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COAL BURNING ARRANGEMENT FOR MHD GENERATORS

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FIG.1.

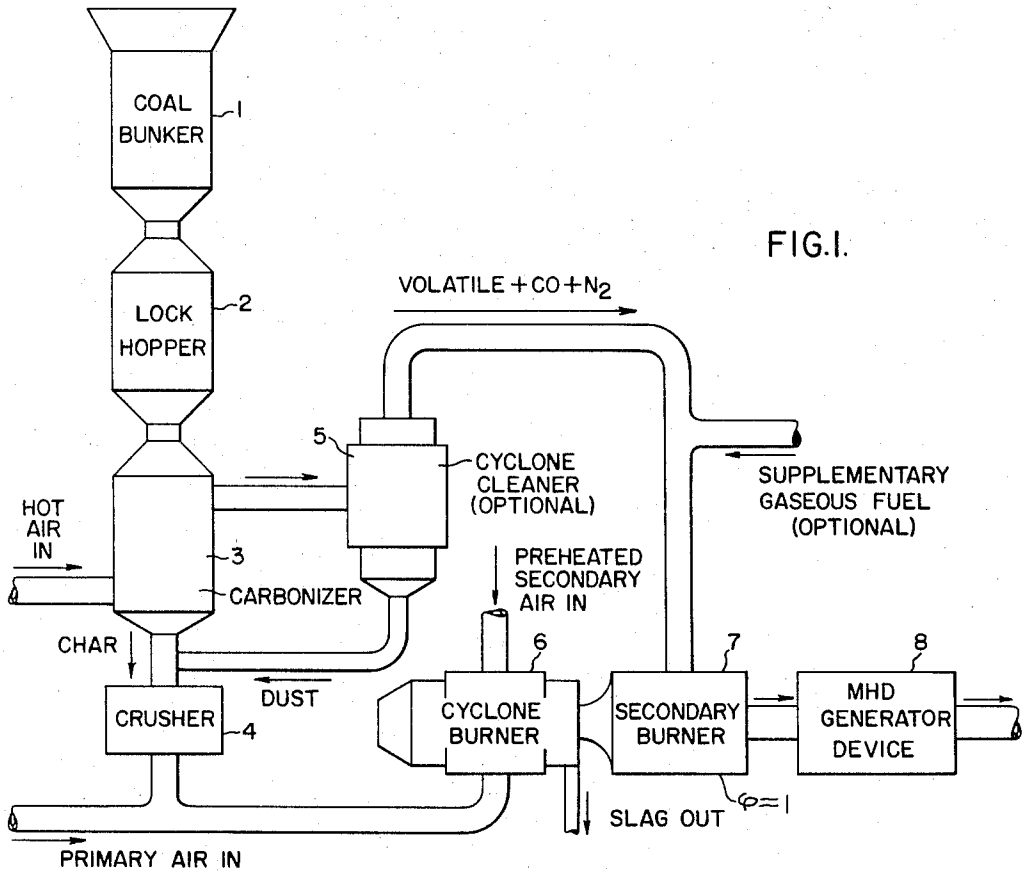
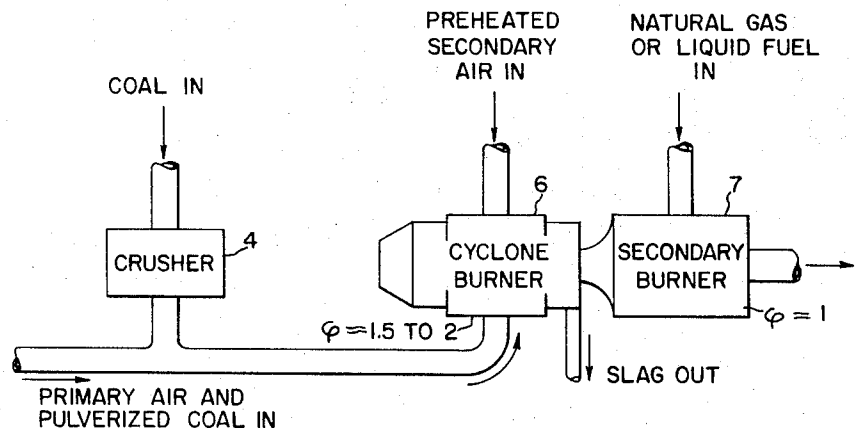


FIG.2.



WITNESSES:

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COAL BURNING ARRANGEMENT FOR MHD GENERATORS

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The present invention relates to improvements in solid fuel combustion apparatus and particularly to solid fuel combustion apparatus for magnetohydrodynamic (MHD) generating devices.

