University of West Hungary

Theses of doctoral (PhD.) dissertation

EMISSION TESTINGS FOR USED CHIPBOARD – ENVIRONMENTAL ASPECT EVALUATION OF COMBUSTION

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DOCTORAL SCHOOL: Kitaibel Pál Doctoral School of Environmental Sciences

PROGRAM: Environmental Sciences

SUBPROGRAM: K1 – Analysis of environmental potential

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INTRODUCTION AND AIMS OF THE RESEARCH

At the beginning of the 21st century, the Earth came up against serious problems. Drastic (not equable) increasing of population, narrowing of habitats, decreasing of multicolority, wastage overgrown everything, limited availability of clear air-earth-water, destruction of ozone layer and remedy of social tenses are challenges for humanity.

Necessity and success of collaboration are shown by gathering into fellowship of nations, continuous organization of worldwide conferences, research of regional and global effects of answers to be given to problems and geographical boundaries are blurred – headway of globalization.

Hungary joined to European Union 2 years ago. Since that time the expectations have increased in economy, production and consumption, regulations have become more severe. Generation of more modern, cleaner and more liveable conditions is necessary in conformity with principle of sustainable development - from individual to whole nation.

Decreasing of wasteful and outsized consumption is one of the large challenge of the 21st century – preservation of resources is primary condition of the human race's surviving. Therefore it is necessary to endeavour for mapping and more intensive utilization of renewable energy resources besides of increasing of fossil materials usage. But, in order to reach this, new technologies must be introduced and modernization of the old ones must be solved. At present, the wood - as renewable energy source - has the largest facility for utilization.

The wood as natural and environmental protective raw material has followed the peoples' way for thousand years. Prehistoric man built a shelter from wood, he warmed at blaze of it, he roasted meats and he scared straying wild animals with its light. Man of present puts up buildings from wood, he produces semi-finished and finished products from it, he warms at camp-fire and roasts meats, he comprehensively uses its shaving.

Intelligent and modern utilization of arising wastage and secondary raw materials is recycling, leading back to production, utilization and extraction of energy.

Wood felled from the forest is utilised half of its energy (primary and secondary wood industry make product of use from the remaining half part). Occurring wood-burning power stations require continuous and large quantity of wood for theirs operation, which is a conflict source for the interests of wood industry.

Since by processing of poor wood selections and waste chipboard and fibreboard industry have created, on wood waste „market", wastes from chipboard and -products appeared which are not made from clear wood regarding to mostly chemical additives added to them. Therefore theirs recycling and burning and making them unharmful require increased care, adequate professional and judicial regulation.

In this thesis, Author's aim was to investigate the recycling of used products made from chipboard by theirs energy, with representative examination and using of low input heat-power furnaces under domestic conditions.

Author looked for the answers for the following questions:

- What circumstances do the market of Hungarian low efficiency heating equipments characterize? What are the technical efficiency and parameters of furnaces?
- What kind of wooden plank based products do little entrepreneurs and inhabitant consumers have utilization facility for?
- What kind of chemicals (qualified as dangerous and not dangerous) are produced wastes associated to and how affects theirs energetic utilisation?
- What emission values can be observed during combustion of chipboard?
- What development of suggestions are expedient to make energetic utilisation of wood-based wastes equivalent and to adapt to an international system?
- What kind of facilities are available for little consumers to modernise theirs heating equipments?

APPLIED METHODS

Author gathered chipboard based product waste (from raw and surface treated sheets made by two Hungarian chipboard manufacturing company), chose suitable furnace for representative purposes and in order to determinate of waste gas according to standards she used instruments of Accredited Measurement Laboratory of Inspectorate for Environmental Protection.

Samples were previously tested in laboratory for determination of heating value, moisture content, solid, liquid and gaseous composition under pirolysis test. After splitting and homogenization of samples for applicability in furnaces, they were put on fire.

