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Combustion of extracted Rape Seeds

Larger utilization of rape oil for technical purposes increases the necessity to use the by-products from the oil pressing process. This by-product is extracted rape seed meal, which has a residual oil content of 2 – 3 %. Besides the utilization as foodstuff, it is necessary to find other ways of using of which one is for energy utilization. We solved the combustion of extracted rape seed meal. Essential fuel characteristics were found out and practical burning tests for emission determination releasing in their combustion were carried out. Gross calorific value of a standard sample (water content of 10 %, oil content of 2,6 %) is 18,6 MJ/kg and calculated net calorific value is 17,1 MJ/kg. The combustion of extracted rape seeds in a boiler ARK 1000 with a fluid pre-combustor showed that it was possible to burn extracted seeds without any problems. All emission limits formulated by law were fulfilled, except the CO-contents in flue-gas caused by the bad technical state of the boiler.

Oilprogram" was started by the Ministry of Agriculture in the Czech Republic in 1991. This program is aimed at utilization of rape for biofuel and biolubricants production as substitutes of traditional fossil sources. During five years, the production volume of about 60000 t of biodiesel per year was built up in the Czech Republic. The firm MILO Olomouc has the largest amount on the market (30000 t/a) which uses hot pressing of rape with additional extraction of residual oil within the technology frame. The final products are extracted rape seeds with oil contents of 2-3 %. Small pressing units produce a rape cake with oil contents of 14-17 %. It is used as foodstuff and its sale is without any problems.

The Czech Republic can enter the European Union and therefore it is necessary to accept some economical principles within agriculture land use. Nowadays, the utilization of agricultural land for food production is decreasing. This set-aside land can be succesfully used for cultivating energy and technical crops. In the future the production of rape can only be used for technical purposes. The rape oil will be used for biodiesel production and the extracted rape seeds for energy utilization. In addition, there is a large competition between rape and soybean meal seeds.

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Table 1: Analysis of extracted rape seeds (contents in % wt)

fuel	C	H	N	S	O	Cl
ERS	41,74	5,31	5,47	0,54	31,20	0,044

Table 2: Fuel characteristics of extracted rape seeds

	Unit	Sample
Water	% wt	9,21
Ash	% wt	6,49
Combustible substances	% wt	84,30
Volatile combustibles	% wt	65,81
Gross calorific value	MJ/kg	16,87
Net calorific value	MJ/kg	15,50
CO_2max	% wt	19,13

Our work was aimed at energy utilization of ERS (extracted rape seeds) i.e. their combustion. It is the most advantageous way for the energy balance. The ratio of energy input to energy output was in one variant of biodiesel production and utilization (without the by-products glycerol, straw, extracted seeds) 1 : 1.17, in another variant of biodiesel production and extracted seed utilization as foodstuff 1 : 1.78, in a third variant of biodiesel production seeds and of straw 1 : 3.42 (IFEU Heidelberg, GER). [Methodology of energy balance calculation is different from author to author and the extent of including inputs into the calculation of the balance.]

It was aim of our work to find out whether ERS were combustible and to carry out practical burning tests and to measure pollutant concentration in the flue-gas.

Methodology

ERS experimental substances were supplied by MILO Olomouc. Their fuel characteristics are the same as for other fuels: chemical composition, gross calorific value and net calorific value, contents of volatile combustibles and contents of ash (*Tables 1, 2*).

Determination of gross calorific value

The calorimetric measurements were carried out for determining the gross calorific value, depending on moisture and oil contents. For this purpose, a calorimeter KL-5 with double water covering and a closed bomb calorimeter filled with oxygen were used. Various samples of rape cakes were collected from several press units in the Czech Republic using different pressing technologies to analyse oil contents. Oil contents were determinated by either extraction of the samples. One extracted seed with an oil contents of 2,6 % was wetted to different moisture and put to the calorimetric test.

