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Preliminary Study of the Solid Powder Combustion Engine

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Abstract: This study presents an inexhaustible, clean, environmental friendly and inexpensive biomass powder fuel as an internal combustion engine fuel. There are two programs. One directly inject the powder into the combustion engine and the other gasify the powder in the internal of the combustion engine. By the means of emission processor and the structure with curved hole chamber piston, a better solution is presented to solve the problem such as the low calorific value of biomass fuels and irrespirable dust emissions. This study gives also a preliminary exploration to the metal powder fuel as the internal combustion engine fuel.

Key words: Energy, the powder explosion, the metal powder, the internal combustion engine

INTRODUCTION

This study is a continued and expanded work based on the powder explosions research. Powder burning and dust explosion characteristics have been studied for a long time. Dates such as the minimum ignition energy of dust explosion concentration limit, the maximum explosion pressure and rate of pressure rise was provided by Nagy and Verakis (1983) and Goroshin *et al.* (1996). Especially since the 1980s, the studies on the way of powder dust, the dust cloud combustion flame structure and propagation mechanism, have made valuable progress (Jarosinski *et al.*, 1986; Demirbas, 2000). But these studies are used to assess the risk of dust processing industry, provide the basis for prevention and control of dust explosion. On the other hand, if the dust explosion could be controlled, the concept of the powder internal combustion engine can be derived .

Due to the complexity of the combustion of solid particulate fuel, the combustion of the fuel of the dust particles, flame propagation structure and the basic research of the propagation mechanism have get wide attention. Combustion of fuel of dust particles has been continuously studied. On the problems such as the different substance, different particle size and density, as well as the combustion characteristics under different conditions, valuable progress has been made. (Demirbas, 2003).

In 2005, we first presented the idea of the internal combustion engine of biomass combustible powder and apply patent of the flammable powder combustion engine (200610126296.7). The corn straw, wheat straw, tree leaves, pine and pulverized coal had been processed into the particles of size 1-20 μm. Two kinds of powder fuels have been organized and put into the internal combustion engine. The engine mentioned here suitable for combustible solid powder, is the transformation of the original internal combustion engine. It Includes the cylinder, piston, connecting rod, crankshaft, intake and exhaust valves, sensors, automatic control unit or the like. There are 2 kinds of engines, one is the gasification type powder combustion engine and another is the internal combustion engine of direct-injection powder. A fuel pre-processor, mixer, electrically controlled fuel injector, processor, emissions and etc. It can pre-process combustible solid powder and then according to the different working conditions of the engine, to control the quantity and timing of fuel injection for and then the filter dust after combustion, in order to reach sewage claim reparable dust. Is designed to produce the raw material powder can be used for engine fuel, able to use raw material powder fuel engine and achieve the following technology index: The effective thermal efficiency: = 20%; engine power: = 10 kW L^{-1}; equivalents of fuel consumption : = 400 g kW h^{-1}; all the emissions are to meet environmental requirements.

In order to state more clearly the novelty of our study in light of similar published works. In particular, how does this work stand out from other reported works on the same research topic. We should clarify the points of originality of work of this study. The characteristics of this paper are using powder as the fuel of the internal combustion engine. While other papers researched only how to use the powder as fuel.

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BIOMASS POWDER COMBUSTION ENGINE PROGRAM

Biomass solid powder fuel: Combustible solid powder is composed of plant residues or combustible waste powder, combined with suitable additives to form the fuel. The plant residue powder includes such as crop straw, sawdust, leaves, firewood, etc. Combustible solid powder includes also combustible waste, such as plastic powder, paper dust powder and metal powder. It must be pulverized and processed to meet the application requirement and environmental sewage requirements. With the development of ultra-fine powder processing technology, combustible solid powder fuel engine has become possible. The combustible powder particle size can be differed according to the materials and engine structure. Different raw materials, the different optimum particle size. In the gasification powder combustion engine, for the combustible solids of low calorific value, such as crop straw, the general size should be less than 10 mm; for the combustible solids with higher calorific value, generally the size should be less than 3 mm in diameter. In the powder combustion engine of direct injection type, generally the combustible solids particle size should less than 5 microns.

The additives mentioned here include flow dispersant, desulfurization and ammonia agent, combustion oxidizer etc., in order to promote powder flow and promote uniform dispersion and promote combustion, reduce pollution and improve the controllability, stability and adjust instantaneous combust speed.