APPLIED MEASUREMENT METHODS

1. Dynamic pressure values for determination of *gas volume flow* were measured with electronic micromanometer type DIGIMA LPU connected to Prandt-pipe in measurement points defined in the standard by moving of Prandtl-pipe towards the inside and outside.
Static pressure values were also measured with this instrument.
Concerning standards: MSZ 21853-1:1976, MSZ 21853-2:1998, MSZ ISO 9096:1994

2. *Gas temperature* was measured with thermometer type JUMO TDat-74/1 which is connected to a Ni-Cr-Ni thermo-couple.

3. G*as moisture content* was determined by frosting method. Condensatum mass and sample gas volume were measured after suction and moisture condensation of sample gas.

4. *Waste gas solid content* was gravimetrically measured by periodical sampling. There were filter material qualified as Schleicher-Schuell 603 G in analyser type STRÖHLEIN STE 4 with clay filter head. Solids concentration was calculated from mass decreasing of separating filler material and measuring of sucked partial gas flow.
Concerning standard: MSZ EN 13284-1

5. *Oxygen concentration of gas* was measured by continuous sampling with SERVOMEX paramagnet susceptibility analyzer type 0420.
Concerning standard: MSZ 21853-27:1993

6. *Carbon-dioxide concentration of gas* was measured continuously in time with SERVOMEX infrared light absorption analyzer type 1420B.
Concerning standard: MSZ 21852-19:1981

7. *Carbon-monoxide concentration of gas* was measured continuously in time with THERMO ENVIROMENTAL INSTRUMENS HC infrared light absorption analyzer type M-48H.
Concerning standard: MSZ 21853-8:1977

8. *Sulphur-dioxide content of gas* was measured continuously in time with Thermo Environmental Instruments fluorescence gas analyzer type model 40. Excitation energy needed for fluorescence was provided impulse operated UV-light emitted lamp, which radiates at 230-190nm absorption band of sulphur-dioxide.
Concerning standard: MSZ 21853-6:1984

9. *Nitrogen-oxides ($NO+NO_2$) concentration of gas* was measured by Thermo Environmental Instruments analyzer type Model 42. Nitrogen-monoxide transforms into excited stated nitrogen-dioxide by the effect of ozone. Excited molecules get to base state with radiating of characteristic wave-length light energy. Radiated energy was converted to electric sign by the instrument. The sign is proportional to nitrogen-monoxide respectively nitrogen-oxides concentration of gas sample. For measuring of nitrogen-oxides concentration amount, nitrogen-dioxide content of gas must be converted to nitrogen-monoxide. Converter is installed in the instrument.
Concerning standard: MSZ 21853/9:1978

10. *Unburnt hydrocarbon concentration of gases* were measured with BERNATH-ATOMIC analyzer type 305. In the measuring chamber of the instrument H_2-flame burns. Air needed for combustion is cleared by the instrument, hydrocarbons are ionized by the effect of the flame. Magnetic field of measuring chamber excites ion current, which is detected and converted to electric sign by FID detector. Measured value defined in *propane* equivalent by the instrument.
Concerning standard: MSZ 13107:1985

Analyzators were calibrated with certified samples before testing

SUMMARY OF SCIENTIFIC RESULTS (THESES)

In the course of burning of chipboard-based and used wood products as well as after evaluation, the following theses were composed:

1. I state that technical state of greater part of Hungarian, low nominal input heat-power (< *140* kW_{th}) furnaces do not meet neither of domestic nor EU expected quality level, concentration of outgoing waste gases is very high because of lack of regulation and inadequate selection of technical parameters, carbon-monoxide values can exceed the upper measurement limit of the instrument.
Subsequently, degree of air pollution is high, not only environmental but public health problems can be also occurred in case of long lasting usage of furnaces.

