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(54) Title: SOLID AND LIQUID/GAS FUELED, FULLY AUTOMATED, SMOKELESS COMBUSTION HOT WATER/STEAM BOILER ADJUSTABLE ACCORDING TO COAL TYPE

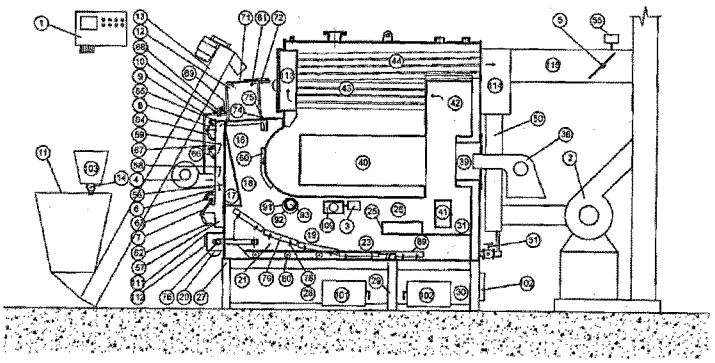

Figure 1

(57) Abstract: Solid and liquid/gas fueled hot water/steam boiler of the invention is a novel technological smokeless combustion, fully automated, solid and liquid/gas fueled hot water/steam boiler developed as an alternate to the domestic and industrial type existing solid and liquid/gas fueled boiler designed with double wall or water tube design according to hot water, superheated water, steam production and operating pressure, having fully automated coal feed and clinker removal system in solid fuel firing chamber, fully automated combustion air hardware that enable means of adjustment according to the volatile ratio within the coal, combustion bed adjustment system that enable means of adjustment according to grain size of the coal and clinker rate and fully automated special grate system, further comprising fully automated dry desulphurization system that enable means of adjustment according to the sulfur content of the coal, that prevents smoke generation at the source by burning the coal smokeless with high combustion efficiency in combustion chamber through automatic continuous feed as being adjusted to the coal type used from the panel of PLC controlled automation and safety system, that prevents sulfur dioxide emission in combustion chamber through fully automated dry desulphurization system, that doesn't require any modification for transformation from solid fueled to liquid/gas fueled or from liquid/natural

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gas fueled to solid fuel by virtue of the special design combustion chamber intended for firing liquid and gas fuel independent from the solid fuel combustion chamber, and adjustable according to the coal type at the solid.

"SOLID AND LIQUID/GAS FUELED, FULLY AUTOMATED, SMOKELESS COMBUSTION HOT WATER/STEAM BOILER ADJUSTABLE ACCORDING TO COAL TYPE"

Present invention relates to a novel technological fully automated smokeless combustion hot water/steam boiler developed as an alternative to the available domestic and industrial type solid and liquid/gas fueled boilers, which is capable of burning the coal as smoke-free in special combustion chamber with high combustion efficiency by virtue of the fully automated coal feeding, combustion air hardware and grate system as being adjusted to the volatile, clinker and sulfur content within the coal, which reduces sulfur dioxide emission via fully automated dry desulphurization system, and which is also capable of burning liquid fuel or natural gas in a secondary special combustion chamber without any modifications.

Liquid and gas fuels can generally be combusted with high efficiency due to their homogeneity. However, the combustion efficiency of the solid fuels, particularly the highly volatile coals, in current boiler or combustion systems that are employed for heating and used in the industry, reduces significantly due to smoke generation, and energy loss can be enormous. Although natural gas increasingly becomes widespread in the modern world, coal can naturally have a broad field of use both in thermal plants generating electrical energy and in heating and industry in countries with rich coal reserves.

Coal can be combusted with relatively high combustion efficiency by means of special burners in the boilers used in thermal plants after being pulverized, or the lump coal can be combusted with relatively high combustion efficiency in fluidized bed systems or by means of mechanical loading stokers in industrial type large capacity boilers and in large capacity boilers used for central heating purposes. However, as complete and smokeless combustion can be achieved neither in the fluidized bed systems nor in combustion systems of traditional overfeed or underfeed stokers, flue dust retainer multi cyclones and wet filters must be used at such combustion systems, yet smoke and pollutant emissions generated as a result of poor combustion leads to considerable amount of air pollution. On the other hand, in existing manual feed small and medium capacity hot water and steam boilers used for heating and in the industry, the coal is combusted on the grate with extremely low efficiency and the air pollution arising from pollutant emissions generated by poor combustion reaches great amounts.

Subject matter of the patent "Solid and Liquid/Gas Fueled, Fully Automated, Smokeless Combustion Hot Water/Steam Boiler Adjustable According to the Coal Type" is a novel type fully automated smokeless combustion hot water/steam boiler developed as an alternate the available solid and liquid/gas fueled boilers, which is capable of burning the coal as smoke-free in special combustion chamber with high combustion efficiency by virtue of the fully automated coal feeding, combustion air hardware and grate system as being adjusted to the volatile, clinker and sulfur content within the coal meanwhile reducing the sulfur dioxide emission via fully automated dry desulphurization system, thus offering a solution for air pollution by preventing smoke generation at the source due to high combustion efficiency and also capable of burning liquid fuel or natural gas in a liquid/gas special combustion chamber with high efficiency without any modifications.

Prior to disclosing the technological differences of Fully Automated Smokeless Combustion Boiler and solid, liquid and gas fueled existing boilers, it would be appropriate to briefly analyze the fact of combustion, complete combustion, combustion properties of the coal and generation of smoke and pollutant emissions.

1. COMBUSTION, COMBUSTION PROPERTIES OF THE COAL, GENERATION OF SMOKE AND POLLUTANT EMISSIONS:

Combustion is a chemical process resulting in release of heat and luminous energy where carbon and other combustible materials within solid, liquid or gas fuels combine with oxygen over a certain ignition temperature.

As oxygen is supplied from air in practice, the fuel must first get in contact with the air in order to ignite. In order to achieve complete combustion of the fuel in any combustion process, the three conditions set forth hereunder must be fulfilled in conjunction with adequate air supply.

a) Temperature above ignition temperature (Temperature)
b) A good blend of fuel and air (Turbulence)
c) Time required for completion of the combustion (Time)

In literature, such three conditions are also known as "The Three T's of Combustion: Temperature, Turbulence and Time".

In terms of firing technique, in order to achieve complete combustion of the fuel in any firing system, first of all adequate amount of air must be supplied and the air and the fuel

should be mixed in turbulently above a certain ignition temperature variable according to fuel type and such condition should be maintained for a certain time.

Whether in solid, liquid, or gas form, any firing system fulfilling such conditions during combustion of the fuel realizes complete combustion and smokeless firing as smoke is the product of a poor combustion.

Coal is a solid fossil fuel comprising of various combustibles, humidity, and incombustible mineral substances. During combustion of the coal, combustible materials comprising of fixed carbon and volatile substances are burned while mineral substances remain as ash.

In general, coals are classified on the basis of their fixed carbon content, volatile substance, humidity and ash ratios. Accordingly, coals are categorized under three main groups as "anthracite" with very low volatile substance ratio, "bituminous coal" or "hard coal" with medium volatile substance level and "lignite" with high volatile ratio.

When coal is heated, the volatile substances within the coal become distilled even at temperatures under ignition temperature and start to emerge as combustible gas (hydrocarbon gasses and tar steam). The coal comprising of the fixed carbon that remains after complete distillation of such volatile substances is called "coke". In this manner, simultaneous combustion of two fuels, one in gas and one in solid form, which are combustible gasses released during combustion of the coal and the fixed carbon part, occurs. As the ignition temperature of the released combustible gasses is higher, the basic problem especially in firing the highly volatile coals like lignite resides in providing necessary conditions in combustion chamber in order to ensure complete combustion of two separate forms (solid and gas) of fuel with distinct ignition temperatures.

Especially when burning highly volatile coals like lignite, poor combustion occurs as the technical specifications of the firing system is not adequate for ensuring the aforementioned complete combustion conditions. Two different types of smoke are generated within the firing system depending on the conditions during poor combustion:

a) Brown Smoke (Grey smoke):

If the temperature in the combustion chamber is below the ignition temperature of the released combustible gasses, then even if adequate amount of air is present, hydrocarbon gasses leave the system without combustion and are exhausted from the stack in the form of smoke. Such smoke comprising of unburned hydrocarbons and tar

steam has brown (or grey, depending on the type of coal) appearance, thus, such type of smoke is called brown smoke (grey smoke). Brown smoke generation leads to loss of fuel due to hydrocarbon gasses leaving the stack unburned –of which approximately 75% is methane gas- and also energy loss as such gasses are heated up to stack gas temperature.

b) Black Smoke (Particle=soot):

If adequate amount of air is not supplied or if turbulent mixture of combustible gasses cannot be achieved even if adequate amount of air is available when the temperature in the combustion chamber is above the ignition temperature of the combustible gasses, poor combustion occurs again. Although a severe combustion occurs at the zones where oxygen is available, carbon particles are formed at zones where no oxygen is present or contact with combustible gasses cannot be achieved with a good mixture as a result of "cracking" reactions due to high temperature and leave the system in the form of soot and as a black colored smoke. Such black smoke formed by particles causes a significant energy loss due to both the unburned fuel, which is carbon particles, and the energy that such particles carry from the system after being heated.

If there is no homogenous temperature distribution within the combustion cell, both grey (brown) smoke and black smoke might be generated simultaneously at different zones of the combustion chambers.

As can be seen, the basic reason of smoke generation during combustion of the coal is failure to burn the released combustible gasses completely, that is to say poor combustion. When complete combustion of the combustible gasses is achieved in the combustion chamber, not only smoke generation shall be prevented, but also energy conservation is achieved as a natural consequence.

Whether in particle or unburned hydrocarbons form, smoke generation is not valid only for coal but also for liquid and gas fuels. Also in combustion systems that burn liquid and gas fuels, generation of such two types of smoke is unavoidable when complete combustion conditions cannot be achieved in the combustion chamber. However, as it is easier to achieve complete combustion of the homogenous liquid and gas fuels and as the liquid and gas fuel burners have design and automatic control systems capable of ensuring high rate of combustion efficiency, in practice, smokeless combustion can easily be achieved in liquid and gas fuel burning boilers with adequate combustion chamber design.

On the other hand, as carbon monoxide (CO), a pollutant emission, is also generated due to insufficient oxygen in the combustion chamber, it also emerges as a product of poor combustion. However, sulfur dioxide (S02) emission generated by combustion of sulfur within the fuel, on the contrary, is not a product of poor combustion, but emerges as a combustion product as a result of combustion of sulfur. Therefore, as it is not possible to reduce sulfur dioxide emission directly by means of a highly efficient combustion, reduction of the sulfur dioxide emission can only be achieved through dry desulphurization method through addition of lime or similar chemicals to the combustion chamber or through wet desulphurization method applicable to the stack gasses.

2. TECHNOLOGY OF THE EXISTING SOLID, LIQUID AND GAS FUEL BURNING BOILERS:

The existing hot water, superheated water and steam boilers used for heating and industrial purposes today can be categorized in two groups as welded steel boilers and sectional cast iron boilers in terms of manufacture and constructive properties. The boilers in these two groups can be evaluated as follows in terms of ability to burn solid, liquid and gas fuel and their areas of usage.

A) Welded Steel Boilers

The boilers in this group are the boilers used for both residence-apartment type domestic heating and for industrial purposes. These boilers can be further categorized in two main groups according to their constructive properties.

a) Flame-Smoke Tube Boilers
b) Water Tube Boilers

Flame-smoke tube boilers are boilers used at low- and medium-capacity domestic type central heating plants and again at relatively low- and medium-capacity industrial steam generation. Such type of boilers can also be classified as three distinct types in terms of constructive properties and design styles.

1) Semi Cylindrical Boilers (DANSK type)
2) Cylindrical Three Pass Boilers (SCOTCH type)
3) Cylindrical Back Pressure (Reverse Flow) Radiation boilers

Semi cylindrical boiler (DANSK) type is the boilers commonly used in Turkey especially for heating and essentially designed for burning solid fuel. In such type of boilers, the grates can be cancelled in order to burn liquid fuels.

Cylindrical three pass boiler (SCOTCH) type is the boilers essentially designed for burning liquid and gas fuels. As it is not efficient to install grates into such type of boilers thus transform them into solid fueled boilers, solid fuels can be used only on the condition to install mechanical loading coal burners (stoker) or preliminary furnace instead of burners.

Cylindrical back pressure (Reverse flow) radiation boilers are low capacity boilers completely designed for burning liquid and gas fuel and used for domestic and rather apartment type home heating purposes. As radiation based heat transfer is achieved through reverse flow in the small combustion chamber in such type of boilers, it is not possible to burn solid fuel by installing grates.

Water tube boilers, on the other hand, are the boilers rather used at large capacity central heating plants or for industrial purposes. Such type of large capacity boilers are further capable of burning solid fuels on the condition to install mechanical coal burners (stoker) instead of liquid and gas fuel burner at the front section. On the other hand, there is also a large number of large capacity water tube boilers designed to operate completely with solid fueled as is the case for thermal plants' boilers.

B) Sectional cast iron Boilers

Such type of boilers are also low-capacity boilers designed for burning liquid and gas fuel. Types operating with solid fuels, such as coke, briquette etc., are also available. Gas fuel operated boilers are available in two distinct types as blown burner and atmospheric burner.

2.1. Firing Technology, Combustion and Smoke Generation at Solid Fueled Boilers:

Solid fueled boilers can be categorized in two main groups as manual feed boilers and mechanical feed boilers in terms of firing technology.

The coal is burned on the grate with a low efficiency in existing domestic type manual feed low- and medium-capacity hot water and steam boilers generally used for heating purposes; as filters are generally not used in such type of boilers, air pollution arising from the pollutant emissions reach to enormous magnitudes.

In large capacity types of the solid fuel operated boilers used for central heating and in the industry, coal is burned by means of mechanical feed coal burners (stoker) or in fluidized bed systems, meanwhile, at larger capacity boilers in thermal plants intended

for electricity generation, coal is burned by means of pulverized system special burners after being pulverized in special mills.