The net calorific value was calculated from the measured gross calorific value by subtracting the water evaporation heat, needed when burning extracted seeds:

$$Q_s = Q_i - 24{,}58\,(W + 8{,}94 \cdot H)\ [kJ/kg]$$

Q_s – gross calorific value [kJ/kg]
Qi – net calorific value [kJ/kg]
W-moisture [% d.b.]
H-hydrogen content [wt %]

Determination of pollutant concentration

The practical burning test was carried out in the boiler Vihorlat Snina ARK 1000 with a modified back wall for a connected fluid reactor. The technology equipment is made up of four operation units: preparation and transportation of fuel, a boiler with a fluid pre-combustor, removing of ash, blowers system and the removing of fly ash (*Fig. 1*). Out of three operations there was one boiler selected marked as K3 with the nominal performance 1160 kW which was kept during the combusti-

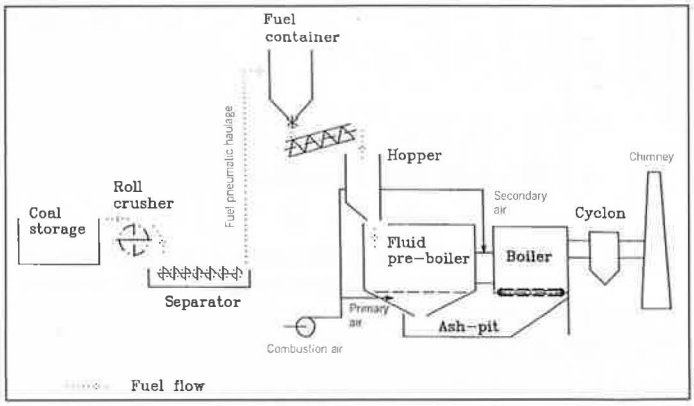

Fig. 1: Scheme of measuring equipment

on on 60 % of the nominal load. A waste grases output from the boiler in their temperature sensing point used for measurement and regulation of boiler room. The measurement was carried out in the boiler room of the farm ZOD Plostina – Loučka (Czech Republic) in autumn 1996. There were incinerated fuels:

- additiv lignitic coarse-dust (Hp4 ad 748-coal with decreased sulphur contents),
- mixtures of 20 % extracted rape seeds and 80 % of additiv lignitic coarse-dust,
- mixutres of 40 % extracted rape seeds and 60 % of additiv lignitic coarse-dust
- extracted rape seeds.

Measuring equipment

The Flue-Gas analyser GA-60 was used as the measuring equipment. The measuring principle is based on the utilization of electro-chemical converters. The equipment shows concentrations of flue-gas components: oxygen, carbon dioxide, carbon monoxide, sulphur dioxide, nitrogen oxide, nitrogen dioxide and hydrogen chloride. At the same time flue-gas temperature and excess air were scanned. The time interval between the separated measured impulses was fixed at two minutes.

Calculations

The measured results are given in three variants:

- volume concentration in ppm
- weight concentration under normal condition (273 K; 101,33 kPa) in mg/Nm^3
- weight concentration under normal condition (273 K; 101,33 kPa) in mg/Nm^3 related to given oxygen contents.

In the Czech Republic the emission limits for solid fuels combustion are valid for converted form to oxygen contents in flue-gas (6 % for vol. for coal combustion and 11 % vol. for wood wastes combustion). The ERS aren't listed as a fuel in the law (Czech Act on environment protection), therefore their valuation was carried out under the emission limit valid for wood. The conversion of concentrations to reference oxygen contents was performed according to:

$$C\,(6\,\%\ \text{resp.}\ 11\,\%\ O_2) = c * \frac{20{,}95 - (6{,}11)}{20{,}95 - O_2}$$

where:

(6 % resp. 11 % O_2) – concentration of pollutant converted to 6 % resp. 11 % oxygen contents in flue-gas

c – concentration of pollutant in flue-gas

O_2 oxygen contents in flue-gas

The integration, valuates averaging and concentration converting from ppm to mg/m^3 are performed by a built – in microprocessor automatically.