2. I state that energetic utilization in heating equipments of chipboard based products and composition of outgoing waste gas are affected by wood base material and additives. Interspan chipboard is mainly made from pine and poplar, however Falco is made from leafy base material. Beyond colour and volume difference of chipboard, deviation is shown up in combustive characteristic because of resin content of pine: resin slightly increases heat efficiency of wood and development of “blue smoke” phenomenon.
In the course of calorimeter tests, heat efficiencies and other data of four types of chipboard can be summarized as follows: heating efficiency of laminate chipboard (because of lamination) is larger then raw on the average with 1-2MJ/kg.
“Bomb sulphur” content of samples is (which is not origin from the wood) about 1%, considerable value, derives from added hardener.

3. Virtually, wood does not contain sulphur. I state, in case of applied hardener (ammonium-sulphate), there is quality and concentration differences (in case of chipboard of different Hungarian factories), thus added hardener is principal source of sulphur-dioxide gas appearing (not typical in wood-burning) during combustion.

4. Based upon my measurements, I state sulphur content of the above mentioned two Hungarian producer's chipboard is different, consequently sulphur-dioxide emission is different: average concentration of I_n sample is *46,39* mg/m^3, average concentration of F_n sample is *141,9* mg/m^3.
In case of surface treated samples: average concentration of I_1 sample is *49,66* mg/m^3, average concentration of F_1 sample is *467,83* mg/m^3.

5. In the course of pirolysis of chipboard, the following values and materials were measured at 800 °C (F - Falco, I - Interspan):
In case of "F" samples, one the fifth of material was remained as charcoal. 56-58 m/m% transformed to liquid with pH 4,2 and composition of gases is the following: ethylene is more than 50%, propylene is 10%, in case of natural samples methane is 7,5% and C_4 saturated 5,4%, in case of laminated methane is 22% and C_4 saturated is 10,5%.
In case of "I" samples, one the sixth of material was remained as charcoal: 56-58 m/m% transformed to liquid with pH 4,2 and composition of gases is the following: ethylene is more than 50%, in case of natural sample methane is 10,8% and propylene is 15,7%, in case of laminated methane is 18,69% and propylene is 10,42%.

6. I state that staying time of waste gases in tested furnaces is extremely low (tenth second instead of 2 seconds minimum), therefore construction modification of furnace (increasing of specific surface of firing area) is essential to realise perfect combustion and keep the low values of wood-burning emission (primarily, in case of NO_x, C_xH_y, CO).
Instead of using of periodical feed, continuous feed, keeping λ-number between 1-2 as optimal (regulated addition of primary and secondary air and parameterization of waste gas ventilator operation) can lead to realise the conditions of perfect combustion.

7. I state, in case of opening the door of firing place, periodical feed from inhomogeneous sample and unregulated addition of combustion air primarily increase the hydrocarbon and carbon-monoxide concentration which is closely followable. In case of Falco samples (because of combustion being unregulated) values of hydrocarbons varied about 2000-3000 mg/m^3, values of carbon-monoxide varied about 6000-11000 mg/m^3. These values in case of Interspan samples, consecutively are 100-1200 and 1800-4200 mg/m^3. Task is: application of regulated combustible feeding and optimal combustion air determined for wood, besides optimization of furnace's technical parameters for wood-burning is essential to realise an environmental protective combustion.

8. I state, a law is missing from Hungarian legislation which is exclusively related to wood and wood wastes and makes wood waste categories, concentration and additives (thus utilization facilities) meaning danger evident. Nowadays, combustion of raw or laminated chipboard (category A II in German regulation) is estimated as harmful as wood wastes, which is serious problem for little entrepreneurs and households.

9. Emission limit values based upon efficiency of the equipment are not specified (in differentiated way either) for low heat-power furnaces used by carpenters, wood industrial entrepreneurs (and households). Based upon completed measurements, after releasing of sufficiently constructed furnaces, waste gas emission can be parameterized, consequently degree of environmental pollution can be decreased.
Defining of emission limit values and categorization of wood waste are essential, I suggest accepting of German regulation adjusted to domestic relations.

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