As combustion continuity is ensured and the stoker factor is deactivated at overfeed or underfeed type stokers, coal can be burned with higher efficiency compared to the manual feed boilers. As fluidized bed combustion systems ensure optimum level of air-fuel mixture in line with the combustion continuity, combustion efficiency is further increased to higher levels.

However, as complete and smokeless combustion cannot be achieved both at combustion systems of traditional overfeed or underfeed stokers and at fluidized bed systems, flue dust retainer multi cyclones and wet filters must be used at such combustion systems; yet, smoke and pollutant emissions generated as a result of poor combustion causes significant air pollution.

On the other hand, the possibility of implementing both mechanical feed coal burners and fluidized bed systems to the low- and medium-capacity boilers used at house-apartment type domestic heating economically is very limited.

2.1.1. Firing system and Combustion of Coal at Manual Feed Fixed Plane Grate Boiler:

The firing system in semi cylindrical boiler, which is in the manual feed boiler group and most commonly used at house-apartment type domestic heating, comprises a manual feed fixed plane grate furnace, which is an extremely old technology.

In such type of solid fueled boiler, the fuel burns over the plane grate installed under semi cylindrical grate room. Coal is fed on the grate via shovel by opening the ignition hatch at the front and the ashes falling into the ashtray under the grate can be pulled out using rake by opening the ashtray cover. Large clinkers that remain on the grate on the other hand are removed from the ignition hatch using slice bar and rake. There are primary air vents on the ashtray cover that enters underneath the grate and enable combustion, while secondary air vents are present on the ignition hatch on the top side where coal is fed. The flame smoke and hot gasses from the furnace passes through the secondary and third pass flame smoke pipes and heats the water in the boiler and then reaches to the stack. Flame smoke pipes clogged with fly ashes and soot is cleaned with wire brush after opening front smoke box covers.

In manual feed semi cylindrical boiler, first a certain amount of wood is ignited on the grate during initial ignition and after cinder is obtained coal is sprinkle loaded on the

cinder using a shovel.

In semi cylindrical manual feed fixed plane grate boiler, the coal is combusted with two distinct methods which are sprinkle burning and padding burning method.

a) Sprinkle Burning Method:

In this method, the coal is fed to the fire on the grate through sprinkling with shovel from the ignition hatch. In case the combustible gasses, which are released rapidly and in an uncontrolled fashion due to high temperature when fresh coal is sprinkled in the form of a thin layer on the glowing fuel bed over the grate, cannot mix with adequate amount of air, this leads to soot formation in the form of black smoke through cracking reactions.

On the other hand, if the coal is sprinkled on the embers as a thick layer, fresh coal first cools the combustion bed significantly, thus, disrupts the combustion regime and then stars to heat and gasify starting from the bottom layers. The flame and the hot gasses released from the combustion bed at the bottom pass through the coal at the top layers and rapidly heats and distill the coal, thus leading to uncontrolled release of the volatile gasses. As such combustible gasses released become distant from the combustion zone when moving upwards; they leave the system as unburned hydrocarbons in the form of grey (brown) smoke without igniting due to low temperature even if adequate amount of air enters from the secondary air vent. At the bottommost layer of the coal in contact with the combustion zone, on the other hand, although sufficient temperature is available, majority of the uncontrollably released combustible gasses transforms into black smoke as a result of cracking reaction due to lack of primary air with limited supply under the grate due to stack draught. When the coal at top layers is quite heated and reaches to ignition temperature, majority of the volatile substances are removed from the stack as smoke.

b) Padding Method:

At this method, the fresh coal is fed not on the entire face of the grate but stacked at the right and left side, respectively in the form of pads. This method aims combustion of the released gasses by progressive heating of the fresh coal compared to the sprinkle burning method at one half of the grate while coked coal burns on the other half of the grate. However, although the gasses are released in longer periods, as the released gasses on one side orients towards the rear side of the grate room as parallel to the hot gasses released from the embers on the other side of the grate and also as the gasses get in contact with the cold surfaces on the grate box bottom, majority of the gasses

leave the system in the form of grey smoke without being ignited. Thus, although grey smoke released at this method is less dense compared to the sprinkle method, this method requires longer duration. After the coal on the side stacked in the form of a pad becomes distilled and then ignites, the coal turns into black smoke in the form of soot due to poor combustion at the upper layers due to high combustion bed thickness. But, at this method, as the secondary air entering from top becomes too much functionless, efficiency is reduced due to excess air.

As can be seen, it is not possible to prevent brown (grey) or black smoke generation at the semi cylindrical boilers as complete combustion conditions cannot be achieved within the firing system even if the coal is burned on the plane grate with sprinkle method or if padding is applied. As the smoke from the stack is unburned hydrocarbons and carbon particles, a considerable portion of the fuel is released from the stack as loss.
In practice, the furnace stokers do not use both burning methods according to the art and feeds large amounts of coal into the boiler at once for convenience. Therefore, fuel loss reaches to maximum levels as a result of first grey smoke, then black smoke (soot) and carbon monoxide generation due to very thick combustion bed.

As soot and smut generated in large quantities as a result of poor and inefficient combustion causes clogging in flame smoke pipes in short time, this fact brings forth operational challenges as pipes should be cleaned frequently, and complicates the heat transfer due to the soot layer on the pipe surfaces, thus reducing the heating efficiency of the boiler.

Moreover, in semi cylindrical boilers, when the hot clinkers are being removed with rake by opening the ignition hatch, unburned coal pieces fall under the grate or outside, and ash losses are also increased.

When performing this operation, excess air entering to the boiler further reduces the boiler efficiency and carbon monoxide emission from the completely burned hot clinker removed sometimes create hazardous situations in terms of the stoker's health.

As can be seen, as complete combustion conditions cannot be achieved in the firing system of the manual feed, traditional plane grate semi cylindrical boilers, which are still used commonly and represent an extremely old technology, coal is burned with very low efficiency and abundant smoke generation cannot be prevented. As stack and ash losses reach to maximum levels, energy loss also increases at the same rate due to unburned fuel. Moreover, stoker factor plays an important role in daily operation and operational challenges further reduces the efficiency.

2.1.2. Combustion of Coal in Sectional cast iron Boiler:

Designed for burning solid fuel, the firing system in sectional cast iron boiler essentially comprises a manual feed furnace and primer air enters to the firing system underneath the grate and the secondary air enters the firing system from the ignition hatch at the front part of the furnace.

As sectional cast iron boiler is designed for rather burning degassed coals such as coke or briquette, coal is burned at a thick combustion bed on a small grate area.

As is the case for semi cylindrical boiler, in solid fueled sectional cast iron boiler, coal is fed via spade from the ignition hatch and the clinker is pulled out from the same hatch using rake. However, in such type of boilers, it is not possible to burn coal with padding method due to small grate area. Fed in the form of a thick layer, the coal leads to grey smoke generation as volatiles released abundantly cannot be ignited as is the case in sprinkle burning method, and then to black smoke generation after a rapid combustion commences. When very low volatile coals such as coke, briquette or anthracite are burned instead of highly volatile coals such as lignite, higher combustion efficiency is achieved. However, when highly volatile coals are used, the combustion efficiency at this boiler can be even lower than the efficiency in semi cylindrical boiler.

2.1.3. Firing Systems and Combustion of Coal in Mechanical Feed Boilers:

The coal combustion systems in mechanical feed boilers can be categorized into four groups in terms of coal feed method and combustion principle.

1) Coal combustion systems with overfeed stoker
2) Coal combustion systems with underfeed stoker
3) Coal combustion systems with fluidized bed
4) Pulverized powder coal combustion systems

Overfeed stokers (coal burners) assumes the firing system function of the boiler as being installed within semi cylindrical and cylindrical three pass boilers and water tube boilers or as being implemented as front furnace in front of the boiler. Combustion air is supplied via forced blowing under the grate while fresh coal is fed on the grate via mechanical feeding. Coal combustion systems with overfeed stoker can be categorized in three groups as jetting type stokers, forward push stokers and rotary grate (palletized) stokers.

In jetting type overfeed stokers, fresh coal is sprinkled on the fire within the combustion chamber with fixed or mobile cascade grate with a mechanical jetting system and the combustion principle is implementing the sprinkle burning method in manual feed boiler by automatic feed. Use of particle retainer multi cyclones or wet filters at the stack outlet becomes mandatory due to black smoke generation as a result of failure to fire the volatiles released rapidly from the fresh coal sprinkled on the combustion bed by means of automatic jetting system.

In combustion systems with forward push type overfeed stokers; a combustion process identical to the firing principle with padding method in manual feed boilers occurs, wherein mechanical feeding enables operational convenience and ability to reach large capacities. As grey and black smoke generation cannot be prevented at these combustion systems, filtration systems such as multi cyclone or wet filter are required again at the stack outlet of the boiler.

In rotary grate (palletized) type overfeed combustion systems, fresh coal fed from one end of the palletized rotary grate starts to burn and completes combustion as ash and clinker at the other end and the combustion principle presents a combustion process similar to combination of padding method and sprinkle burning method in manual feed boilers. Large capacities can be achieved in such type of overfeed combustion systems as it is possible to extend palletized rotary grate and increase rotation speed; however,

as smoke generation cannot be prevented due to poor combustion as a result of combustion principle, filtration systems are again needed at the stack outlet.

Underfeed stokers (coal burners) again assume the firing system function of the boiler as being installed within grate box of the semi cylindrical and cylindrical three pass boilers or as being implemented as front furnace in front of the boiler. In coal firing system with underfeed stoker, the coal is fed to the fixed grate combustion chamber from below using a helix and the combustion air is again supplied with a forced blowing fan parallel to the underfed coal. As coal is fed into the combustion chamber with a certain preheating, more efficient combustion in terms of firing the volatiles is achieved when compared to the firing system at manual feed boiler and firing system in overfeed stokers. However, not only the ash losses increase, but also the smoke generation cannot be avoided as the combustion regime is disrupted and combustion efficiency is reduced during manual removal of combustion waste ash and clinker from the fixed grate by the stoker. Thus, use of filtration systems such as dust retainer multi cyclone and wet filter becomes mandatory at the stack outlet where firing system with underfeed stoker is implemented.

Coal combustion systems with fluidized bed are rather suitable for burning pulverized or fine grained coals and are combustion systems applied to the large capacity industrial type water tube boilers. Combustion systems with fluidized bed are based on the principle of burning the coal as fluidizing the coal as if the water in a boiling pan together with the sorbent material at the combustion bed with the pressurized hot air fed under the perforated plate resistant to high temperature under the combustion chamber. Coal is overfed to the fluidized combustion bed automatically via spiral conveyor. As a good mixture (turbulence) of fixed carbon part of the coal at the combustion bed with air is ensured, a good combustion is achieved and fixed carbon part of the coal is combusted, but grey smoke and particle (black smoke) comprising of unburned hydrocarbons is generated also at this system as volatiles within the fresh coal fed to the combustion chamber cannot be burned completely. Therefore, flue dust retainer multi cyclone and wet filter must be used at the stack outlet of the boiler.

Pulverized powder coal combustion systems are combustion systems with broad area of usage at very large capacity water tube boilers especially in thermal plants generating electrical energy. In these combustion systems, after the coal is pulverized at special grinding mills, the pulverized coal is sprayed into the combustion chamber of the boiler with an air-fuel mixture suitable to the lower heating value of the fuel from several spots in such manner to create turbulence and is burned in a pulverized manner. Highly

efficient combustion is achieved due to suitable air-fuel ratio and the turbulent mixture in the combustion chamber. However, some of the volatile substances cannot be burned as the volatiles within the fresh pulverized coal sprayed into the combustion chamber are released rapidly and turn into particles by means of cracking reactions. Therefore, large capacity wet desulfurization systems and wet filters are used at the stack outlet in order to reduce sulfur dioxide emission arising from coals with high sulfur content.

2.3. Combustion at Liquid and Gas Fueled Boilers:

The function of the firing system in boilers designed for liquid and gas fuel combustion is fulfilled by the liquid or gas fuel burners which are installed in front of the boiler and which operate as fully automated. The burner is activated at the temperature set depending on the thermostat controlled by the boiler exit water temperature and is deactivated automatically when a certain temperature is achieved. Other automatic control systems that enable control depending on the exterior temperature can also be implemented in such boilers with ease due to such automatic deactivation feature of the burner.

Liquid fueled boilers generally use fuel-oil as fuel, which is known as central heating fuel. Liquid fuel burner is capable of spraying fuel-oil, which is a homogenous fuel, into the combustion chamber of the boiler together with the combustion air and burning in a turbulent manner and as complete combustion conditions are fulfilled when the combustion chamber design of the boiler, spray angle of the burner and combustion capacity are suitable, smoke generation is prevented. Adjustable air fuel mixture of the burner can increase combustion efficiency, and adjustment of burner nozzle enables operation at the desired capacity within the capacity range. However, as complete combustion cannot be ensured when a good air-fuel adjustment is not made or in cases where boiler's combustion chamber is not suitable, smoke in the form of soot or as unburned hydrocarbons can be released from the stack.

Natural gas is commonly used as fuel in gas fueled boilers. There are two types of gas fuel burners, which are blowing (fan) burner and atmospheric burner. Atmospheric burners can only be used in the boilers with atmospheric burner specially designed only for such burners. Blowing burners, on the other hand, can be implemented in cylindrical three pass boiler, back pressure radiation boiler and three pass sectional cast iron boilers.

In cylindrical three pass steel boilers and the sectional cast iron three pass boilers, after the air-gas mixture supplied to the combustion chamber by the burner completes combustion in cylindrical combustion chamber, the combustion product hot gasses pass from the secondary and third passage pipes or ducts and then leave the boiler and reach to the stack. The heat transfer in cylindrical three pass boilers is ensured through radiation in combustion chamber and through convection and conduction at the secondary and third passage pipes. In the event that soot and smut is accumulated that might be generated as products of poor combustion at the pipes due to defective operation or otherwise at such type of boilers, the front smoke box covers of the boiler can be opened and pipes can be cleaned using wire brush.

