperature and superheated steam containing water vapor.

[0040] As for the combustion method, heavy oil A or the like is first sprayed from the first burner 2 and burned to heat the heat resistant reflectors 4 and 5. When the temperature of the thermometer T1 reaches 700° C. or above for having an aqueous gas reaction, or possibly 1000° C. or above, the organic aqueous solution starts to be sprayed.

[0041] Spraying of the organic aqueous solution is preferably started with an amount which is the same as the fuels. However, if the temperature is as high as 1000° C., it can be also sprayed in an amount of 2 to 5 times. The sprayed organic aqueous solution (water containing an organic compound) is collided with the heat resistant reflectors 4 and 5, and after sprayed water instead of vapor film on the surface receives the heat directly from the heat resistant reflectors 4 and 5 heated to a high temperature, water vapor microexplosion occurs. In such case, if a W/O type emulsion is used instead of an organic aqueous solution, heat transfer becomes slow, and as a result, possibility of having water vapor microexplosion is extremely low.

[0042] Water containing methanol or ethanol in an organic aqueous solution forms an azeotropic mixture with methanol or ethanol to lower the boiling point. As a result, the water vapor microexplosion can occur more easily. Further, since methanol and ethanol are soluble in water and also alcohols are inside of water cluster to get dissolved therein, in accordance with water vapor microexplosion, alcohols undergo partial decomposition or have weak bonding, and having the aqueous gas reaction and oxidation reaction at the same time, combustion with high efficiency can be achieved.

Example 1

[0043] In this example, a device having a combustion chamber 1 to which a chamber for heat treatment 201 is connected is used as illustrated in the frontal view of FIG. 1.

[0044] Specifically, the combustion chamber 1 and the chamber for heat treatment 201 are connected to each other via a pathway 301 with reduced diameter, which connects an exit of the combustion chamber 1 and an entrance of the chamber for heat treatment 201.

[0045] Further, in the combustion chamber 1, a first burner 2 for elevating the interior temperature to a high temperature of 700° C. or above and a second burner 3 for spraying an aqueous solution of an organic compound are installed.

[0046] Further, thermometers are placed at three spots in the device, that is, a first thermometer T1 is placed in the combustion chamber 1, a second thermometer T2 is placed in the pathway 301, and a third thermometer T3 is placed in the chamber for heat treatment 201.

[0047] Meanwhile, the chamber for heat treatment 201 is a place for utilizing heat under various purposes and power generation, running a boiler, metal refining, quenching, and incinerating food waste or the like are performed therein.

[0048] According to a conventional technique, a burner is directly attached to a chamber for heat treatment. According to the invention, however, a combustion chamber is prepared separately and fuels are burned in a small combustion chamber. After heating to the temperature of 700° C. or above, preferably 1000° C. or above, an aqueous solution of an organic compound like an aqueous alcohol solution is sprayed to cause water vapor microexplosion, and as result high-temperature gas is produced and transported to the chamber for heat treatment 201 to be utilized for power generation or the like.

[0049] By using the device illustrated in FIG. 1, heavy oil A was sprayed at 5.9 L/H from the first burner 2 (air ratio: 1.5) to pre-heat the combustion chamber 1.

[0050] When the exit temperature of the combustion chamber is about 800° C. as measured by the thermometer T2, 40% by volume aqueous ethanol solution was sprayed at 11 L/H by using the second burner 3.

[0051] After 20 minutes, the thermometer T2 showed 1010° C., indicating temperature increase of 210° C.

[0052] At that time, temperature of the chamber for heat treatment 201 (the thermometer T3) increased by 170° C. from 610° C. to 780° C.

[0053] Meanwhile, when 30% by volume aqueous ethanol solution was used under the same condition, the temperature increase was rather slow, that is, the thermometer T2 showed 980° C., indicating an increase of 180° C. and the thermometer T3 showed 750° C., indicating an increase of 140° C.

[0054] The above results are illustrated in the FIG. 3 (a graph illustrating the temperature change inside the device).

[0055] The reason for above needs to be further clarified. However, it is believed that, according to collision of liquid micro-droplets of an aqueous ethanol solution with a heat resistant reflector which has been heated to 700° C. or above, water vapor microexplosion occurs. The microexplosion exhibits more intense energy as the temperature increases. In particular, ethanol is dissolved in water while sharing clusters with water, and also by having low boiling point of 78.4° C., molecular bonding in ethanol is broken or weakened by intense water vapor microexplosion, and with rapid progress of an aqueous gas reaction and an oxidation reaction, a significant temperature increase is caused.