In magnetohydrodynamic electrical energy generating devices, hereinafter referred to as MHD devices, a thermally ionized working fluid is directed through a duct containing a transverse magnetic field. Electrical energy is produced in the duct and collected by electrodes disposed therein. To produce this thermally ionized fluid, a combustion chamber is used in which solid, liquid or gaseous fuels are burned at very high temperatures. With the use of solid fuels, such as coal, ash and slag (molten ash) formation and disposal becomes more of a problem. If the combustion chamber is allowed to produce excessive ash-slag content, this content will travel through the MHD generating device and into heat exchanger units located at the exhaust end of the device. The accumulation of ashes in such units would involve costly cleaning and repair of the units. Also, since the gases must be seeded with an alkali method (e.g. cesium or potassium) and this material must be recovered, the presence of large amounts of ash would complicate the recovery problem.

Another problem encountered in high temperature combustion devices is the high heat loss through the walls of the combustion chamber. In a cyclone burner, the molten ash content (hereinafter referred to as slag) resulting from the burning of solid fuel will tend to collect and solidify on the inside wall of the burner due to the centrifugal forces within the burner if the burner is operated at an optimum temperature. (A burner of the cyclone or vortex type is one wherein fuel particles are burnt in air which enters a combustion chamber tangentially, or nearly so, and moves from the periphery inwards with a vortex motion towards the center axis of the chamber.) The solidified slag collected on the inside of the burner functions as a natural insulator thereby preventing excessive heat losses through the chamber walls and possible consequent overheating of an associated liquid cooling system. Thus, the cyclone burner is an ideal means for burning solid fuels since the ash carry over and heat loss problems are both taken care of within the burner itself; i.e., the ash content, resulting from solid fuel combustion, deposits itself on the inside walls of the burner in the form of slag. The slag, in turn, functions as a natural insulator against high losses through the walls of the burner. The surface of the slag layer, due to the high temperatures, is in a liquid state, and liquid slag is continually tapped off from the cyclone furnace. About 90% of the coal ash can be eliminated in this way.

The present invention uses a cyclone burner, for burning a solid fuel such as coal, in combination with a secondary burner, and an amount of excess air in the cyclone burner for effecting optimum operating temperatures for the burners which produce a thermally ionized fluid for an MHD generating device. As will be explained more fully, the excess air and optimum operating temperature for the cyclone burner provides the necessary ash control.

It is therefore the object of the present invention to provide a new and improved method and means for burning solid fuels in MHD power plants.

It is a further object of this invention to burn solid fuels as a means and method for heating thermally ionized working gases for MHD electrical energy generating devices without ash content being carried over to the MHD device and its associated heat exchange units.

For a better understanding of the invention, its operating advantages and specific objects obtained by its use, reference is had to the following descriptive matter and the accompanying drawing in which:

FIGURE 1 is the schematic diagram of an installation and process constructed in accordance with my invention.

FIGURE 2 is a schematic diagram showing in partial form another embodiment of my invention.

In reference to FIGURE 1, the installation is characterized by a combination of a carbonizer unit 3 adapted to operate under pressure conditions for preheating a solid fuel received from lock hopper 2, a dust extractor in the form of a cyclone cleaner 5 or other suitable device for purifying combustion gases developed in preheating unit 3, a primary cyclone burner 6 for burning the devolatilized solid fuel with excess air and secondary burner 7 for using the excess air from primary burner 6 in burning combustion gases produced in carbonizer 3.

Cyclone cleaner 5 is intended to purify the combustion gases for secondary burner 7 by the substantial elimination of entrained dust or solid particles contained therein. If the dust carry over from the carbonizer is not excessive, the cleaner 5 would not be needed.

Preheater unit 3 is primarily designed to drive off the volatile constituents and possibly also to partially gasify the solid fuel, such as coal, to carbon monoxide. The preheating unit receives coal from lock hopper 2 under pressure while a small amount of hot air is fed into the carbonizer in a pipe schematically shown on the left thereof.

The char residue from carbonizer 3 drops down into crushing unit 4 designed to reduce the char residue to a pulverized form after which it is carried along in a primary air stream into cyclone burner 6. The char residue is a highly carbonaceous substance about half way between coal and coke.

In cyclone burner 6, the pulverized char residue, or new coal in the version of the invention shown in FIGURE 2, is burnt in an atmosphere of excess air, the air equivalent ratio φ being in the range of 1.5 to 2. Air equivalent ratio is the ratio of air consumed to the stoichiometric amount of air. The stoichiometric amount is that amount of air exactly needed to burn all of the fuel, that is, effect complete combustion to products CO_2, H_2O and SO_2.

