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DESIGN APPROACHES OF A BIOMASS HOT AIR UNIT OPERATING A SMALL AUTOMOTIVE MOBILE MAINTENANCE FACILITY

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Abstract: *Combustion technologies convert biomass fuels into several forms of useful energy for commercial and/or industrial uses. In a furnace, the biomass fuel converted via combustion process into heat energy. The heat energy is released in form of hot gases to heat exchanger that switches thermal energy from the hot gases to the process medium (steam, hot water or hot air). Biomass and has the advantage that it can be grown, stored and transported and although it does emit carbon dioxide when burnt, it is considered as being close to carbon-neutral because the amount of carbon emitted when it is burnt is the same as that which is absorbed during growth. It is effectively recycling the carbon and preventing consumption of carbon stored in fossil fuels. The principle of functionality is described in detail in the paper with the emphasis on the mechanical and physical aspects. It is remarkable that the absorption process of combustion gas is supported by a ventilator, a method resembling the supercharging of internal combustion engine.*

Keywords: *Optimization, heating unit, biomass, design, automotive*

1. GENERAL VIEW ABOUT HEATING WITH WOOD CHIPS

For most owners, extremely low fuel cost is the main attraction of burning wood chips, and other biomass fuels such as sawdust and bark. There are other reasons to use biomass for energy as well. Some are the statements of good public policy, some are based on user preference for "green" energy, and others are practical.

This technology promises higher efficiency, better emissions, and easier operation when compared to cogeneration using steam boilers.

District heating is the use of a central heating plant to provide heat to many buildings, using buried pipes to distribute the energy. Wood-fired district heating is an appropriate technology for providing heat to small communities, college campuses, groups of public buildings and also a small automotive mobile maintenance unit. For example, in Scandinavia it is common to use biomass cogeneration in the central plants of community district heating systems, providing both heat for the system and power to the community.

The most common type of biomass used in heating systems is chipped wood, a by product that usually comes from sawmills. Mills have stationery chippers that chip up slabs and other green (un-dried) wood that is not suitable for lumber. Some biomass energy facilities use chips that come from harvesting operations in the woods. Mobile chippers are used to turn diseased and other "cull" logs into chips, while most of the tops and branches stay in the forest to return nutrients to the soil. These chips are blown from the chipper into delivery trucks, which deliver them to pulp and paper mills and to biomass energy users. Because chips from the woods are less uniform than mill residue chips, energy users may prefer mill chips, unless there is a significant price difference.

The third common source of biomass comes from the waste stream of forest products industries, such as furniture manufacturers. These wastes are typically dry, so they include more wood and less water per ton of biomass. Manufacturing wood wastes are often used by the plants that produce them, and are less likely to be available for purchase by energy users.

In Fig. 1 is given a comparison between heating value of different fuels and wood chips:

FUEL TYPE	HEATING VALUE
Propane	50.0 MJ/kg
Kerosene	46.5 MJ/kg
Diesel Oil	45.6 MJ/kg
Fuel Oil	43.0 MJ/kg
Natural Gas	37.3 MJ/kg
Coal	29.2 MJ/kg
Wood Pellets	19.8 MJ/kg

Fig. 1 – Heating value of different fuels

Typical household carbon emissions when using different fuels are shown in the adjoining table (Fig. 2):

Electricity	128 kg
Coal	116 kg
Oil	88 kg
Gas	67 kg
Coal/wood (50%)	58 kg
Wood	0 kg

Fig. 2 – CO_2 emissions of different fuels

Calculation of the net calorific value as received: minimum value to be stated (calculated by taking into account the selected moisture category and the typical variation of the net calorific value of dry matter at constant pressure):

$$q_{p,net,ar} = q_{p,net,d} \times \left(\frac{100 - M_{ar}}{100} \right) - 0{,}02443 \times M_{ar} ;$$

$q_{p,net,ar}$ = net calorific value as received, (MJ/kg);

$q_{p,net,d}$ = net calorific value (constant pressure) dry basis (MJ/kg);

M_{ar} = total moisture (w - %);

0,02443 is the correction factor of the enthalpy of vaporization (constant pressure) for water (moisture) at 25 °C [MJ/kg per 1 w-% of moisture]. Calculation formula is available in EN 14961-1.

A single cubic metre (m^3) of wood chips, depending on its quality, is equivalent to approximately 330 kg of wood chip – which represents the calorific equivalent of 100 litres of heating oil.

2. PRESENTATION OF THE HOT AIR UNIT

The Technology - Wood chips boilers are relatively simple systems that are easily installed and operated. The wood chips are typically stored in a standard outdoor silo. Wood chips are delivered in trucks similar to those that deliver grain. Wood chips fuel is automatically fed to the boiler via auger systems similar to those used for conveying feed and grain on farms. The wood chips are discharged from the silo and conveyed to the boiler using automatically controlled augers set to provide the right amount of fuel based on the building's demand for heat.