[0056] Further, in this example, the high-temperature gas within the pathway 301 and the chamber for heat treatment 201 is high-temperature and superheated steam containing a large amount of water vapor.

Example 2

[0057] Next, another example is explained.

[0058] First, heavy oil A was sprayed at 6.6 L/H (5.7 kg/H) from a first burner 2 to heat a combustion chamber 1. After heating for about one hour, temperature of a chamber for heat treatment 201 was 630° C. as measured by T3.

[0059] When 30% by volume aqueous ethanol solution (ethanol 4.6 L+water 10.6 L) was sprayed at 15.2 L/H by using a second burner 3, temperature of the chamber for heat treatment 201 as measured by T3 showed an increase of 190° C. from 630° C. to 820° C.

[0060] For the comparison, instead of 30% by volume aqueous ethanol solution, the same amount of pure ethanol was added and sprayed at 4.6 L/H by using the second burner 3, and as a result, temperature of the chamber for heat treatment 201 showed an increase of only 130° C., i.e., from 630° C. to 760° C.

[0061] The results are illustrated in FIG. 4.

[0062] Since the chamber for heat treatment 201 is used as a heating device for actual industrial use, the temperature increase in the chamber for heat treatment 201 is most critical in terms of thermal efficiency.

[0063] Further, when heat calorie is compared between the addition of pure ethanol and addition of 30% by volume aqueous ethanol solution, amount of gas produced by combustion of heavy oil A at 6.6 L/H (5.7 kg/H) was 97 Nm³, which is then changed to 101 Nm³ with addition of 4.6 L of ethanol or 114 Nm³ with addition of 15.2 L of 30% by volume aqueous ethanol solution.

[0064] Specific heat of gases is as follows: CO₂ 0.54 kcal/m³, H₂O (water vapor) 0.46 kcal/m³, O₂ 0.35 kcal/m³, N₂ 0.35 kcal/m³. Gas analysis after burning heavy oil is as follows: CO₂ 8.4%, H₂O 8.8%, O₂ 6.4%, N₂ 76.4% and the specific heat of gas was 0.376. Gas analysis after burning heavy oil+ethanol is as follows: CO₂ 11.6%, H₂O 13.8%, O₂ 0.8%, N₂ 73.7% (when ethanol is added, air was not particularly introduced, and therefore 6.4% of residual O₂ was consumed by burning heavy oil, lowering O₂ to 0.8%), and specific heat of gas was 0.387. Gas analysis after burning heavy oil+30% by volume aqueous ethanol solution is as follows: CO₂ 10.3%, H₂O 23.8%, O₂ 0.7%, N₂ 65.2%, showing higher ratio of H₂O and specific heat of gas was increased to 0.396. When heat calorie for the heat treatment is calculated from these numerical values, it was 25580 kcal/H for heavy oil only, 32940 kcal/H for heavy oil+pure ethanol, and 40590 kcal/H for heavy oil+30% by volume aqueous ethanol solution.

[0065] Thus, the heat calorie of the heavy oil+30% by volume aqueous ethanol solution was increased by 23% compared to the heat calorie of heavy oil+pure ethanol in the same amount.

[0066] The results given as a drawing are illustrated in FIG. 5. From the results of FIG. 5, the energy was 40590 kcal/H when 30% by volume aqueous ethanol solution is added while it was 32940 kcal/H when only pure ethanol is added. Thus, it is understood that the net energy of 7650 kcal/H, which corresponds to the difference between them (40590-32940=7650 kcal/H), is gained.

[0067] As it is understood from the explanations of this example and FIG. 5, the high-temperature gas (about 900 to

1100° C.) obtained in this example contains a large amount (23.8%) of H₂O (water), and it is also high-temperature and superheated steam.

[0068] Taken together, according to the invention, a large amount of high-temperature and superheated steam can be produced with a simple means.

Example 3

[0069] The test was carried out in the same manner as Example 2 for 30% by volume aqueous methanol solution and pure methanol in the same amount.

[0070] The results are illustrated in FIG. 6.