In back pressure radiation boilers, on the other hand, turbulence is achieved with reverse flow by rotating the air-fuel mixture supplied through the burners at the central axis of the cylindrical combustion chamber around the combustion chamber with closed rear section, accordingly some sort of secondary pass is achieved within the combustion chamber while combustion efficiency is further increased. The combustion product hot gasses that return to the combustion chamber with reverse flow pass through the flame smoke pipes in the periphery and leave the boiler through reverse flow. Heat transfer in such type of boiler is substantially ensured through radiation within combustion chamber due to reverse flow. In literature, such type of boilers are called "Boiler with reverse flow furnace". When natural gas is used as fuel, as radiation of the natural gas is lower compared to liquid fuel, the heat transfer at the flame-smoke pipes gains importance; in this respect turbulators are installed within the pipes in order to improve the heat transfer rate on the unit surface. However, as the front cover to which the burner is connected cannot be opened during operation as natural gas piping and burner are fixed in such type of boiler, it is not possible to clean the soot accumulated in the pipes due to smut that might be generated as a product of poor combustion due to insufficient air in case the burner air setting is disrupted due to operational errors, accordingly the heating efficiency at the pipes can decrease under operating conditions.

In semi cylindrical boilers transformed into natural gas from solid fuel, the combustion efficiency is lower in semi cylindrical combustion chamber compared to the cylindrical boiler and as the heating surfaces of the secondary and third smoke pipes calculated according to the solid fuel is excessive, stack gas temperature falls dramatically in natural gas; this fact improves the general heating efficiency of the boiler but this time the excessive condensation and corrosion problem emerges in the boiler and the stack due to excessive water vapor, a product of combustion of the natural gas.

3. "SOLID AND LIQUID/GAS FUELED, FULLY AUTOMATED, SMOKELESS COMBUSTION HOT WATER/STEAM BOILER ADJUSTABLE ACCORDING TO COAL TYPE"

Subject matter of the patent "Solid and Liquid/Gas Fueled, Fully Automated, Smokeless Combustion Hot Water/Steam Boiler Adjustable According to the Coal Type", is a novel technological smokeless combustion, fully automated solid and liquid/gas fueled hot water/steam boiler developed as an alternate to the domestic and industrial type existing solid and liquid/gas fueled boiler as being equipped with new invention steps as a result of the long research-development and optimization studies on the boiler forming subject matter of the patent no 27751 entitled 'Improved Special Design Dual Fueled High Efficiency Smokeless Boiler with Two Combustion Chambers'; designed with double wall or water tube design according to hot water, superheated water, steam production and operating pressure; comprising fully automated coal feed and clinker removal system in solid fuel firing chamber, fully automated combustion air hardware that enable means of adjustment according to the volatile ratio within the coal, combustion bed adjustment system that enable means of adjustment according to grain size of the coal and clinker rate, and fully automated special grate system; further comprising fully automated dry desulphurization system that enable means of adjustment according to the sulfur content of the coal, that prevents smoke generation at the source by burning the coal smokeless with high combustion efficiency in combustion chamber through automatic continuous feed as being adjusted to the coal type used from the panel of PLC controlled automation and safety system, that prevents sulfur dioxide emission in combustion chamber through fully automated dry desulphurization system which does not require any modification for transformation from solid fueled to liquid/gas fueled or from liquid/natural gas fueled to solid fuel by virtue of the special design combustion chamber intended for firing liquid and gas fuel independent from the solid fuel combustion chamber, and adjustable according to the coal type at the solid fuel.

The novel boiler of the invention is designed with graded completely mobile grate system or cascaded mobile-fixed special grate system according to low, medium and large capacity requirements in domestic and industrial types. Novel technological boiler is designed with double wall or with water tube design depending on hot water, superheated water, steam generation and operating pressure. Figure I illustrates domestic type low or medium capacity double wall design hot water generating boiler with graded completely mobile grate system. Figure 2 illustrates the central heating and

industrial type medium and large capacity double wall design hot water/superheated water generating boiler with cascaded mobile-fixed special grate system. Figure 3 on the other hand illustrates the central heating and industrial type large capacity water tube design superheated water/steam generating boiler with cascaded mobile-fixed special grate system.

In Figures 1, 2 and 3, functional system and parts in boiler of the patent are enumerated and corresponding parts and systems are illustrated as listed below.

1) Temperature or pressure sensitive PLC controlled automation and safety system
2) Forced aspiration fan with inverter controlled from automation panel
3) Vacuum gauge measuring the solid fuel combustion chamber pressure
4) Forced blowing fan with inverter controlled from automation panel
5) Stack by-pass damper
6) Boiler front panel pertaining to the solid fuel air hardware
7) Main air inlet valve controlled from automation panel
8) Low capacity -idle- air inlet valve controlled from automation panel
9) Coal feed silo air circulation pipe
10) Coal feed silo circulation air valve -butterfly valve-
11) Coal main silo
12) Double wall coal feed silo with air circulation
13) Spiral conveyor enabling automatic coal feed
14) Lime feed spiral feeding lime to the dry desulphurization system
15) Lime feed silo
16) Coal pre-heating chamber
17) Front chamber with triangular water jacket or water tube
18) Coal distillation chamber
19) Solid fuel combustion chamber
20) Grate motion reducer with inverter
21) Graded complete mobile grate system
22) Cascade mobile-fixed special grate system
23) Clinker flow duct
24) Intermediate chamber with water jacket or water tube
25) Combustion chamber rear wall with water jacket or water tube
26) Flame passage duct
27) Steel construction boiler frame
28) Ashtray

29) Ashtray-clinker intermediate chamber
30) Clinker trap
31) Volatile ash collector
32) Undergrate ash removal spiral conveyor
33) Clinker removal spiral conveyor
34) Volatile ash removal spiral conveyor
35) Clinker pool
36) Wet clinker discharge spiral
37) Liquid / gas fuel burner access hatch
38) Liquid / gas fuel burner
39) Liquid / gas fuel flame inlet with water jacket or refractor
40) Liquid / gas fuel combustion chamber
41) Liquid/gas fuel blast hatch
42) Fire box
43) Secondary passage flame-smoke pipes
44) Third passage flame-smoke pipes
45) Water tube first vertical passage duct
46) Water tube secondary vertical passage duct
47) Water tube third vertical passage duct
48) Water tube fourth vertical passage duct
49) Water tube fifth vertical passage duct
50) Stack gas condenser
51) Condenser by-pass valve
52) Steam drum
53) Superheater
54) Stack gas economizer
55) Stack by-pass damper actuator
56) Forced intake air distributer
57) Primary air duct
58) Secondary air duct
59) Coal type volatile damper controlled from automation panel
60) Secondary air heating ducts
61) Silo circulation air guide brackets
62) Main air intake valve actuator
63) Main air intake valve screwed adjustment mechanism
64) Low capacity - idle - air intake valve actuator
65) Low capacity - idle- air intake valve screwed adjustment mechanism

66) Coal type volatile damper actuator
67) Coal type volatile damper screwed adjustment mechanism
68) Coal feed silo circulation air valve actuator
69) Coal feed silo circulation air valve screwed adjustment mechanism
70) Coal feed silo level sensor
71) Coal feed silo cover
72) Coal feed silo cover actuator
73) Coal flow adapter from coal feed spiral to silo
74) Coal feed silo tracks
75) Coal feed silo reels
76) Camshaft with adjustable stroke
77) Connecting rod arms
78) Complete mobile grate frame
79) Complete mobile grates
80) Complete mobile grate reels
81) Cascade mobile grate frame
82) Cascade mobile grate carrier shafts
83) Cascade mobile grates
84) Cascade fixed grate frame
85) Cascade fixed grate carrier shafts
86) Cascade fixed grates
87) Cascade mobile grate frame carrier ball bearings
88) Cascade mobile grate frame carrier balls
89) Fixed clinker cooling grates
90) Thermocouple measuring clinker temperature
91) Combustion bed adjusting tube refractor sheath
92) Combustion bed adjusting tube cooling air blowing fan
93) Air-cooled combustion bed adjusting tube
94) Water-cooled combustion bed adjusting tube
95) Water-cooled bladed-tube special designed combustion bed adjusting plate
96) Undergrate ash discharge duct submerged into clinker pool
97) Clinker discharge duct
98) Volatile ash discharge duct
99) Float supplementing water to the clinker pool
100) Waste clinker silo
101) Ashtray hatch
102) Clinker tray hatch

103) Lime main silo
104) Lime feed valve
105) Actuator activating/deactivating lime feed valve
106) Vibrator enabling lime flow
107) Lime flow duct
108) Lime feed silo level sensor
109) İgnition hatch with observation window
110) Linker tray hatch with observation window
111) Camshaft housing panel
112) Lubrication hatches
113) Front stack gas box
114) Rear stack gas box
115) Boiler stack gas outlet duct
116) Volatile ash collector hatches with observation window

As illustrated in Figures 1, 2 and 3, novel technological boiler of the invention is designed as hot water, superheated water or steam boiler for domestic or industrial purposes or for heating, steam and energy generation purposes, and comprises three main sections, which are solid fuel firing section comprising of thirty six functional parts, which are temperature or pressure sensitive PLC controlled automation and safety system (1), forced aspiration fan (2) with inverter controlled from automation panel depending on the boiler operation capacity and coal type and forced blowing fan (4) with inverter controlled from automation panel by means of vacuum gauge (3) measuring the solid fuel combustion chamber pressure, main air inlet valve (7) controlled from automation panel and low capacity -idle- air intake valve (8) located on stack by-pass damper (5) of the boiler front panel (6) pertaining to the solid fuel air hardware, coal feed silo air circulation pipe (9), coal feed silo circulation air valve -butterfly valve- (10), band or spiral conveyor (13) that enables automatic coal feed from coal main silo (11) to double wall coal feed silo (12) with air circulation, lime feed spiral (14) that feeds lime to the dry desulphurization system parallel to the coal feed, lime feed silo (15), coal pre-heating chamber (16), front chamber (17) with triangular water jacket or water tube, coal distillation chamber (18), solid fuel combustion chamber (19), grate motion reducer (20) with inverter controlled by the program selected according to the coal type from automation panel, graded complete mobile grate system (21) or cascade mobile-fixed special grate system (22) again depending on boiler capacity, clinker flow duct (23), intermediate chamber (24) with water jacket or water tube, combustion chamber rear wall (25) with water jacket or water tube, flame passage duct (26), ashtray (28) located inside

steel construction boiler frame (27), ashtray-clinker tray intermediate chamber (29), clinker tray (30), volatile ash collector (31), undergrate ash removal spiral conveyor (32), clinker removal spiral conveyor (33), volatile ash removal spiral conveyor (34) and clinker pool (35) and wet clinker discharge spiral (36); liquid/gas fuel firing section comprising liquid/gas fuel burner (38) connected to the boiler by means of liquid/gas fuel burner access hatch (37), water jacket or refractor liquid /gas fuel flame inlet (39), special designed liquid/gas fuel combustion chamber (40) independent of solid fuel combustion chamber; and heat transfer area comprising of common fire box (42) wherein flame, leaving the combustion chambers with heat transfer through radiation, ensures heat transfer again with radiation, where liquid/gas fuel blast hatch (41) is located at lateral bottom side and volatile ash collector, where volatile ashes generated during coal combustion are collected, is located at the bottom side, and common secondary passage flame-smoke pipes (43) and third passage pipes (44) in double wall design, and in water tube design, heat transfer area comprising of first vertical passage duct (45), secondary vertical passage duct (46), third vertical passage duct (47), fourth vertical passage duct (48) and fifth vertical passage duct (49) formed by vertical water pipes, in order to ensure heat transfer through convection and conduction of combustion product gasses.

The liquid/gas fuel firing section of the boiler of the patent comprises liquid/gas fuel burner access hatch (37) located at the rear part of the boiler in double wall design as illustrated in Figure 1 and 2, and located at the frontal top section of the boiler in water tube design as illustrated in Figure 3, and liquid/gas fuel burner (38) connected to the boiler, liquid/gas fuel flame inlet (39) with water jacket or refractor, and two blast hatches (41) at lateral bottom sides of the fire box (42) used commonly by water tube special designed liquid/gas fuel combustion chamber (40), which is located at the cylindrical structure characterized as reverse flow furnace located at top section of the solid fuel combustion chamber at double wall design and again at the top section of the solid fuel combustion chamber at water tube design, and solid fuel firing unit.

In the boiler with double wall design illustrated in Figure 1 and 2, the flame and hot gasses returning through reverse flow by grazing the peripheral surfaces of the cylindrical liquid/gas fuel combustion chamber head for upwards from the fire box (42), which is common with the solid fuel firing unit, and then passes from the secondary passage flame-smoke pipes (43) first and from the third passage pipes (44), then leaves the boiler. In this manner, in the novel boiler with double wall design, when firing solid fuel, there are three passes in total with passage of solid fuel in the combustion chamber (19) and passage at the secondary passage pipes (43) and third passage pipes (44) common with liquid/gas fuel firing section; when firing liquid/gas fuel, on the other hand, if two

passages in the cylindrical liquid/gas fuel in the combustion chamber (40) characterized as reverse flow furnace are taken into consideration, there are four passages in total together with the passage in the secondary and third passage pipes.

In the boiler with water tube design illustrated in Figure 3, on the other hand, there are six passages in total for both liquid/gas fuel firing and solid fuel firing: in addition to the horizontal passage in the liquid/gas fuel combustion chamber (40) or solid fuel in the combustion chamber (19), passages from first vertical passage duct (45), secondary vertical passage duct (46), third vertical passage duct (47), fourth vertical passage duct (48) and fifth vertical passage duct (49) formed by water pipes.