Gasification-powder combustion engine: This kind of engine composed of feeding device, pre-processor of the gasified fuel, the air-fuel ratio regulator, the automatic control unit (s), emission processor. The gasified fuel pre-processor composed of gasifier feed system, cyclone, tar processor, fan. It controls gasifier feed rate and the air volume, based on the requirements of the engine, so that the powder fuel within the gasifier is generated under the action of high temperature, composed of combustible gases such as CO, H_2, CH_4, C_mH_n and suspended combustible solids particulates the cyclone, tar processor, suitable air-fuel ratio by the air-fuel ratio regulator supply to the engine Fig. 1.

Powder combustion engine of a direct injection type: Including a fuel pre-processor (50), electrically controlled fuel spray for (32), the automatic controller (46) and the exhaust processor (40). As shown in Fig. 2.

Combustible solid is pre-compressed into a fine powder fuel with particle size less than 5 microns, less than 5% moisture and has a small amount of additives. The powder fuel (2) is stored in the fuel tank (53), the conveying pump (52) the timely supplying fuel according to the instruction of the automatic control unit (15) pre-processor (50). Conveying pump (52) and between the fuel pre-processor (50) is provided with a one-way valve, in order to avoid backflow pretreated fuel. Electrically controlled fuel injector supply (32) leading the pretreated fuel.

Fuel pre-processor heats, looses and vaporizes the powder fuel and does other pretreatments in the sealed