[0071] By using the device illustrated in FIG. 1, heavy oil A was sprayed at 6.6 L/H from a first burner 2 into a combustion chamber 1 and heated. After heating for 1 hour, a thermometer T2 in the pathway connecting the exit of a combustion chamber reached 800° C. and exhibited an almost stable state. Thus, 30% by volume aqueous methanol solution was sprayed at 15.2 L/H (pure methanol 4.6 L/H and water 10.6 L/H) from a second burner 3. After 20 minutes, the thermometer T2 in the pathway connecting the exit of a combustion chamber showed 940° C., indicating a temperature increase of 140° C. while a thermometer T3 in a chamber for heat treatment showed a temperature increase of 130° C., i.e., from 630° C. to 760° C.

[0072] Meanwhile, for the comparison, pure methanol was sprayed at 4.6 L/H by using the second burner 3, and as a result, the thermometer T2 in the pathway connecting the exit of a combustion chamber showed a temperature increase of 140° C., i.e., from 800° C. to 940° C., which is the same increase as the 30% by volume aqueous methanol solution. However, the thermometer T3 in the chamber for heat treatment increased from 630° C. to 720° C. only.

[0073] In this regard, since the utilization of heat in a boiler for power generation or an incinerator is determined by the temperature and flow amount (heat flow amount) of a chamber for heat treatment, it is found by calculation that the heat calorie in a chamber for heat treatment is increased by about 19% in the case in which 30% by volume aqueous methanol solution is added compared to the case in which pure methanol is added in the same amount.

[0074] FIG. 7 illustrates such results.

[0075] From the results illustrated in FIG. 7, it is understood that energy was 37,620 kcal/H when 30% by volume aqueous methanol solution is added and the net energy of 5,980 kcal/H, which corresponds to the difference between them (i.e., 37,620-31,640=5,980 kcal), is gained.

[0076] As illustrated in the above, 23% heat calorie increase was obtained from the 30% by volume aqueous ethanol solution (Example 2). The heat calorie increase was only 19% for the 30% by volume aqueous methanol solution (Example 3). However, it is believed to have equal to or more than 20% heat calorie increase when the test is carried out under an optimum condition.

[0077] Also in this example, the high-temperature gas within the pathway 301 and the chamber for heat treatment 201 was high-temperature and superheated steam containing a large amount of high-temperature water vapor.

Example 4

[0078] With the device of in FIG. 1, heavy oil was first sprayed at 6.6 L/H and the combustion chamber was heated.

[0079] A thermometer T1 measures the temperature at the center of the combustion chamber, a thermometer T2 measures the temperature at the exit of the combustion chamber, and a thermometer T3 measures the temperature around the exit of the chamber for heat treatment. Since the chamber for heat treatment is a place for multipurpose use, it is expected to be used for power generation, or as a boiler or an incinerator or the like. Thus, the thermal efficiency will be improved more as the temperature of the thermometer T3 increases.

[0080] After heating with heavy oil at 6.6 L/H, 30% by volume aqueous methanol solution was sprayed at 21 L/H.

[0081] As a result, the thermometer T2 showed a temperature increase of 120° C., i.e., from 960° C. to 1080° C. and the thermometer T3 showed a temperature increase of 100° C., i.e., from 800° C. to 900° C. The results are as illustrated in FIG. 8.

Example 5

[0082] In this example, the same device (FIG. 1) as Example 1 was used. As pre-heating of a combustion chamber, heavy oil A was used at 6.6 L/H and the pre-heating time was 30 minutes. When the temperature of thermometers T2 and T3 is almost stabilized, 30% by volume aqueous methanol solution was sprayed at 25 L/H.

[0083] As a result, the thermometer T2 showed a temperature increase of 135° C., i.e., from 965° C. to 1100° C. and the thermometer T3 showed a temperature increase of 130° C., i.e., from 810° C. to 940° C. Since the spray amount of 30% by volume aqueous methanol solution was different between Example 4 and Example 5, i.e., 21 L/H and 25 L/H, respectively, the temperature increase measured by the thermometer T3 was also different, i.e., Example 4: 900° C. (+100° C.) and Example 5: 940° C. (+130° C.). The results are as illustrated in FIG. 9.

Example 6

[0084] With the device illustrated in FIG. 1, heavy oil A was sprayed at 6.6 L/H from a first burner 2 to heat the inside of a combustion chamber 1 to 700° C. or above, and then 30% by volume aqueous ethanol solution was sprayed at 15.2 L/H from a second burner 3 (ethanol 4.6 L+water 10.6 L).