The novel technological boiler of the patent is fitted with temperature or pressure sensitive PLC controlled automation and safety system (1) addressing to both hem solid fuel firing section and the liquid/gas fuel firing section. When firing solid fuel, coal feed, control of combustion rate with combustion air flow rate and grate motion, operation of the dry desulphurization system and removal of clinker is performed as fully automated by virtue of this system within the frame of the program and settings made from the panel on the system board according to the coal type used and according to the requirements of the enterprise. When firing both solid fuel and liquid gas fuel, the safety system is activated in order to protect the boiler when the water in the boiler is depleted due to temperature and in similar cases that might pose hazards.

Combustion air is supplied to the solid fuel firing section of the boiler of the invention with the forced blowing fan (4) with inverter that provides desired pressure in combustion chamber as being controlled from the automation panel by means of the forced aspiration fan (2) with inverter controlled by the automation system (1) and the vacuum gauge (3) that measures the combustion chamber pressure. The aspiration fan and the blowing fan running with the inverter supplies combustion air flow rate suitable for the operation capacity that the enterprise requires at staged revolutions selected according to the needs of the enterprise from the panel of the automation system. Moreover, combustion air can also be supplied with three options, which are induced draught only with stack aspiration fan by deactivating the forced blowing fan or only natural draught by deactivating the stack aspirator and by opening stack by-pass damper (5).

In hot water boiler with double wall design as illustrated in Figure 1 and 2, stack gas condenser (50) comprising of stainless steel pipes is located at the rear section of the boiler in order to exploit the energy of the steam within the stack gasses. While the stack gasses are passing through the condenser via induced draught when the stack by-pass damper is at closed position, the condenser improves the boiler efficiency by transferring vaporization latent heat to the low temperature boiler return water through condensation

of the steam arising from the humidity content of the natural gas or coal. At natural stack draught domestic type small sized boilers not running with the low temperature boiler return water, on the other hand, the condenser might also be deactivated by opening the condenser by-pass valve (51) between the condenser and the boiler after deactivating the aspirator by opening the stack by-pass damper (5).

In industrial type boiler with water tube design as illustrated in Figure 3, saturated steam leaving the steam drum (52) above the boiler can be transformed into superheated steam by means of the superheater (53) located inside the fire box (42). The steam in superheater outlet is heated up to the desired temperature with the automation system and covers the high temperature steam requirements of the enterprise for process purposes. If the enterprise aims to generate electricity, superheated steam is again increased to the desired temperature with the automation system and is directed to the steam turbine. In such boilers with industrial type water tube design, stack gas economizer (54) is located in boiler outlet for the purpose of preheating the boiler feed water by the stack gasses leaving the boiler at high temperatures due to high pressure steam.

The boiler front panel (6), which is detachable to the boiler from front, pertaining to the air hardware is located at the front side of the solid fuel firing section of the novel boiler, and natural draught or only aspiration common main air intake valve (7) and natural draught low capacity -idle- air intake valve (8) are located on this panel. There is a coal feed silo air circulation pipe (9) which is connected to the bottom side of the double wall coal feed silo (12) over the forced blowing fan (4) outlet connected to the boiler front panel and coal feed silo circulation air valve -butterfly valve- (10) is located on said pipe.

In cases where operation with only aspiration fan is sufficient depending on the coal type and the requirements of the enterprise, at the time when the forced blowing fan is stopped, combustion air can be supplied only by means of forced aspiration with the main air intake valve (7) that opens automatically by means of the main air intake valve actuator (62). Again, the stack by-pass damper (5) that turns on and off with a by-pass damper actuator (55) controlled by the automation panel turns on automatically when the aspiration fan is deactivated and supplies combustion air at lower capacity through natural draught of the stack. In cases where heating or steam requirement is at very low, even negligible, levels, on the other hand, main air valve also turns off automatically and only the low capacity -idle- air valve (8) turns on automatically. In this manner, combustion air can be supplied with three options; first of which is forced draught where forced blowing fan and forced aspiration fan operates simultaneously; second is forced draught only with forced aspiration fan and the third one is only natural draught.

In cases where natural stack draught is only sufficient at certain times of the day in low-capacity boilers intended for domestic type heating, as forced draught is not required aspiration fan or blowing fan are not considered necessary except for the emergencies and in such cases combustion air can be supplied only by means of natural draught depending on the heating requirements.

Regarding the operation only with natural draught, on the other hand, combustion air can be supplied with two options; first of which is when the main air valve is at fully open position and the second is when the main air valve is closed and the low capacity -idle- air valve is at open position.

Forced intake air distributer (56) is located across the forced blowing fan outlet connected to the boiler front panel (6), and primary air duct (57), to which the primary air is directed, is located at the bottom side of the duct formed between the air distributor and panel, while the secondary air duct (58), to which the secondary air is directed, and the coal type volatile damper controlled from automation panel (59), which enables adjustment of the system according to the volatile ratio in the coal content are located at the top side of the same. After the secondary air heading upwards passes from the top side of the coal pre-heating chamber, it then heads down as illustrated in the figure and extends into the secondary air heating ducts (60) on the rear wall of the distillation chamber.

The silo circulation air fed to the double wall coal feed silo (12) and adjusted with the circulation air valve -butterfly valve- (10), on the other hand, enters from the bottom side of the silo and is directed downwards, towards the coal within the silo by means of the circulation air guide brackets (61) located at the top side.

The forced draught combustion air supplied via forced aspiration and blowing fan hits the forced intake air distributer (56) across the front panel and is separated into two branches heading upwards and downwards. The combustion air supplied through natural stack draught enters from the main air intake valve (7) during operation at normal capacity; during operation at low capacity, on the other hand, the main air valve controlled from the automation panel is turned off completely and the combustion air is supplied only from low capacity -idle- air intake valve (8).

During operation at normal capacity with forced draught, as the main air intake valve and the low capacity - idle- air intake valve are at closed position, the primary air entering with the forced aspiration and the forced blowing fan controlled from the vacuum gauge depending on the pressure within the combustion chamber heads downwards and passes through primary air duct (57) and reaches to the combustion chamber from below

the grate. The secondary air heading upwards, on the other hand, circulates the top section of the coal pre-heating chamber after passing the coal type volatile damper (59) on the secondary air duct (58) and becoming subject to a certain preheating, and then is completely heated at the secondary air heating ducts (60) at the rear side of the distillation chamber (18) then reaches to the combustion chamber (19) from above.

During operation at normal capacity with natural draught, forced aspiration and blowing fan are deactivated and the stack by-pass damper is opened and the combustion air entering the system through natural draught of the stack and opening of the main air valve controlled from the automation panel reaches to the combustion chamber in the same manner by means of primary and secondary air ducts. During low capacity operation, on the other hand, the low capacity -idle- air valve opens concurrently with closing of the main air valve and the combustion air contributes to the firing of volatile combustible gasses released at low amounts only as secondary air.

Main air intake valve (7) can be opened and closed automatically in a staged manner depending on the temperature or pressure level desirable at the enterprise as being connected to an actuator (62) controlled by the panel of the PLC controlled automation system. Main air valve can also be manually adjusted and fixed by means of a screwed adjustment mechanism (63) in cases where the automation system becomes deactivated or wherever considered necessary.

Likewise, the low capacity -idle- air intake valve (8) is also capable of opening and closing automatically during low capacity operation as being connected to an actuator (64) controlled by the panel of the PLC controlled automation system, and being adjusted manually by means of a screwed adjustment mechanism (65) whenever necessary.

The coal type volatile damper (59) can also be adjusted in a staged manner depending on the type of coal used as being connected to an actuator (66) controlled by the panel of the PLC controlled automation system; moreover the damper can also be manually adjusted and fixed by means of a screwed adjustment mechanism (67) with butterfly cap wherever considered necessary according to the rate of volatiles in the coal used.

The coal type volatile damper (59) can be set at six distinct positions on average depending on the type of coal to be used, which are, for instance fully (100%) open for very highly volatile coals, approximately 80% open for highly volatile coals, approximately 60% open for medium volatile coals, approximately 40% open for relatively low volatile coals, approximately 20% open for very low volatile coals such as anthracite, and closed for non-volatile coals such as coke. Adjusting this valve just once, either from PLC controlled automation panel or manually, depending on the type of coal to be used during

daily operation shall be sufficient.

The coal feed silo circulation air valve -butterfly valve- (10) on the coal feed silo air circulation pipe (9) connected to the forced blowing fan outlet from top side can be adjusted in a staged manner depending on the type of coal used as being connected to an actuator (68) controlled by the panel of the PLC controlled automation system; moreover it can also be manually adjusted and fixed by means of a screwed adjustment mechanism (69) wherever considered necessary.

The fully automated novel boiler enables adjustment of primary and secondary air amounts, which have distinct functions during combustion; automatic control of the primary and secondary air flow rates from PLC controlled automation panel and further enables the primary and secondary airs to perform their functions in the best manner for complete combustion with the distribution mechanism of the ducts. On the other hand, double wall coal feed silo circulation air and the air directed towards the coal from above within the silo and the pre-heating chamber not only prevents overheating of the silo, but also directs the combustible gasses that might be released in the chamber as a result of distillation towards the combustion chamber by applying pressure from above. Moreover, in case of operation at very low capacity or in case the boiler remains idle for long periods, a multidimensional combustion optimization is ensured by means of low capacity -idle- air setting only intended for firing released volatile-combustible gasses at very low flow rate.

The fully automated novel smokeless combustion boiler of the invention contain coal main silo (11) and double wall coal feed silo with air circulation (12) and the band or spiral conveyor (13) that enable automatic coal feeding from coal main silo to the coal feed silo is controlled from the coal feed silo level sensor (70), and activates and deactivates automatically as the coal level in the coal feed silo is reduced as being connected to PLC controlled automation system. The cover of the coal feed silo (71) opens automatically by means of the coal feed silo cover actuator (72) controlled from the PLC controlled automation system before the coal feed conveyor goes into action and closes automatically after the coal feed conveyor stops. In domestic type low capacity boilers that doesn't require feeding of coal with conveyors, on the other hand, the cover of the coal feed silo can be opened and closed manually.

In order to avoid frequent opening and closing of the silo cover in medium and large capacity industrial type boilers, a coal flow adapter (73) with an angle conforming to the natural from of coal to the silo from the coal feed spiral outlet is available instead of the cover and the coal flow adapter is detachable when necessary as being bolted between the spiral outlet and silo inlet. In this manner, capacity fluctuations arising from opening

and closing the hatch during coal feeding operation are avoided. Means for uninterrupted coal feed is also provided in domestic type boilers suitable for coal feed using spiral by implementing coal flow adapter.

Coal feed silo tracks (74) installed on the coal pre-heating chamber (16) are available at the bottom part of the double wall coal feed silo with air circulation (12) and the coal feed silo is moved left and right by means of the coal feed silo reels (75) on said tracks, thus enable opening and closing of the front smoke box covers of the boiler with double wall design. As the boilers with water tube design lack flame smoke pipes and front smoke box, coal feed silo is tightly bolted and fixed in place.

Graded complete mobile grate system (21), which can be seen in Figure 1, for domestic type low- and medium-capacity boilers is present under the solid fuel combustion chamber (19) of the novel boiler of the patent, which is adjustable through the command received from the automation panel depending on the type of coal used. For the central heating and industrial type medium- and large capacity boilers, on the other hand, cascade mobile-fixed special grate system (22) as illustrated in Figure 2 and Figure 3 is present. The grate motion reducer (20) with inverter, the movement rate and duration of which is adjusted from the PLC controlled automation panel depending on the clinker rate within the coal and lower heating value of the coal drives reciprocating motion to the graded complete mobile grate system (21) or the mobile grates of the cascade mobile-fixed special grate system (22) by means of the camshaft (76) with adjustable stroke and the connecting rod arms (77).

As illustrated in the figure, the graded complete mobile grate system comprises the graded complete mobile grate frame (78), complete mobile grates (79) resistant to high temperatures and installed on the stages on the grate frame and the reels (80) installed at the lateral walls of the boiler. Cascade mobile-fixed special grate system, on the other hand, comprises cascade mobile grates (83) placed on the mobile grate carrier shafts (82) on the cascade mobile grate frame (81) and the cascade fixed grates (86) placed on the fixed grate shafts (85) on the cascade fixed grate frame (84). Mobile grate moves on the grate frame carrier balls (88) installed within a special mobile grate frame carrier ball bearings (87) installed under the frame (81) and at the lateral walls of the boiler.

As can be seen from the figure, the fixed clinker cooling grates (89), which enable cooling of the hot clinkers before falling into the clinker spiral at the clinker tray, is located at the top side of the clinker tray (30) section after the last step of the fixed grates installed above the top section of the double wall or water tube of the ashtray-clinker tray intermediate chamber (29) located within the steel construction boiler frame (27). There

are two thermocouples (90) installed at the central section of the fixed clinker cooling grates and that measure clinker temperature. The reducer moving the grate from the panel of the automation system by means of the thermocouple measuring clinker temperature is controlled in order to ensure that the clinker temperature varies in the range of certain values to be set according to the coal type. The stability of the clinker temperature, which maximizes the combustion efficiency, is ensured by means of the thermocouple that either moves or stops the grate according to the lower and upper limits for clinker temperature set according to the coal type from the panel of the automation system. In this manner, regardless of the capacity of operation at the system, the combustion losses arising from removal of glowing unburned coals together with the clinker to the clinker tray and excessive cooling of the clinker and clinker formation at the last steps of the combustion chamber are minimized.

The combustion bed thickness adjustment system with three options set forth below is present at the top section of the inception part of the solid fuel combustion chamber (19) of the novel boiler of the invention which enable adjustment of the thickness of the combustion bed over the grates according to the grain size of the coal to be burned; comprising of, depending on the boiler capacity and operating conditions, air-cooled combustion bed adjusting tube (93) of different diameter ratings, which is detachable from outside as illustrated in the domestic type small- or medium capacity double wall boiler in Figure I, where secondary air and combustible gasses pass from the top section, surrounded by refractor sheath (91) resistant to high temperatures with cooling air blowing fan (92) on one side; or water-cooled combustion bed adjusting tube (94) as illustrated in the central heating and industrial type medium- and large capacity double wall boiler in Figure 2; or water-cooled bladed-tube special designed combustion bed adjusting plate (95) as illustrated in the central heating and industrial type large capacity water tube boiler in Figure 3; which is also detachable from outside and able to perform rotational movement and again fitted with refractor sheath and comprising of water-cooled two or three tubules and sheet plate.