The excess air in burner 6 should be about 50 to 100% (φ=1.5 to 2). This excess air, however, should be in approximate stoichiometric relation to the separated volatile and carbon monoxide (air equivalent ratio of 1 overall). This ratio φ=1.5 to 2.0 provides an optimum flame temperature within burner 6 that allows the slag forming content to solidify and deposit itself on the inside water cooled walls of the burner. The optimum gas temperature is about 2200° K. At this furnace temperature, the slag deposited remains in liquid form as it moves along the solidified layer beneath, which permits its removal from burner 6 as shown in FIG. 1. Otherwise, and with an air equivalent ratio of say about 1 and air preheated to around 1300° K., the flame temperature within cyclone burners runs approximately 2700° K. At this temperature, the slag would vaporize and pass into secondary burner 7 and MHD device 8. By use of excess air in the order of air equivalent ratio of 1.5 or 2, the temperature of the hot gas core within burner 6 is cooled to about 2200° K. which brings the cyclone burner close to conditions of operation it has with conventional coal fired boilers even though the air is preheated to a high temperature. Thus

an optimum operating temperature range is reached for the cyclone operation and for the elimination of the slag content from the hot gases used in the MHD generating device.

The excess air has further utilization in secondary burner 7 in combustion of the volatile components produced from the solid fuel, or with the liquid or gaseous fuels separately supplied as shown in the embodiment of FIG. 2.

As shown in FIGURE 1 secondary burner 7 receives only hot fuel gases from carbonizer 3 and excess air and combustion products from cyclone burner 6. The secondary burner can be any suitable burner designed to burn fluid fuels and to operate in the temperature ranges required for MHD generating devices. As previously mentioned, if there is a tendency to carry over particulate matter from the carbonizer into secondary burner 7, a cleaner 5 may be used to remove the dust and other particulate matter from the volatile and gaseous components produced in carbonizer 3 while the cyclone burner 6 removes most of the ash component resulting from the burnt coal or char residue by draining off the molten slag content formed therein. Thus, substantially ash free hot gases are forwarded to secondary burner 7 and from the secondary burner to MHD generating device 8.

In the second embodiment of my invention a suitable liquid or gaseous fuel, such as natural gas or residual oil, is used for combustion in secondary burner 7, see FIG. 2. In this embodiment, the amount of gaseous fuel generated from the coal by preheating and partial oxidation could be smaller and even absent altogether. Otherwise, the structure and process is the same as that described above in connection with the first embodiment of my invention as shown in FIG. 1.

In both embodiments it can be seen that applicant's cyclone burner burns substantially all of the coal or char supplied to it leaving only a slag component that is removed from the cyclone burner. The secondary bruner burns the volatile components produced by carbonizer 3, or the separate liquid or gaseous fuels that are provided as shown in the embodiment of FIGURE 2. By operating the cyclone burner at a temperature somewhere around 2200° K. the slag partly solidifies along the inside walls of the burner thereby providing a natural insulation against excessive heat loss through the burner walls, and a protective coating against chemical corrosion of the walls. By applicant's method and means very high final temperatures are obtained for thermally ionizing gases used in MHD generating devices while at the same time allowing only a very small ash content to pass through the device with the use of coal burning combustion means.

While the present invention has been described with a certain degree of particularity, it should be understood that the present disclosure has been made by way of example only and that numerous changes in the details of construction and materials used may be resorted to without departing from the scope and spirit of the invention.

I claim as my invention:

1. A combustion apparatus in combination with a magnetohydrodynamic generator, the apparatus comprising,

primary cyclone burner means for burning a solid fuel with excess air in the amount effective to produce an optimum temperature within the burner which is effective to allow slag content in the solid fuel to deposit and solidify to form a solid layer on the inside walls of the burner, and to allow further slag content to deposit on the solid layer in liquid form,

means for removing the liquid slag from the burner,

means for supplying the solid fuel to the cyclone burner means, the cyclone burner adapted to produce a hot gaseous medium,

a secondary burner means,

means for directing the hot gaseous medium with the excess air from the cyclone burner means to the secondary burner means for further heating of the gaseous medium,

means for directing a low ash content fuel to the secondary burner means for burning therein with the excess air, the secondary burner means adapted to produce a thermally ionized gas stream, and

means for directing the thermally ionized gas stream to the magnetohydrodynamic generator.

2. The combination of claim 1 including

preheating means for heating the solid fuel before it is directed to the cyclone burner and for driving off volatile components, and

means for directing the volatile components to the secondary burner means for burning therein.

3. A method of burning a solid fuel for producing a substantially ash free thermally ionized gaseous stream for a magnetohydrodynamic generator, the method comprising the steps of:

directing a solid fuel with excess air into a cyclone burner,

bruning the solid fuel with the air to produce a hot gaseous medium with a minimum of ash content, and to effect the disposition of solid and liquid layers of slag on the inside walls of the burner,

removing the liquid slag from the burner,

directing the hot gaseous medium with the unused portion of the excess air to secondary burner means,

directing a fuel with a low ash content to the secondary burner means, and

heating further the hot gaseous medium by burning the fuel in the secondary burner means with the excess air to produce the thermally ionized gaseous stream for the magnetohydrodynamic generator.

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