[0085] As a result, the thermometer T2 showed a rapid temperature increase of 220° C., i.e., from 780° C. to 1000° C. and the thermometer T3 showed a temperature increase of 190° C., i.e., from 630° C. to 820° C. Eight minutes later, heavy oil A was reduced by 23%, i.e., from 6.6 to 5.1 L/H, and as a result, the thermometer T2 was recovered to the level before the addition of ethanol. Meanwhile, although the thermometer T3 also showed a decrease of 70° C., indicating the temperature of 730° C., but it is still 110° C. higher than the level before the addition of ethanol. The results are as illustrated in FIG. 10.

Example 7

[0086] The test was carried out under the same condition as Example 6 to determine the reproducibility. First, to heat a combustion chamber to 700° C. or above, heavy oil A was sprayed at 6.6 L/H from a first burner 1 to increase the temperature of the combustion chamber.

[0087] About forty minutes later, the thermometer T2 and the thermometer T3 showed 800° C. and 640° C., respectively. At that time, 30% by volume aqueous ethanol solution was sprayed at 15.2 L/H.

[0088] As a result, the thermometer T2 showed 980° C., representing a temperature increase of 180° C. and the thermometer T3 showed 800° C., representing a temperature increase of 160° C.

[0089] Twenty minutes later, heavy oil A of the pilot was decreased by 22%, i.e., from 6.6 L/H to 5.1 L/H.

[0090] As a result, the thermometer T2 at the exit of the combustion chamber showed a temperature decrease of 160° C., i.e., from 980° C. to 820° C. and the thermometer T3 at the exit of the chamber for heat treatment showed a temperature decrease of only 70° C., i.e., from 800° C. to 730° C. (however, there is still a difference of 90° C. compared to the temperature of 640° C. obtained originally from heavy oil A only). The results are as illustrated in FIG. 11.

[0091] Since the heat utilization according to this type is determined by heat calorie of a chamber for heat treatment, the amount of heavy oil A may be further reduced by 22%, thus it is believed that overall 44% reduction can be achieved.

Example 8

[0092] Addition amount of 30% by volume aqueous methanol solution was changed in this test.

[0093] Specifically, it was added in an amount of 10.6 L/H in Example 8, compared to 21 L/H and 25 L/H in Example 4 and Example 5, respectively.

[0094] As a result, the thermometer T2 showed a temperature increase of 135° C., i.e., from 800° C. to 935° C. and the thermometer T3 showed a temperature increase of only 125° C., i.e., from 625° C. to 745° C. in this example.

[0095] After that, heavy oil A was decreased by 17%, i.e., from 6.6 L/H to 5.5 L/H. However, the temperature of the thermometer T3, which determines the available heat calorie, was decreased to 695° C., showing a decrease of 55° C. Still, there is a difference of 70° C. compared to the temperature of 625° C. obtained originally from heavy oil A at 6.6 L/H. The results are as illustrated in FIG. 12.

[0096] Based on the results, the amount of heavy oil A may be further reduced by 17%, thus it is believed that overall 34% reduction can be achieved.

Example 9

[0097] In this example, test was carried out by adding methanol-based waste water (i.e., waste water containing 40% by volume of methanol and slight amount of others like amine and formalin).

[0098] First, heavy oil A was sprayed at 5.7 L/H from a first burner 2 into a combustion chamber 1 and burned therein followed by heating for about 70 minutes.

[0099] When the thermometer T1 of the combustion chamber shows 1050° C. and the thermometer T2 at the exit of the combustion chamber shows 750° C., the methanol-based waste water was added and burned at 11.4 L/H with a second burner 3. As a result, ten minutes later, the temperature was increased by about 200° C. Thirty minutes after spraying the waste water, the thermometer T2 showed an increase of 230° C., i.e., from 750° C. to 980° C. The results are as illustrated in FIG. 13.

[0100] Further, the temperature of a chamber for heat treatment, which can be used as a thermal engine, showed an increase of 160° C., i.e., from 600° C. to 760° C. Thus, it was confirmed that the methanol-based organic waste water can be used for the invention.

[0101] Conventionally, as a waste, waste water containing methanol in an amount of 40% by volume or so is handed over to a waste water management company with charge since the waste water is not burned as it is. However, according to the invention, it may be fully utilized as a fuel and also a cost required for handing over to a waste management company can be saved.

[0102] In Examples 4 to 9, the high-temperature gas within the pathway 301 and the chamber for heat treatment 201 was also high-temperature and superheated steam containing a large amount of water vapor.