The refractor sheath on the combustion bed adjusting tube or plate not only has positive impact on the coal distillation but also improves the strength of the pipe or plate by protecting the same from high temperature due to radiation. The blowing fan connected to one side of the air-cooled combustion bed adjusting tube ensures cooling with forced circulation while it is further possible to ensure a natural air circulation within low capacity boilers by closing, in half, the ends in reverse direction. In water-cooled combustion bed adjusting tube and plate, on the other hand, natural circulation of the heated water is ensured as being connected to the double wall or water tube lateral walls of the

combustion chamber from outside via one inlet and outlet flange.

The bed height of the coal flowing onto the grates can be adjusted by using small or large diameter pipe depending on the grain size of the coal to be used. It is further possible to detach and attach the bladed special designed combustion bed adjusting plate comprising of two or three tubules and sheet plate from outside and adjustment of the height of the combustion bed is enabled through rotational motion. In this manner, when burning small grained coals (for instance coal with 0.5/10 grain size), the resistance of the combustion bed to the primary air entering from below the grates is reduced by means of lower combustion bed thickness, thus high efficiency combustion of the coals with very small grains is ensured by supplying air-fuel mixture up to the upper layers of the combustion bed.

The movement rate and movement duration of the mobile grates in reciprocating motion according to the coal type and grain size used in the grate system below the combustion chamber can be set from the automation panel and can be adjusted by means of the grate reducer with inverter controlled by the thermocouple measuring clinker temperature, which enables burning of all coal types from coals with high clinker rate and low calorific value to coals with low clinker rate and high calorific value in an efficient manner.

The aspiration fan with inverter and the forced blowing fan set within the frame of the programs selected at the automation panel according to the pressure or temperature level desired at the enterprise supplies the combustion air required in line with the grate motion set according to the coal type and grain size of the coal. When the pressure or temperature level reaches to the desired values, the revolution of the aspiration fan, and accordingly of the forced blowing fan, and the grate motion rate reduces gradually depending on the program at the automation panel, thus automatically reducing the firing capacity. When the pressure or temperature is down to a certain level, the flow rate of the stack aspiration fan and the forced blowing fan increases automatically; then the grate motion rate increases in line with the increasing flow rate, thus increasing the firing capacity. In this manner, it is ensured that the system operates under full automation according to the program at the PLC controlled automation panel in the pressure or temperature range desired at the enterprise.

In boilers where natural stack draught is sufficient, on the other hand, the firing capacity is set through setting the grate motion rate and durations and main air intake valve stages only by means of grate motion reducer from the automation panel according to the desired temperature or pressure level, thus operation in the desired temperature or pressure range is ensured.

In solid fuel firing section of the novel boiler of the patent, fine ashes falling under the grates are discharged by means of the undergrate ash removal spiral conveyor (32) under the ashtray (28), while the clinkers falling to the clinker tray (30) section by sliding from the top of the clinker cooling grates are discharged by means of the clinker removal spiral conveyor (33) at the bottom section of the clinker tray, and the volatile ashes accumulated under the volatile ash collector (31) are discharged by means of the volatile ash removal spiral conveyor (34) to the clinker pool and the wet ash and clinker in the pool (35) are automatically removed from the system through the command received from the panel of the PLC controlled automation system by means of the wet clinker discharge spiral (36).

Undergrate ash discharge duct (96) submerged into clinker pool is located at the outlet of the undergrate ash removal spiral conveyor (32); clinker discharge duct (97) submerged into ash-clinker pool is located at the outlet of the clinker removal spiral conveyor (33); and the volatile ash discharge duct (98) submerged into clinker pool is located at the outlet of the volatile ash removal spiral conveyor (34). There is float (99) supplementing water to the clinker pool which is activated as the water level falls is located on the clinker pool (35) to which ash, clinker and volatile ashes are discharged, thus preventing drop of water level in the pool. Wet clinker discharge spiral (36) discharges the wet ash and clinker from the clinker pool to the waste clinker silo (100). In this manner, when the clinkers are removed from the boiler through spiral conveyors which are controlled from the automation system and which are activated as fully automatic in periods and intervals set from the automation panel according to the coal type, not only ingress of cold air not contributing to the combustion to the boiler is prevented, but also dust emission is prevented due to wet ash and clinker, thus avoiding pollution.

The ashtray hatch (101) and clinker tray hatch (102) with access to the ashtray and clinker tray within the steel construction boiler frame (27), to which the main frame of the boiler of the patent with double wall or water tube design is installed in a sliding manner, are available and such hatches are used in cases that require intervention due to maintenance and repair at medium and large capacity boilers. At the domestic type low-capacity boilers that doesn't require handling of ash and clinker with conveyor, on the other hand, ashtray hatch and clinker tray hatch are used for removal of the ash and clinker manually.

The novel boiler of the patent is fitted with fully automated dry desulphurization system with two fully automated options adjustable according to the sulfur content in the coal

depending on the boiler capacity and the coal type used in the enterprise, the first of which is used to feed the coal main silo (11), and the second is used to feed the lime feed silo (15) located at top section of the coal pre-heating chamber (16), as illustrated in Figure 1, 2 and 3. It is possible to use the desulphurization system with these two options together, but only one of these options might also be used depending on the boiler capacity and the grain size and sulfur content of the coal used at the enterprise.

Performing lime feed from two optional points enabled improvement of the efficiency of the desulfurization process especially at coals with very high sulfur content by ensuring a good contact of the powdered lime with the coal prior to the combustion and with the coal and gasses during preheating with an aim to minimize the sulfur dioxide emission.

In dry desulphurization system of the first option, the boilers with coal grain size suitable for feeding with spiral conveyor include lime feed spiral (14) that feeds suitable amount of lime automatically from the lime main silo (103) to the coal main silo (11) and it is ensured that the powdered lime fed in quantities adequate for the sulfur content of the coal is well-mixed with the coal during conveyance with the coal feed spiral (13).

The dry desulphurization system of the second option, on the other hand, comprises the lime feed spiral (14), lime feed silo (15), special lime feed valve (104) that adjusts flow of the powdered lime in the lime feed silo at a flow rate suitable to the sulfur content of the coal, actuator (105) activating/deactivating lime feed valve, vibrator (106) enabling lime flow by vibrating the lime feed valve, and lime flow duct (107) that enable powdered lime to flow down in a regular manner, and the lime feed spiral (14) activates and deactivates automatically and feeds the silo as the lime level in the silo drops in line with the coal feed with the powdered lime received from the main silo as being controlled by the level sensor (108) on the lime feed silo (15) and from PLC controlled automation panel (1). The special lime feed valve (104) adjusting the lime flow rate according to the sulfur content of the coal can be adjusted automatically with an actuator (105) controlled from the panel of the PLC controlled automation system, and it is further possible to adjust the valve manually according to the coal type used whenever necessary or by disabling the automation system.

The dry desulphurization system adjusted according to the sulfur content of the coal is activated and deactivated automatically in line with the automatically fed coal quantity and the grate motion and enables chemical reaction of the powdered lime, which is fed to either coal main silo or lime feed silo prior to combustion, with the sulfur dioxide, a combustion product, and transforms sulfur dioxide into calcium sulfate. In this manner, the novel boiler also minimizes the sulfur dioxide emission arising from coals with high

sulfur content by virtue of this fully automated dry desulphurization system in addition to the smoke and carbon monoxide emissions through fully automated smokeless combustion.

As can be seen from the figure, the novel smokeless boiler of the patent incorporates two ignition hatches (109) with observation window that access into the combustion chamber from both sides and used for initial ignition and fitted with observation window resistant to high temperature. Likewise, two clinker tray hatches (110) with observation window are present at the top side of the clinker tray section which are used for observing the clinkers at the last step of the grates and the clinker spiral; which enable maintenance and repair activities within the boiler when necessary, again fitted with observation window resistant to high temperature.

The front lower part of the boiler is equipped with the camshaft moving the grates and the camshaft housing panel (111) which houses the bearings of the camshaft, and which is detachable to the boiler from front side; and the panel is fitted with lubrication hatches (112) that enable lubrication of the bearings camshaft and connecting rod arms.

In boiler with double wall design, flame and hot gasses coming from the flame passage duct (26) head towards the secondary passage flame-smoke pipes (43) after passing the fire box (42), and then shift course in the front stack gas box (113) and passes through the third passage pipes (44) and from the rear stack gas box (114) and is exhausted from boiler stack gas outlet duct (115). Cleaning of the flame-smoke pipes of the boiler is performed by opening the front stack gas box covers while the ash and soot accumulated at the rear side is removed by opening the cleaning hatch or latch on the rear stack gas box. The fly ashes that leave the flame outlet duct together with the flame and that accumulate under the fire box of the boiler in time, on the other hand, are removed using a rake by opening the blast hatch (41) on the side of the boiler at the start of each season.

In boiler with water tube design, on the other hand, flame and hot gasses coming from the flame passage duct (26) first pass from the fire box (42) and then through the water tube first vertical passage duct (45), and after this shift course and pass through the water tube secondary vertical passage duct (46), water tube third vertical passage duct (47), water tube fourth vertical passage duct (48) and water tube fifth vertical passage duct (49) respectively and reach to the boiler stack gas outlet duct (115). While the volatile ashes in the combustion product hot gasses shift course, the volatile ash accumulated in the volatile ash collector at the bottom are discharged to the clinker pool by means of the volatile ash removal spiral conveyor (34) which is activated

automatically at certain times and intervals selected from the automation panel according to the coal type. Volatile ash collector hatches (114) with observation windows that open to the section where the hot gasses shift course are present at the top side of the volatile ash collector. Such hatches can also be used in cases that necessitate maintenance and repair of the water tube vertical passage ducts of the boiler.

It may be contemplated that the automatic coal feed using spiral and clinker removal system might not be economical in domestic type natural stack draught boilers with very low capacity and manual processes for filling the coal feed silo and clinker removal might be preferable. As such type of low capacity boilers are designed on the basis of filling the coal feed silo either twice per day, in the morning and in the evening, or once in 24 hours under normal operating conditions, automation of only the grate motion system and the main air valve will be sufficient. In such type of small boilers, main air valve can be adjusted to the desired temperature either manually or with mechanical thermostat. After ash and clinker is dropped by moving the grates via grate motion reducer, the coal feed silo, whose level is dropped, is replenished with new coal and the ash in the ashtray is removed manually by opening the ashtray hatch while the clinkers falling into the clinker tray are also removed manually by opening the clinker tray hatch.

Combustion of the coal in the Fully Automated Smokeless Combustion Boiler occurs through the process as set forth below in order to prevent smoke and pollutant emissions:

In the novel fully automated boiler adjustable according to the coal type, fresh coal is automatically fed to the double wall coal feed silo by means of the coal feed spiral controlled from the panel of the PLC controlled automation and safety system. Going into the pre-heating chamber from the coal feed silo, the coal is first subjected to a certain preheating and then advances to the combustion chamber over the grates from the coal distillation chamber in a fully automated manner due to its self-weight and again with the motion that the grate motion reducer with inverter automatically drives the mobile grates of the grate system at a speed suitable for the coal type. Distilled by means of a gradual preheating, the coal can be burned as smokeless under complete combustion conditions in the combustion chamber together with the combustible gasses released in a controlled manner and with the coked fixed carbon part. The combustion waste ashes fall into the ashtray under the grates while the clinkers that remain over the grate fall into the clinker tray by sliding from the fixed clinker cooling grates after the last step of the fixed grate by virtue of the motion of the cascade mobile grate that perform reciprocating motion automatically. Fine ashes accumulated in the ashtray are automatically discharged into the clinker pool by means of the ash removal spiral conveyor controlled from the

automation panel, while the ash and clinker in the clinker tray are automatically discharged into the clinker pool by means of the clinker removal spiral conveyor again controlled from the automation panel.

In this manner, while the coal is fed through a fully automated mechanism that ensures a stable flow into the combustion chamber, the combustion waste ash and clinker are also removed from the combustion chamber automatically again by means of this mechanism, thus a stable and uninterrupted combustion is ensured.

Fully automated dry desulphurization system minimizes the sulfur dioxide emission through desulphurization of the sulfur content of the coal by virtue of the powdered lime flow rate adjustable depending on the amount of sulfur content of the coal depending on the coal type in line with this automatic and uninterrupted combustion process.

Combustion of the coal and prevention of smoke generation and pollutant emissions in fully automated, smokeless combustion solid fuel firing unit of the domestic or industrial type novel boiler of the patent adjustable according to the coal type as illustrated in Figures 1, 2 and 3 occurs through a process set forth hereunder:

The fresh coal fed to the coal feed silo by means of the coal feed spiral controlled from the panel of the PLC controlled automation system first becomes subject to a certain preheating process at the coal pre-heating chamber of the boiler and then gets in contact with hot coal at the entrance of the distillation chamber and gradually starts to heat. The coal in the distillation chamber is heated by receiving a certain amount of heat released in the combustion chamber through radiation and conduction. As the coal in the combustion chamber is burned, the coal in the distillation duct moves towards the combustion chamber while the coal in the pre-heating chamber concurrently starts to slide downwards due to grate motion and it's self-weight and enters into the distillation chamber. In line with the coal feed spiral, powdered lime is automatically fed into the lime feed silo by means of lime feed spiral of the special desulfurization system. In line with the downward flow of the coal, the powdered lime also flows downwards towards the entrance section of the combustion chamber after being adjusted according to the sulfur content of the coal.