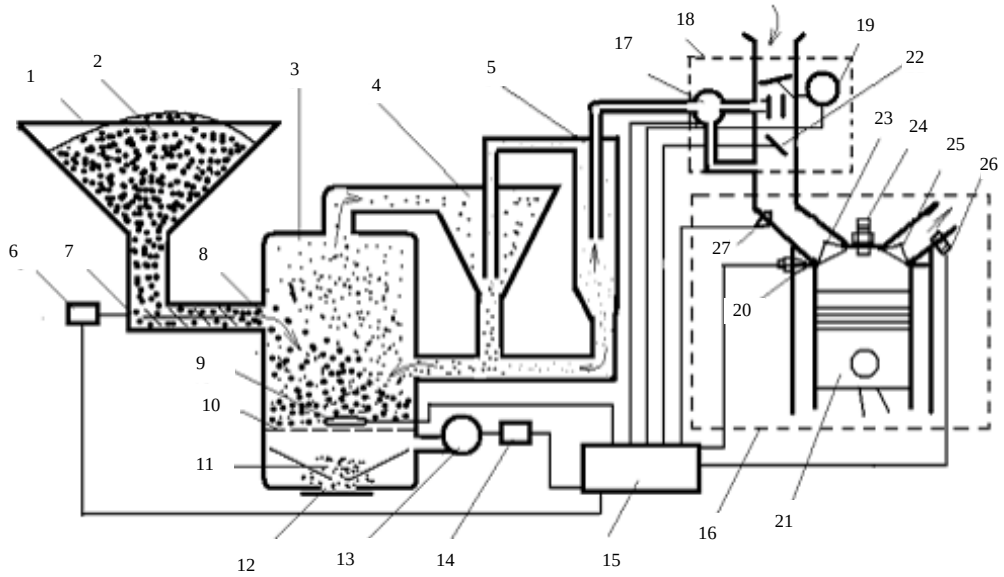

Fig. 1: Gasification-power combustion engine

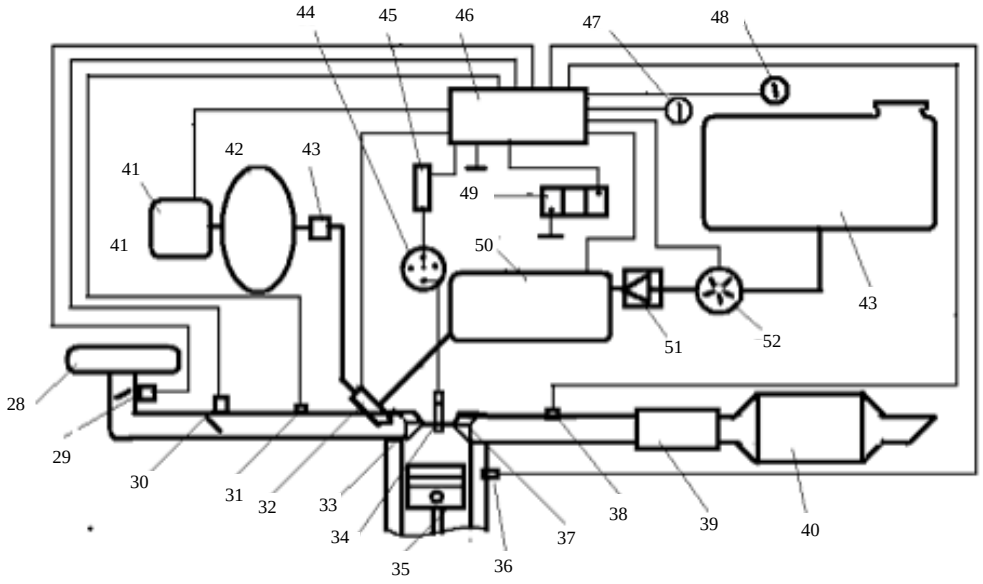

Fig. 2: Power combustion engine of a direct injection type

container without oxygen, so that the combustible powder has suitable characteristics for instantaneous full combustion, as well as suitable additives. The combustible powder changes into a combustible mixed gas. By the electrically controlled fuel injector, the powder is directly injected and is supplied to the engine. Electrically controlled fuel injector directly connected to the fuel pre-process supplies the pretreated powder fuel. Another path is connected to the compressed air. Then all the way they connected the automatic controller which supplied signal the operation command. The amount of the fuel supply is adjusted by the length of time the spout opens.

Emissions processor: After the powder fuel combustion, the amount of the emissions of CO, CH_2, NO_X is not large. but there will be reparable dust generation and emission. In order to meet the requirements of environmental protection, emission processor (40) should be set in the exhaust pipe, next to the muffler (39). This is a method for trapping and filtering ashes after combustion. By impact, interception, diffusion, ashes after the combustion are trapped and filtered. And the amount of emissions of reparable dust can be controlled. With the increasing of deposited particles on the Emissions processor, the flux will reduce, causing the back pressure of the exhaust gas to increase and therefore the power to decrees. Therefore required to periodically replacement of the filter, remove the particles in the emission processor (40).

Convex Arc piston: Solid powder as a fuel interred into the cylinder, together with the dust produced from the combustion, will exacerbate the wear of the cylinder liner and the piston ring groove (54). Both of which have relatively high requirements of the combustion chamber in the cylinder. In order to reduce the dust in the powder fuel after combustion and prevent it from staying in the cylinder, a convex arc piston is adopted.

Convex arc piston (35) method (Fig. 3). A square hole (57), is opened at the top portion (56) in the piston (35) and a convex arc hole is opened at the lower portion of the piston. The area of the arc hole is larger than that of the square one.

When the electrically controlled fuel injector injects and when the piston moves up and down, a strong extrusion vortex is produced. Since the special round structure of the combustion chamber, it results in a difference in speed of the airflow movement. In squeez eddy combustion chamber, the formation of strong turbulence improves the mixture formation of flame acceleration, promotes exhaust thorough, reduce dust stays in the cylinder wall.

Others: Before the fuel enters the cylinder, powder must be heated by the fuel pre-heating processing. Therefore, in the cold start stage, the warm-up switch (48) must be opened first, to set up the preheating device of the fuel for heating. While in the normal working hours, the