1. A high-temperature combustion method using fuels and an aqueous solution of an organic compound, comprising: in a combustion chamber,

(1) spraying and burning a fuel with a first burner to heat the interior temperature of a combustion chamber to a high temperature of 700° C. or above; and

(2) spraying subsequently an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature.

2. A high-temperature combustion method using fuels and an aqueous solution of an organic compound, comprising:

(1) spraying and burning in a combustion chamber a fuel with a first burner to heat the interior temperature of the combustion chamber to a high temperature of 700° C. or above;

(2) spraying subsequently in the combustion chamber an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature; and

(3) burning completely in a chamber for heat treatment, which is installed to be connected to the combustion chamber, the combustion gas introduced from the combustion chamber for elevating the temperature to a high temperature.

3. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 1, comprising:

(1) spraying and burning in a combustion chamber a fuel with a first burner to heat a heat resistant reflector installed within the combustion chamber to 700° C. or above; and

(2) spraying subsequently in the combustion chamber an aqueous solution of an organic compound with a second burner into high-temperature combustion gas obtained with the first burner followed by mixing and burning, and further elevating the interior temperature to higher temperature by colliding with the surface of the heat resistant reflector being heated.

4. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 3, wherein the heat resistant reflector is a metal or ceramic reflector including several holes.

5. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 1, wherein the organic compound of the aqueous solution of an organic compound has boiling point of 100° C. or less and is soluble in water.

6. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to

claim 1, wherein the organic compound of the aqueous solution of an organic compound is one or more types that are selected from water-soluble alcohols, organic acids, aldehydes, and ketones.

7. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 1, wherein the aqueous solution of an organic compound is an aqueous alcohol solution comprising 10 to 50% by volume of ethanol or methanol.

8. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 1, wherein the fuel sprayed with the first burner is any one or more types that are selected from petroleum oils like kerosene oil and light oil, organic solvents like alcohols, city gas, LPG, natural gas, hydrogen gas, and brown gas.

9. The high-temperature combustion method using fuels and an aqueous solution of an organic compound according to claim 1, wherein the aqueous solution of an organic compound comprises hardly-decomposable toxic materials including a benzene ring as a skeleton structure like dioxin and PCB and the benzene ring of the toxic materials are detoxified by decomposition in a combustion chamber.

10. A method of producing high-temperature and superheated steam by using the method described in claim 1.

11. A device for high-temperature combustion using fuels and an aqueous solution of an organic compound, comprising

- (1) a combustion chamber,
- (2) a first burner attached thereto to spray and burn a fuel in the inside of the combustion chamber so that the interior temperature of the combustion chamber is heated to a high temperature of 700° C. or above, and
- (3) a second burner which is attached close to the first burner and used for spraying an aqueous solution of an organic compound into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature.

12. A device for high-temperature combustion using fuels and an aqueous solution of an organic compound, comprising

- (1) a combustion chamber,
- (2) a first burner attached thereto to spray and burn a fuel in the inside of the combustion chamber so that the interior temperature of the combustion chamber is heated to a high temperature of 700° C. or above,

- (3) a second burner which is attached close to the first burner and used for spraying an aqueous solution of an organic compound into high-temperature combustion gas obtained with the first burner followed by mixing and burning for further elevating the interior temperature to higher temperature, and

- (4) a chamber for heat treatment which is installed to be connected to the combustion chamber.

13. The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 11, wherein a means for connecting the combustion chamber and the chamber for heat treatment is a pathway with reduced diameter, which is installed between an exit of the combustion chamber and an entrance of the chamber for heat treatment.

14. The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 11, wherein a heat resistant reflector is disposed and installed in the combustion chamber.

15. The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 13, wherein the heat resistant reflector is a metal or ceramic reflector including several holes.

16. The method for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 10, wherein the organic compound of the aqueous solution of an organic compound has boiling point of 100° C. or less and is soluble in water.

17. The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 10, wherein the aqueous solution of an organic compound sprayed with the second burner is an aqueous alcohol solution comprising 10 to 50% by volume of ethanol or methanol.

18. The device for high-temperature combustion using fuels and an aqueous solution of an organic compound according to claim 10, wherein the fuel sprayed with the first burner is any one or more types that are selected from petroleum oils like kerosene oil and light oil, organic solvents like alcohols, city gas, LPG, natural gas, hydrogen gas, and brown gas.

19. A device for producing superheated steam using the device described in claim 11.

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