The coal in the distillation chamber becomes subject to gradual distillation as it approaches downwards to the combustion chamber and the volatile substances within the coal is distinctly released as combustible gas. The combustible gasses that are released in a controlled manner and that have an ignition temperature (700 -750 ℃) higher than the normal ignition temperature of the coal are diverted through forced draught provided by means of the forced aspiration fan with inverter and the forced

blowing fan and enter into the hottest zone (around 850-900℃) of the system over the combustion bed in the combustion chamber and mix with adequate amount of well-heated secondary air coming from the secondary air ducts in a turbulent manner due to high temperature, and burned. As this temperature required for complete combustion is maintained for a certain period thanks to the special design of the combustion chamber, all gasses are combusted under such complete combustion conditions achieved in combustion chamber, thus preventing smoke generation in the form of grey and black smoke at the source, and the pollutant emissions and carbon monoxide emission, which are also the product of a poor combustion, are also prevented due to complete combustion. As the coal in the distillation chamber releases the majority of the volatile substances within its content as combustible gas at the end of the distillation process, the coal enters the combustion chamber as semi-coke or coke.

The fixed carbon part of the coal, which is in solid form, that enter into the combustion chamber of the fully automated boiler as majority or all of the combustible gasses content released is burned with the primary air entering between the special designed mobile-fixed grates. The carbon monoxide generated due to poor combustion at the upper layers of the combustion bed where air cannot fully penetrate is also ignited at high temperature together with the released combustible gasses of the coal within the distillation chamber with the aid of the well-heated secondary air supplied from top section of the boiler and incinerates under complete combustion conditions. In this manner, the coke part of the coal within the combustion chamber comprising of fixed carbon and the gas part of the coal which is still in the distillation chamber are incinerated simultaneously under complete combustion conditions created in the combustion chamber above the grates, and as complete combustion of the coal together with solid and gas parts is achieved, smoke generation and carbon monoxide generation is prevented in the combustion chamber, thus smokeless combustion process is achieved.

In the fully automated novel boiler adjustable according to the coal type, the pollutant sulfur dioxide emission generated due to combustion of the sulfur within the coal is converted into calcium sulfate (plaster) with the fully automated, special dry desulphurization system adjustable according to the sulfur content of the coal by reacting with the powdered lime (calcium hydroxide) conveyed to the combustion chamber, thus sulfur dioxide generation is also prevented in combustion chamber.

In the combustion chamber of the boiler, while the portion of the combustion waste ash and clinker that can fall down from the grate openings accumulate in the ashtray, the portions that remain on the grates slide towards the fixed clinker cooling grates located at the back of the combustion chamber. These fully burned ash and clinkers at the end of

the combustion chamber are sifted as the grate motion reducer automatically drives the special designed mobile grate into reciprocating motion and the clinkers that remain on the grate are pushed over the fixed clinker cooling grates after the last step of the fixed grate. Cooled to the desired levels by means of the thermocouple measuring clinker temperature on the fixed clinker cooling grates, the clinkers slide with the motion of the grate controlled from the thermocouple and fall into the clinker removal spiral conveyor in the clinker tray. In this manner, while the combustion waste ash and clinker are removed from the combustion chamber thanks to a fully automatic mechanism by means of the motion of the grates adjusted according to the coal type and due to its self-weight, the coked coal in the form of embers advance towards the end of the combustion chamber. When the coal subjected to gradual distillation in the distillation chamber enters into the combustion chamber, the coal in the pre-heating chamber advances to the distillation chamber through this fully automated mechanism. The double wall coal feed silo, the coal level of which drops at the end of this process, is automatically fed with fresh coal through coal feed spiral controlled from the PLC controlled automation panel, and newly fed coal is also subjected to the same process. In this manner, complete and smokeless combustion process is repeated uninterruptedly in a periodical manner without any interruption both when the coal is fed and when the ash and clinker drops down or removed.

As can be seen, in the solid fuel firing section of the fully automated, novel smokeless combustion hot water/steam boiler of the invention adjustable according to the coal type, the coal automatically fed by means of the coal feed spiral is subjected to the gradual and controlled distillation through preheating and incinerated in the combustion chamber with its solid and gas portions under complete combustion conditions with high efficiency, thus preventing smoke generation and carbon monoxide emission; moreover, the sulfur dioxide emission is also prevented with the fully automated special dry desulphurization system adjustable according to the sulfur content of the coal in line with flow of coal to the combustion chamber.

Incineration of liquid /gas fuel and heat transfer in the fully automated smokeless combustion boiler occurs as set forth below:

It is possible to burn liquid fuel or natural gas at the liquid/gas fuel firing section of the boiler by means of closing the main air intake valve, low capacity - idle- air valve without requiring any modification at the solid fuel firing unit of the domestic or industrial type novel dual fueled boiler illustrated in Figures 1, 2 and 3. Prior to operating the boiler with liquid fuel or gas fuel, attention should be paid to keep air intakes, such as ignition hatch of the solid fuel firing unit and the ash and clinker hatches, closed.

The boiler can instantaneously be operated with liquid or gas fuel by operating the liquid or gas fuel burner connected to the burner access hatch. However, naturally, it is not possible to operate the boiler with both liquid fuel and gas fuel simultaneously. If the liquid fuel burner and installation is connected to the boiler, then the boiler operates with liquid fuel; if natural gas burner and installation is connected to the boiler, then the boiler operates with natural gas. In case dual fueled burner and installation capable of burning both liquid fuel and gas fuel is employed, then it is possible to operate the boiler with liquid fuel or gas fuel any time so desired.

The air-fuel mixture and the flame supplied by the liquid fuel or natural gas burner from refractor or double wall liquid/gas fuel flame inlet enters into the liquid/gas fuel combustion chamber designed in compliance with the spray angle and capacity of the burner.

In double wall boiler illustrated in Figures 1 and 2, the air-fuel mixture that starts to burn hits the rear wall of the cylindrical special combustion chamber and returns with a circular reverse flow and can not only find adequate time for complete combustion but also complete combustion of the fuel can be achieved by virtue of the turbulence generated with collision of two flows in reverse directions. The flame and hot gasses, which return with reverse flow by grazing the peripheral surfaces of the cylindrical special combustion chamber with water jacket, heads upwards from the fire box, which is common with the solid fuel firing unit. The combustion product hot gasses headed upwards from the fire box passes through the secondary passage and then the third passage pipes and leave the boiler again via boiler stack. In this manner, if two passages in the cylindrical special combustion chamber, which is characterized as reverse flow furnace in the boiler, are taken into consideration, total of four passages occur together with secondary and third passages. The heating efficiency can also achieve very high levels in line with the high combustion efficiency at the novel boiler not only through the radiation oriented heat transfer with two turbulent passages in the combustion chamber, but also through the convection and conduction oriented heat transfer at the secondary and third passage flame-smoke pipes. As this construction with cylindrical special combustion chamber and four passages, which differ from existing back pressure (reverse flow) radiation boilers in burning liquid fuel, further enables cleaning of the flame smoke pipes through front smoke box, its efficiency is further improved compared to the existing back pressure boiler under operating conditions.

As is known, it is not possible to open the front hatch, to which the burner is connected, and clean the pipes under operating conditions especially in existing back pressure radiation boilers with natural gas installation connected due to fixed natural gas

installation. As the heat transfer rate at the pipes reduces in case of accumulation of soot and smut, which might be generated due to poor combustion as a result of deteriorated burner settings or any other reason whatsoever, in the pipes at such type of boilers, the boiler can operate with low heating efficiency for long time.

In industrial type boilers with water tube design illustrated in Figure 3, on the other hand, the flame ignited with air/fuel mixture that the burner provides from the liquid/gas fuel flame inlet with refractor to the special designed combustion chamber with a suitable downward inclined angle first heads towards the bottom section of the combustion chamber, then grazes the pipes of the steam superheater and advances upwards to the first vertical passage duct. After changing direction at the top side of the first vertical passage duct and head downwards from the secondary vertical passage duct, it then heads upwards again towards third passage duct after the turn at the bottom side and then passes through the fourth and fifth vertical passage ducts, respectively and leaves the boiler from stack gas outlet duct. In this manner, the combustion gasses that complete six passages together with the horizontal passage in the combustion chamber leaves the boiler with a higher heat transfer efficiency especially without any contamination and clogging such as the flame smoke pipes and passes to the economizer. Entering the economizer at a temperature close to the saturated steam temperature of the high pressure steam, the stack gasses enable further heating of the boiler feed water in the economizer, thus further improving the overall heat transfer efficiency.

This design with total of six passages together with the horizontal passage in the combustion chamber is also valid for solid fuel incineration and as contamination and clogging of the pipes especially at the vertical passage ducts with volatile ashes is not in question, a higher heat transfer efficiency is achieved under operating conditions also with the solid fuel at this novel boiler compared to the existing industrial type boilers.

If it is intended to incinerate solid fuel in fully automated smokeless combustion dual fueled boiler of the patent currently operating with liquid fuel or natural gas, then it is possible to convert to solid fuel combustion process again without any need for mechanical modification by activating the solid fuel firing section independent from the liquid-gas fuel combustion chamber of the boiler. Prior to converting to solid fuel combustion process, it is sufficient to deactivate the liquid fuel/natural gas burner and bring the burner air intake damper into closed position. After coal is completely fed by means of fully automated coal feed spiral, the boiler can instantly start to operate with solid fuel by igniting the coal in the combustion chamber with a suitable igniter from above from the ignition hatch.

In conclusion, "Solid and Liquid/Gas Fueled, Fully Automated Smokeless Combustion Hot water/steam boiler adjustable according to the coal type" of the invention presents the flexibility of firing different fuels with both special designed combustion chamber that burns liquid/gas fuels with high efficiency, and fully automated smokeless combustion solid fuel firing section adjustable according to the coal type without requiring any modification for conversion from solid fueled to liquid/gas fueled or from liquid/natural gas fueled to solid fuel, and prevents carbon monoxide emission with complete combustion when burning the coal in its combustion chamber with efficiency and with no smoke generation with its fully automated coal feed, fully automated combustion air hardware and special grate system as being adjusted to the grain size of the coal, and volatile substance, clinker and sulfur content within the coal, and further prevents sulfur dioxide emission with its fully automated special dry desulphurization system. Fully automated smokeless combustion boiler provides a remedy for air pollution by preventing grey smoke, particle and carbon monoxide generation at its source due to its high combustion efficiency and ensures significant ease of operation and comfort in line with fuel conservation due to high efficiency and full automation.

CLAIMS

1. A solid and liquid/gas fueled hot water/steam boiler characterized in that the boiler is a fully automated smokeless combustion boiler adjustable according to the coal type, designed as hot water, superheated water or steam boiler intended for domestic or industrial purposes or for heating, steam and energy generation, and comprises three main sections, which are solid fuel firing section comprising of thirty six functional parts, which are temperature or pressure sensitive PLC controlled automation and safety system (1), forced aspiration fan (2) with inverter controlled from automation panel depending on the boiler operation capacity and coal type and forced blowing fan (4) with inverter controlled from automation panel by means of vacuum gauge (3) measuring the solid fuel combustion chamber pressure, main air inlet valve (7) controlled from automation panel and low capacity -idle- air intake valve (8) located on stack by-pass damper (5) of the boiler front panel (6) pertaining to the solid fuel air hardware, coal feed silo air circulation pipe (9), coal feed silo circulation air valve -butterfly valve- (10), band or spiral conveyor (13) that enables automatic coal feed from coal main silo (11) to double wall coal feed silo (12) with air circulation, lime feed spiral (14) that feeds lime to the dry desulphurization system parallel to the coal feed, lime feed silo (15), coal pre-heating chamber (16), front chamber (17) with triangular water jacket or water tube, coal distillation chamber (18), solid fuel combustion chamber (19), grate motion reducer (20) with inverter controlled by the program selected according to the coal type from automation panel, graded complete mobile grate system (21) or cascade mobile-fixed special grate system (22) again depending on boiler capacity, clinker flow duct (23), intermediate chamber (24) with water jacket or water tube, combustion chamber rear wall (25) with water jacket or water tube, flame passage duct (26), ashtray (28) located inside steel construction boiler frame (27), ashtray-clinker tray intermediate chamber (29), clinker tray (30), volatile ash collector (31), undergrate ash removal spiral conveyor (32), clinker removal spiral conveyor (33), volatile ash removal spiral conveyor (34) and clinker pool (35) and wet clinker discharge spiral (36); liquid/gas fuel firing section comprising liquid/gas fuel burner (38) connected to the boiler by means of liquid/gas fuel burner access hatch (37), water jacket or refractor liquid /gas fuel flame inlet (39), special designed liquid/gas fuel combustion chamber (40) independent of solid fuel combustion chamber; and heat transfer area comprising of common fire box (42) wherein flame, leaving the combustion chambers with heat transfer through radiation, ensures heat transfer again with radiation, where liquid/gas fuel blast hatch (41) is located at lateral bottom side and volatile ash collector, where volatile ashes generated during coal combustion are collected, is located at the bottom side, and common secondary passage flame-smoke pipes (43) and third passage pipes (44) in double wall design, and in water

tube design, heat transfer area comprising of first vertical passage duct (45), secondary vertical passage duct (46), third vertical passage duct (47), fourth vertical passage duct (48) and fifth vertical passage duct (49) formed by vertical water pipes, in order to ensure heat transfer through convection and conduction of combustion product gasses, wherein said boiler also having fully automated coal feed and clinker removal system in solid fuel firing chamber, fully automated combustion air hardware that enable means of adjustment according to the volatile ratio within the coal, combustion bed adjustment system that enable means of adjustment according to grain size of the coal and clinker rate and fully automated special grate system, further comprising fully automated dry desulphurization system that enables means of adjustment according to the sulfur content of the coal.

2. A hot water/steam boiler according to Claim 1, characterized in that in the boiler with double wall design, when firing solid fuel, while there are three passes in total with passage of solid fuel in the combustion chamber (19) and passage at the secondary passage pipes (43) and third passage pipes (44) common with liquid/gas fuel firing section; when firing liquid/gas fuel, on the other hand, if two passages in the cylindrical liquid/gas fuel in the combustion chamber (40) characterized as reverse flow furnace are taken into consideration, there are four passages in total together with the passage in the secondary and third passage pipes; in the boiler with water tube design, on the other hand, there are six passages in total for both liquid/gas fuel firing and solid fuel firing: in addition to the horizontal passage in the liquid/gas fuel combustion chamber (40) or solid fuel in the combustion chamber (19), passages from first vertical passage duct (45), secondary vertical passage duct (46), third vertical passage duct (47), fourth vertical passage duct (48) and fifth vertical passage duct (49) formed by water pipes.