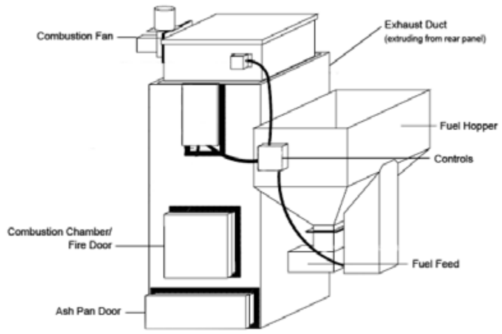

Fig. 3 – Schematic of wood chips furnace

A typical system includes a fuel storage silo with an auger system that delivers the wood chips from the silo to the fuel hopper. The wood chips are fed from the fuel hopper through the fuel feed system into the combustion chamber at a rate determined by the control settings. The combustion fan supplies air to the combustion chamber and the exhaust is ducted to the chimney through a port at the rear of the system. Ash must periodically be removed through the ash pan door.

Explanation of Components - The boiler is usually delivered completely assembled; however, some pieces, like the fuel hopper, may be removed to facilitate the installation of the boiler.

Combustion Chamber/Fire Door - The combustion chamber is where the wood chips are burnt to produce heat. It is accessible for cleaning or maintenance through the fire door.

Combustion Fan - The combustion fan provides air to the fire in the combustion chamber.

Primary Controls - The control unit allows the user to control the flow of wood pellets and combustion air into the boiler based on temperature settings. The unit also gives readings on boiler and exhaust temperatures.

Fuel Storage Silo - Wood chips fuel for the institutional - or commercial - scale market is typically delivered in bulk, where it is stored in the same type of standard outdoor silo used to hold grain or animal feed, or in silos specifically made for fuel pellets.

Fuel Hopper & Feed System - Wood chips are delivered by automatic conveyors from the storage silo into the fuel hopper. From the fuel hopper, the wood chips are delivered into the boiler through the fuel-feed system at a rate determined by the control settings.

Exhaust Duct - The combustion exhaust gases are ducted through a port at the rear of the system, which connects to either a new or existing chimney.

Fig. 4 – 3D model of a mobile wood chips furnace

The container construction and the built-reservoir system are compact, independent and fully automatic. The furnaces are used wherever where warm air is needed for drying processes. The high-performance boiler is produced as a stress-free welded construction. High combustion temperatures and a long furnace duration of the gases is the guarantee for a clean burning process. Furthermore, the hot air burner is for heating of buildings and greenhouses suitable. The next image (Fig. 4) presents the complete 3D model of such a wood chips furnace.

3. APPLICATION FOR THE HOT AIR UNIT

An application concerning heating of buildings is presented in the Fig. 5:

Fig. 5 – Heating of buildings with a biomass (wood chips) mobile air unit

A big fan is used to push the fresh air over the heat exchanging device. After that, warmed up, this air is going through the flexible tube and further to the room to be heated. Another exhaust fan is used to evacuate the burnt gases (CO_2 neutral exhaust gases). The unit is fully automatically controlled and can find out the moisture percentage of the wood chips and set the burning parameters.

The heating of a mobile maintenance service unit can be another application which could be done (Fig. 6). That can be placed somewhere around the world. That is why it is important to have as much as possible a relative fuel autonomy. In many cases wood chips can be provided in huge amounts and at a small price.

Fig. 6 – Heating of mobile automotive maintenance facility (rally camp)

The supply chain of the wood chips can be easily organised as compared to other fuels. For example, a mobile unit can get supplies by also using a tractor (Fig. 7):

Fig. 7 – Simplicity and efficiency of the wood chip supply chain: tractor delivering

Military application – It is known that military exercises take place in various areas, far away from the civilised area. In this case, fuel autonomy can be very useful and environmentally friendly. Fig. 8 shows a tent heating unit (outdoor):

Fig. 8 – Heating of mobile military tent

4. CONCLUSIONS

There are many reasons for using a wood pellet/wood chip boiler to heat a building/mobile maintenance unit. Apart from the fact that such systems are eco-friendly and have proven themselves in technical terms, they constitute an economically viable solution. The carbon dioxide emitted when wood fuel is burnt is the same amount that was absorbed over the previous months and years as the plant was growing. Burning wood can be a convenient means of disposing of the waste that might otherwise be sent to a landfill site.

Briefly, the advantages of such heating solutions are: carbon neutral - extremely low carbon emissions, high efficiency, advanced control package, reduced fuel costs, compact design and mobility.

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