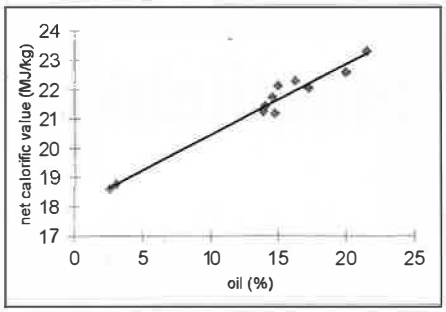

Fig. 2: Dependence on net calorific value on oil contents

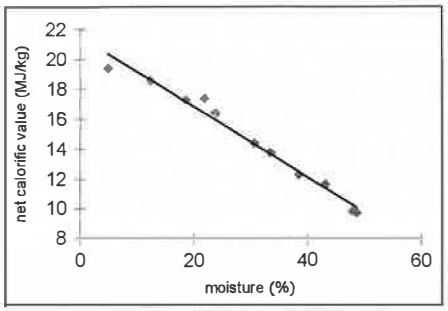

Fig. 3: Dependence on net calorific value on water contents

Results

According to elementary analysis of seeds it is possible to say, that the seeds contents of C, H, O are raughly at the same as for wood. Lower oxygen content in the seeds is substituted by higher ash and nitrogen contents. In contrast to other biomass types the seeds contain a certain percentage of sulphur in spite of the fact that the „00" rape is only cultivated now.

The dependences of gross calorific value on moisture and oil contents are demonstrated in *Fig. 2, 3.*

The middle value of concentrations of gases pollutants released in the combustion process for individual fuel types and values of concommitant quantities are showed in *Fig. 4.*

The net calorific value of additivited lignitic coarse-dust is 9,34 MJ/kg and ERS 17,1 MJ/kg.

Discussion

The net calorific value of ERS is increasing in accordance with oil contents in seeds and is decreasing in accordance with the water content. The technology process of oil pressing and extraction of rape oil produce extracted seeds with the constant percentage of residual oil and the loose form which is a great advantage for the combustion in a fluid furnace. It would be necessary to granulate the seeds for burning in a grate furnace. The combustion of seeds with moisture up to 15 % seems to be the most optimum.

The practical burning test has proved good combustibility of seeds. From the point of view of fulfilling the emission limits only the combustion of ERS seems to be the most advantageous. Above all, CO decreasing evoked by the better mixing of released volatiles and the combustion air is very expressive. The lower sulphur contents in the seeds are caused by the lower SO_2 concentration.

The course of NO_x contents measurement in flue-gas is according to NO_x rise from nitrogen substances contained in fuel. During coal and mixtures with ERS combustion the mild growing of NO_x contents in flue-gas is appeared caused by increasing of percentage contents of nitrogen substances in combustion mixtures. During ERS combustion change of combustion regime, burning temperature and pyrolisis velocity are resulted in better burning out of nitrogen substances under lower air excess and therefore lower NO_x creation.

More heated seeds could cause damage to the furnace lining in the long-term combustion. Therefore we recommend the combustion of 20 % ERS and 80 % coal mixture which is better in regard with emission than 40 % ERS and 60 % coal mixture.

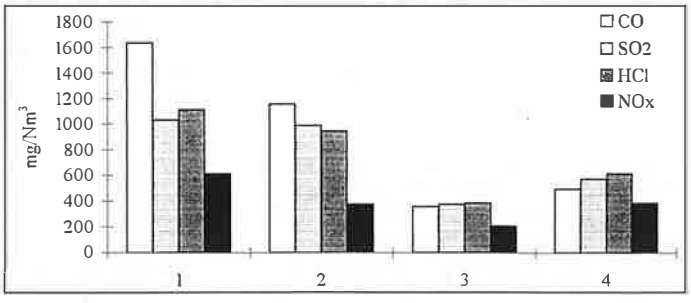

Fig. 4: Emission rising in coal and seeds combustion; 1) additivited lignitic coarse - dust (alcd), 2) mix of 20 % ERS and 80 % of alcd, 3) mix of 40 % ERS and 60 % of alcd, 4) ERS

References

[1] *Ľadomerský J.:* Combustion of wood waste from the ecological and energy point of view. Science and Pedagogical News, (1993), no. 6

[2] Czech Act n. 309/1991 on air protection against pollutants and interpretations

[3] Measurement of Ministry of Environment n. 84/92

Keywords

Rape, extracted rape seeds, combustion, emission