3. A hot water/steam boiler according to Claims 1 and 2, characterized in that the liquid/gas fuel firing section of the boiler comprises liquid/gas fuel burner (38) connected to the boiler by means of liquid/gas fuel burner access hatch (37), water jacket or refractor liquid /gas fuel flame inlet (39), and two blast hatches (41) at lateral bottom sides of the fire box (42) used commonly by water tube special designed liquid/gas fuel combustion chamber (40), which is located at the cylindrical structure characterized as reverse flow furnace located at top section of the solid fuel combustion chamber at double wall design and again at the top section of the solid fuel combustion chamber at water tube design, and solid fuel firing unit.

4. A hot water/steam boiler according to Claims 1, 2 and 3, characterized in that the boiler which doesn't require any modification for conversion from solid fueled to liquid/gas fueled or from liquid/natural gas fueled to solid fuel is fitted with temperature or

pressure sensitive PLC controlled automation and safety system (1) addressing to both solid fuel firing section and the liquid/gas fuel firing section and when firing solid fuel, coal feed, control of combustion rate with combustion air flow rate and grate motion, operation of the dry desulphurization system and removal of clinker is performed as fully automated by virtue of this system within the frame of the program and settings made from the panel on the system board according to the coal type used and according to the requirements of the enterprise, moreover when firing both solid fuel and liquid gas fuel, the safety system is activated in order to protect the boiler when the water in the boiler is depleted due to temperature and in similar cases that might pose hazards.

5. A hot water/steam boiler according to Claims 1, 2 and 4, characterized in that combustion air can be supplied with three options, which are supply of combustion air to the solid fuel firing section of the boiler with the forced blowing fan (4) with inverter that provides desired pressure in combustion chamber as being controlled from the automation panel by means of the vacuum gauge (3) that measures the combustion chamber pressure and the forced aspiration fan (2) with inverter controlled by the automation system (1), by means of forced aspiration only with the stack aspiration fan with the main air intake valve (7) that opens automatically by means of the main air intake valve actuator (62) by disabling forced blowing fan whenever necessary or only by natural draught by disabling the stack aspirator and opening the stack by-pass damper (5) that turns on and off with a by-pass damper actuator (55) controlled by the automation panel turns on automatically.

6. A hot water/steam boiler according to Claims 1, 2 and 4, characterized in that in hot water boiler with double wall design, stack gas condenser (50) is located at the rear section of the boiler in order to exploit the energy of the steam within the stack gasses, that at natural stack draught domestic type small sized boilers not running with the low temperature boiler return water, on the other hand, the condenser might also be deactivated by opening the condenser by-pass valve (51) between the condenser and the boiler after deactivating the aspirator by opening the stack by-pass damper (5).

7. A hot water/steam boiler according to Claims 1, 2 and 4, characterized in that in industrial type boiler with water tube design, saturated steam leaving the steam drum (52) above the boiler can be transformed into superheated steam by means of the superheater (53) located inside the fire box (42) and that stack gas economizer (54) is located in boiler outlet for the purpose of preheating the boiler feed water by the stack gasses leaving the boiler at high temperatures due to high pressure steam.

8. A hot water/steam boiler according to Claims 1, 2 and 4, characterized in that the

boiler front panel (6), which is detachable to the boiler from front, pertaining to the air hardware is located at the front side of the solid fuel firing section of the boiler, and natural draught or only aspiration common main air intake valve (7) and natural draught low capacity -idle- air intake valve (8) are located on this panel and that there is a coal feed silo air circulation pipe (9) which is connected to the bottom side of the double wall coal feed silo (12) over the forced blowing fan (4) outlet connected to the boiler front panel and coal feed silo circulation air valve -butterfly valve- (10) is located on said pipe.

9. A hot water/steam boiler according to Claims 1, 2 and 8, characterized in that forced intake air distributer (56) is located across the forced blowing fan outlet connected to the boiler front panel (6), and primary air duct (57), to which the primary air is directed, is located at the bottom side of the duct formed between the air distributor and panel, while the secondary air duct (58), to which the secondary air is directed, and the coal type volatile damper controlled from automation panel (59), which enables adjustment of the system according to the volatile ratio in the coal content of the system are located at the top side of the same.

10. A hot water/steam boiler according to Claims 1, 2 and 8, characterized in that the silo circulation air fed to the double wall coal feed silo (12) and adjusted with the circulation air valve -butterfly valve- (10) enters from the bottom side of the silo and is directed downwards, towards the coal within the silo by means of the circulation air guide brackets (61) located at the top side.

11. A hot water/steam boiler according to Claims 1, 5 and 8, characterized in that the combustion air supplied through natural stack draught enters from the main air intake valve (7) during operation at normal capacity; during operation at low capacity, on the other hand, the main air valve controlled from the automation panel is turned off completely and the combustion air is supplied only from low capacity -idle- air intake valve (8).

12. A hot water/steam boiler according to Claims 1, 5 and 8, characterized in that main air intake valve (7) can be opened and closed automatically as being connected to an actuator (62) controlled by the panel of the PLC controlled automation system; furthermore, main air valve can also be manually adjusted and fixed by means of a screwed adjustment mechanism (63) in cases where the automation system becomes deactivated or wherever considered necessary.

13. A hot water/steam boiler according to Claims 1, 5 and 8, characterized in that the low capacity -idle- air intake valve (8) is capable of opening and closing automatically during low capacity operation as being connected to an actuator (64) controlled by the

panel of the PLC controlled automation system, and be adjusted manually by means of a screwed adjustment mechanism (65) whenever necessary.

14. A hot water/steam boiler according to Claims 1, 5 and 8, characterized in that the coal type volatile damper (59) can be adjusted in a staged manner depending on the type of coal used as being connected to an actuator (66) controlled by the panel of the PLC controlled automation system; moreover the damper can also be manually adjusted and fixed by means of a screwed adjustment mechanism (67) with butterfly cap wherever considered necessary according to the rate of volatiles in the coal used.

15. A hot water/steam boiler according to Claims 1, 5 and 8, characterized in that the coal feed silo circulation air valve -butterfly valve- (10) on the coal feed silo air circulation pipe (9) connected to the forced blowing fan outlet from top side can be adjusted in a staged manner depending on the type of coal used as being connected to an actuator (68) controlled by the panel of the PLC controlled automation system; moreover it can also be manually adjusted and fixed by means of a screwed adjustment mechanism (69) wherever considered necessary.

16. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the boiler contains coal main silo (11) and double wall coal feed silo (12) with air circulation and the band or spiral conveyor (13) that enable automatic coal feeding from coal main silo to the coal feed silo is controlled from the coal feed silo level sensor (70), and activates and deactivates automatically as the coal level in the coal feed silo is reduced as being connected to PLC controlled automation system that the cover (71) of the coal feed silo opens automatically by means of the coal feed silo cover actuator (72) controlled from the PLC controlled automation system before the coal feed conveyor goes into action and closes automatically after the coal feed conveyor stops.

17. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the medium and large capacity industrial type boilers contains a coal flow adapter (73) with an angle conforming to the natural from of coal to the silo from the coal feed spiral outlet, and that the coal flow adapter is detachable when necessary as being bolted between the spiral outlet and silo inlet.

18. A hot water/steam boiler according to Claims 1, 2 and 16, characterized in that coal feed silo tracks (74) installed on the coal pre-heating chamber (16) are available at the bottom part of the double wall coal feed silo (12) with air circulation, the coal feed silo is moved left and right by means of the coal feed silo reels (75) on said tracks, thus enable opening and closing of the front smoke box covers of the boiler with double wall

design.

19. A hot water/steam boiler according to Claims 1, 4 and 16, characterized in that graded complete mobile grate system (21) for domestic type low- and medium-capacity boilers is present under the solid fuel combustion chamber (19) of the boiler, which is adjustable through the command received from the automation panel depending on the type of coal used, and that cascade mobile-fixed special grate system (22) is present for the central heating and industrial type medium- and large capacity boilers.

20. A hot water/steam boiler according to Claims 1, 4 and 19, characterized in that the grate motion reducer (20) with inverter, the movement rate and duration of which is adjusted from the PLC controlled automation panel drives reciprocating motion to the graded complete mobile grate system (21) or the mobile grates of the cascade mobile-fixed special grate system (22) by means of the camshaft (76) with adjustable stroke and the connecting rod arms (77).

21. A hot water/steam boiler according to Claims 1, 4 and 19, characterized in that the graded complete mobile grate system comprises the graded complete mobile grate frame (78), complete mobile grates (79) resistant to high temperatures and installed on the stages on the grate frame and the reels (80) installed at the lateral walls of the boiler, that cascade mobile-fixed special grate system, on the other hand, comprises cascade mobile grates (83) placed on the mobile grate carrier shafts (82) on the cascade mobile grate frame (81) and the cascade fixed grates (86) placed on the fixed grate shafts (85) on the cascade fixed grate frame (84) and that mobile grate moves on the grate frame carrier balls (88) installed within a special mobile grate frame carrier ball bearings (87) installed under the frame (81) and at the lateral walls of the boiler.

22. A hot water/steam boiler according to Claims 1, 4 and 19, characterized in that the fixed clinker cooling grates (89), which enable cooling of the hot clinkers before falling into the clinker spiral at the clinker tray, is located at the top side of the clinker tray (30) section after the last step of the fixed grates installed above the top section of the double wall or water tube of the ashtray-clinker tray intermediate chamber (29) located within the steel construction boiler frame (27), that there are two thermocouples (90) installed at the central section of the fixed clinker cooling grates and that measure clinker temperature, and that the stability of the clinker temperature, which maximizes the combustion efficiency, is ensured by means of the thermocouple that either moves or stops the grate according to the lower and upper limits for clinker temperature set according to the coal type from the panel of the automation system.

23. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the combustion bed thickness adjustment system with three options is present at the top section of the inception part of the solid fuel combustion chamber (19) of the boiler, which enable adjustment of the thickness of the combustion bed over the grates according to the grain size of the coal to be burned; comprising of, depending on the boiler capacity and operating conditions, air-cooled combustion bed adjusting tube (93) of different diameter ratings with cooling air blowing fan (92) on one side, which is detachable from outside in the small- or medium capacity double wall boiler, where secondary air and combustible gasses pass from the top section, surrounded by refractor sheath (91) resistant to high temperatures; or water-cooled combustion bed adjusting tube (94) at industrial type medium- and large capacity double wall boiler; or water-cooled bladed-tube special designed combustion bed adjusting plate (95) in the central heating and industrial type large capacity water tube boiler; which is also detachable from outside and able to perform rotational movement and again fitted with refractor sheath and comprising of water-cooled two or three tubules and sheet plate.

24. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that in solid fuel firing section of the boiler, fine ashes falling under the grates are discharged by means of the undergrate ash removal spiral conveyor (32) under the ashtray (28), while the clinkers falling to the clinker tray (30) section by sliding from the top of the clinker cooling grates are discharged by means of the clinker removal spiral conveyor (33) at the bottom section of the clinker tray, and the volatile ashes accumulated under the volatile ash collector (31) are discharged by means of the volatile ash removal spiral conveyor (34) to the clinker pool (35) and the wet ash and clinker in the pool are automatically removed from the system through the command received from the panel of the PLC controlled automation system by means of the wet clinker discharge spiral (36).

25. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that undergrate ash discharge duct (96) submerged into clinker pool is located at the outlet of the undergrate ash removal spiral conveyor (32); clinker discharge duct (97) submerged into ash-clinker pool is located at the outlet of the clinker removal spiral conveyor (33); and the volatile ash discharge duct (98) submerged into clinker pool is located at the outlet of the volatile ash removal spiral conveyor (34) and there is float (99) supplementing water to the clinker pool which is activated as the water level falls is located on the clinker pool (35) to which ash, clinker and volatile ashes are discharged, thus preventing drop of water level in the pool, and that wet clinker discharge spiral (36) discharges the wet ash and clinker from the clinker pool to the waste clinker silo (100).

26. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the

ashtray hatch (101) and clinker tray hatch (102) with access to the ashtray and clinker tray within the steel construction boiler frame (27), to which the main frame of the boiler of the patent with double wall or water tube design is installed in a sliding manner, are available and such hatches are used in cases that require intervention due to maintenance and repair at medium and large capacity boilers, and that ashtray hatch and clinker tray hatch are used for removal of the ash and clinker manually at low-capacity boilers.

27. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the boiler is fitted with fully automated dry desulphurization system with two fully automated options adjustable according to the sulfur content in the coal depending on the boiler capacity and the coal type used in the enterprise, the first of which is used to feed the coal main silo (11), and the second is used to feed the lime feed silo (15) located at top section of the coal pre-heating chamber (16) and that it is possible to use the desulphurization system with these two options together, but only one of these options might also be used.

28. A hot water/steam boiler according to Claims 1, 2 and 27, characterized in that in dry desulphurization system of the first option, there is a lime feed spiral (14) that feeds suitable amount of lime automatically from the lime main silo (103) to the coal main silo (11), and that it is ensured that the powdered lime fed in quantities adequate for the sulfur content of the coal is well-mixed with the coal during conveyance with the coal feed spiral (13).

29. A hot water/steam boiler according to Claims 1, 2 and 27, characterized in that the dry desulphurization system of the second option comprises the lime feed spiral (14), lime feed silo (15), special lime feed valve (104) that adjusts flow of the powdered lime in the lime feed silo at a flow rate suitable to the sulfur content of the coal, actuator (105) activating/deactivating lime feed valve, vibrator (106) enabling lime flow by vibrating the lime feed valve, and lime flow duct (107) that enable powdered lime to flow down in a regular manner, and that the lime feed spiral (14) activates and deactivates automatically and feeds the silo as the lime level in the silo drops in line with the coal feed with the powdered lime received from the main silo as being controlled by the level sensor (108) on the automatic lime feed silo (15) and from PLC controlled automation panel (1).

30. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the boiler contains two ignition hatches (109) with observation window that access into the combustion chamber from both sides and used for initial ignition and fitted with observation window resistant to high temperature and that two clinker tray hatches (110)

with observation window are present at the top side of the clinker tray section which are used for observing the clinkers at the last step of the grates and the clinker spiral again fitted with observation window resistant to high temperature.

31. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that the front lower part of the boiler is equipped with the camshaft moving the grates and the camshaft housing panel (111) which houses the bearings of the camshaft, and which is detachable to the boiler from front side; and the panel is fitted with lubrication hatches (112) that enable lubrication of the bearings camshaft and connecting rod arms.

32. A hot water/steam boiler according to Claims 1, 2 and 5, characterized in that in boiler with water tube design, when flame and hot gasses coming from the flame passage duct pass from the first vertical passage duct and then shift course and pass through the secondary, third, fourth and fifth vertical passage duct, respectively, the volatile ash accumulated in the volatile ash collector are discharged to the clinker pool by means of the volatile ash removal spiral conveyor (34) which is activated automatically at certain times and intervals selected from the automation panel and that volatile ash collector hatches (114) with observation windows that open to the section where the hot gasses shift course are present at the top side of the volatile ash collector.

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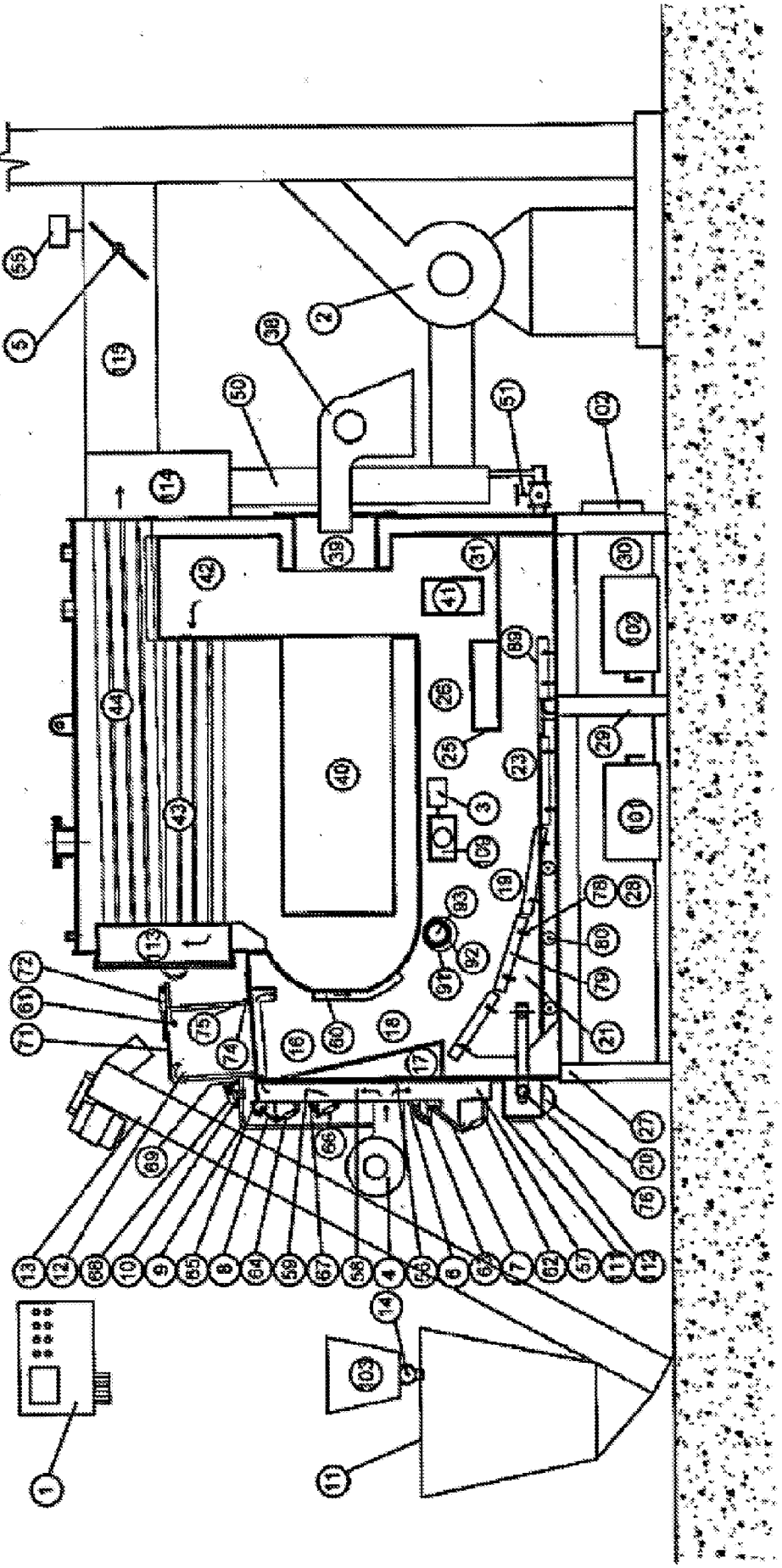

Figure 1

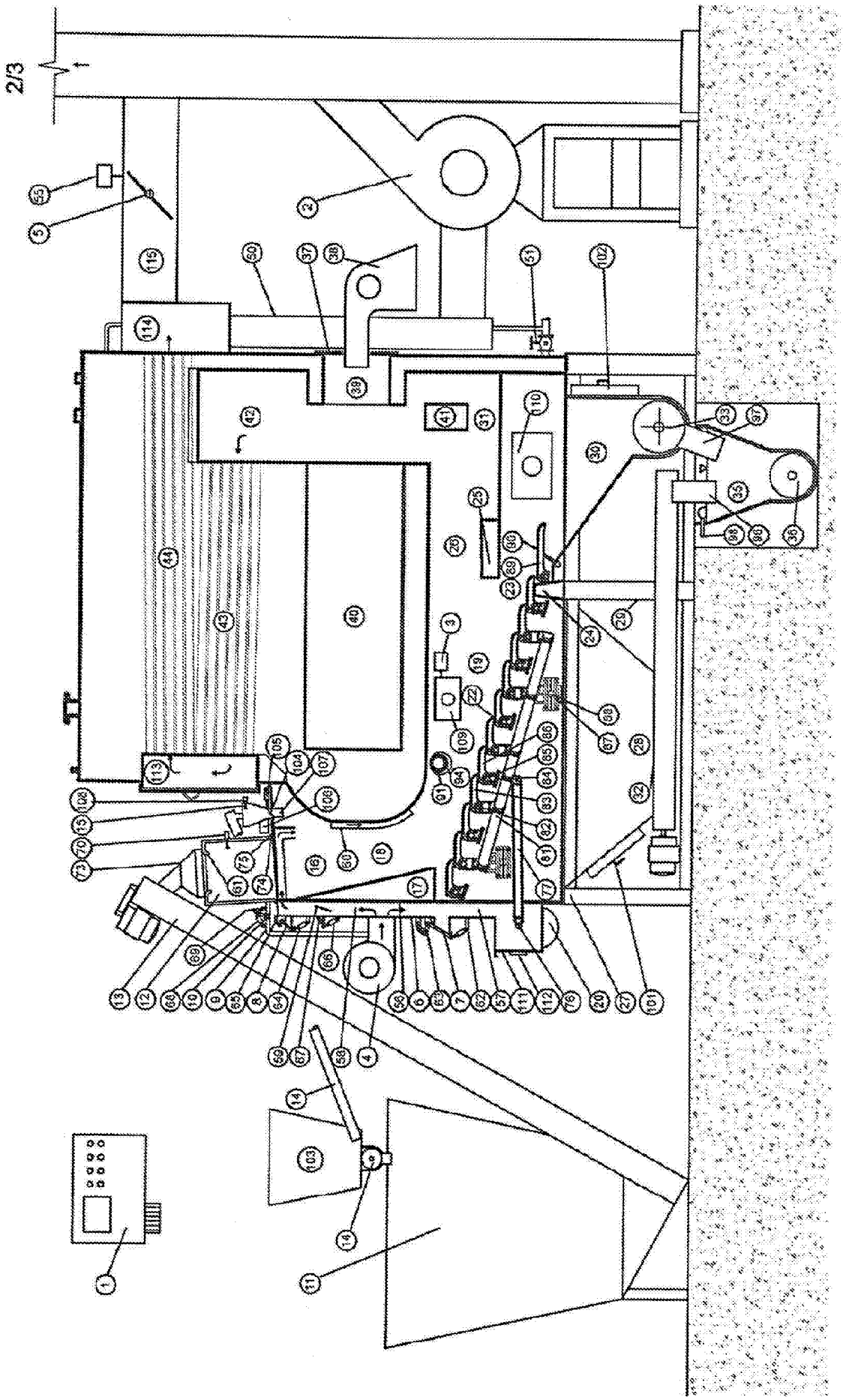

Figure 2

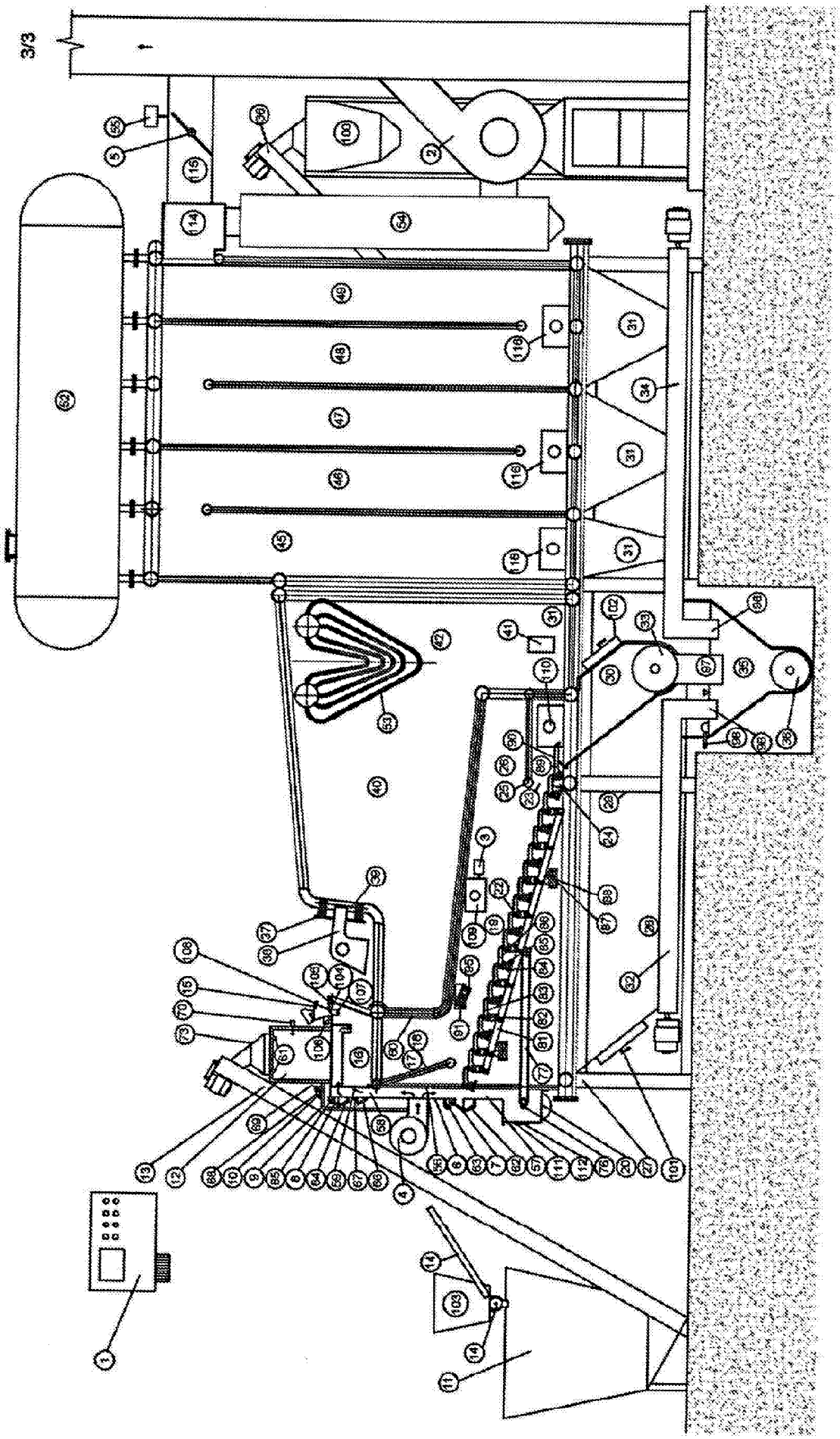

Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2015/050077

A. CLASSIFICATION OF SUBJECT MATTER
INV. F23J15/00 F23K3/08 F23L5/02 F23L17/00 F23N1/04
F23B30/00 F23B30/10 F23G5/12 F23G5/16 F23J1/06
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F23J F23K F23L F23N F23B F23G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2010/096026 A2 (OZCAN ALI NIZAMI [TR]) 26 August 2010 (2010-08-26) page 1, line 6 - line 10 page 10, line 25 - page 18, line 47 figures 1,2	1-32

Y	WO 2006/004563 A1 (OZCAN ALI NIZAMI [TR]) 12 January 2006 (2006-01-12) page 11, line 7 - page 18, line 8 figures 1,2	1-32

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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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
17 December 2015	05/01/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/TR2015/050077

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010096026 A2	26-08-2010	EA 201190128 A1	30-10-2013
		TR 201108126 T1	21-02-2012
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		EP 1815184 A1	08-08-2007
		TR 200401596 A2	23-01-2006
		WO 2006004563 A1	12-01-2006