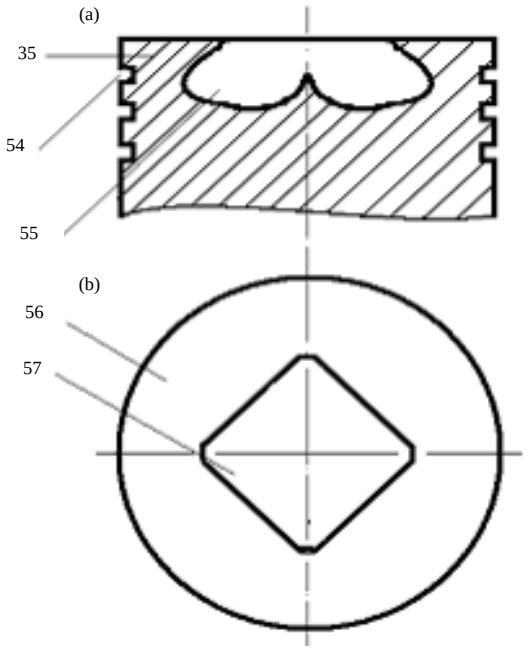

Fig. 3(a-b): Convex are piston, (a) Convex are hole and (b) A square hole

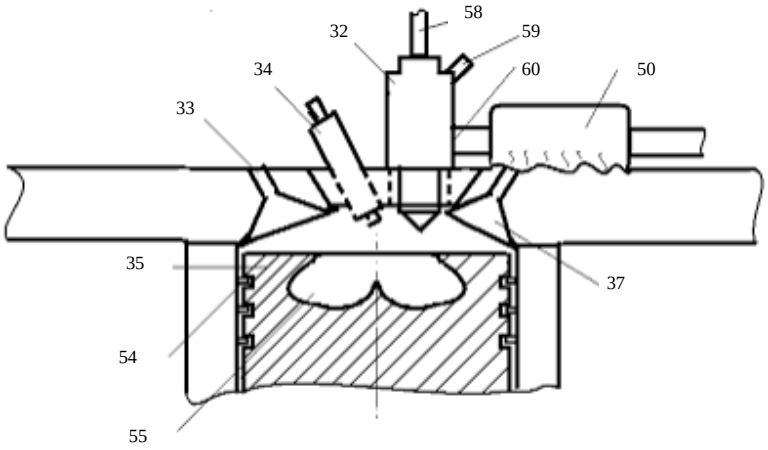

Fig. 4: Fuel pre-heating processor

preheating apparatus stops working, exhaust manifold and fuel pre-processor (50) connected with each other in Fig. 4. The high temperature of the exhaust gas can be used for fuel preheating .

Instantaneous combustion speed the outer characteristic curve of the engine and different powder fuel measured value from the point of view of economy, power, security and environmental protection, set various parameters to select the air-fuel ratio, compression ratio and ignition way.

METAL POWDER COMBUSTION ENGINE CONCEIVED

Biomass powder fuel has many advantages such as wide distribution, a huge amount of supply, easy facilities, processing industrialization. Products of its combustion are CO_2 and H2O, so there are fewer contaminant emissions. Other characteristics include: turning waste into treasure, clean and green, inexhaustible, low cost. The new technique will play an important role in energy

development and utilization, protecting the environment, reducing pollution, reducing greenhouse gas emissions, global warming control, as well as solving the problems of agriculture. New energy has not only obvious economic and social benefits but also ecological environmental benefits.

However, biomass powder fuel has shortcomings, such as low heat per unit mass, seasonal supply, high cost of energy, emissions of reportable dust. For these reasons, internal combustion engine using metal powder as a fuel is proposed.

The metal under the normal state cannot be used as fuel, but when the metal is processed into ultrafine particles, it has a high reactivity. It can be ignited and release a lot of energy. Iron, Aluminum and Zinc can be used as a new alternative energy. For example, when the Iron is processed into nano-scale particles and is scattered in the air, it will quickly become of Fe_2O_3 of Fe_3O_4 FeO_2, releasing large amounts of energy. Ignite the compressed air as power released when the iron is processed into particles of a certain size, mixed with air and the air is compressed and ignited, power will be released.

It has no carbon dioxide, nitrogen oxides output, there is no dust and soot emissions. It can even be recycled by heating as long as the used the ultrafine particles is placed under a hydrogen atmosphere, they will be restored to be available fuel.

The advantages of metal powder fuel is very obvious. There is almost no pollution at all. In addition to environmental protection, the metal fuel has other advantages as well, such as ease in carriage, security in storage, smallness in size, highness of quality in energy properties. Metal fuel cannot be consumed, it can be recycled forever. The cost of the metal fuel will not be affected by the price fluctuation. With so many advantages, after deep going research, once the technology is mature, various kinds of engines will be substituted by the metal powder fuel engine.

CONCLUSION

The solid powder fuel and the powder combustion engine is a new method to use energy. To develop the solid combustible powder energy technology and to let it become a high-grade energy, have broad prospects. Although there are only preliminary exploration and researches at present, it can be predicted that, if we make deep-going investigations and continuous improvements, the internal combustion engine with combustible solid powder fuel will become a reality. A new era of powder energy will come true. mankind will find a renewable and environment protective energy for the internal combustion engine.

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