

## Technical possibilities of the cutting oils filtration residues combustion

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### Abstract

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The value of consumption share of electricity from renewable sources in the Czech Republic up to 8% in 2010 stems from an individual obligation adopted by the Czech Republic when signing the Kyoto Protocol of the United Nations Framework Convention on Climate Change. One of the possibilities how to reduce greenhouse gases emissions from fossil fuels consists in biomass burning. Biomass used for power purposes is obtained on purpose as a result of production activities or it originates from utilization of wastes from agricultural, forest and industrial production. In biomass burning, the boiler used produces carbon dioxide, recyclable in nature. Increase of the amount of municipal and technological waste including materials that are heavily soiled and difficult to recycle pushed up demand to obtain the best possible solutions in terms of both technological and economic terms. Recycling of materials can provide multiple circulations which have to lead to final solution such as storage or use in energy production. One of the solutions shall consist in recommending the installation of the sorting line, the homogenizer, and possibly a pelletizer to ensure sufficient homogeneity of the material.

**Keywords:** renewable sources of energy; gases emissions; biomass; municipal wastes; burning

In the engineering industry a lot of wastes is produced that, by their nature, are hardly processable without employing sophisticated technologies for their treatment, and therefore, their subsequent utilisation or their distribution in the quality of alternative fuel is hardly feasible in the present situation (NIEMINEN, KIVELA 1998).

One of the ways of processing these wastes is their utilisation as fuel for units combusting coal and pellets, as admixture to alternative fuels and/or binding agent in the manufacture of pellets. The examination of technical possibilities of their use should be accompanied by examination of emis-

sion limits, in order to avoid possible risks to atmosphere and to the equipment itself as much as possible. The examination of technical possibilities of the equipment in relation with the material to be combusted will show potential possibilities of combustion of individual types of the presented samples together with black coal or with brown coal (LIU et al. 2009).

Due to increasing environmental concerns especially related with the use of fossil fuels, new solutions to limit the greenhouse gas effect are continuously sought. Among the available alternative energy sources, including hydro, solar, wind etc., to

Table 1. Characteristics of the samples

ID	Description
AR	Arbocel BC1000, Arbocel BC200 + cutting oils dark-brown lumps and clotty matter with leaking oil of light-brown colour, unable of homogenisation
AE	Arbocel BC1000 + cutting emulsions clots of grey-white up to off-white colour and filtration residues, locally white with grey surface, moist, unable of homogenisation
RR	Reofix + cutting oil grey lumpy matter, moist, greasy, and unable of homogenisation
CU	black coal
HU	brown coal

mitigate greenhouse emissions, biomass is the only carbon-based sustainable option. On one hand, the versatile nature of biomass enables it to be utilized in all parts of the world, and on the other hand, this diversity makes biomass a complex and difficult fuel. Especially the high percentages of alkali (potassium) and chlorine, together with high ash content, in some brands of biomass prove to be a major source of concern (KHANA et al. 2008). However, mechanisms leading to corrosion and high dust emission problems have been identified and a range of possible solutions is already available. Among the technologies that can be used for biomass combustion, fluidized beds seem as the best solution due to their flexibility and high efficiency.

One of the methods of mitigating these environmental impacts is increasing the fraction of renewable and sustainable energy in the national energy usage. A number of techniques and methods have been proposed to reduce gaseous emissions of  $\text{NO}_x$ ,  $\text{SO}_2$  and  $\text{CO}_2$  from fossil fuel combustion. Some of the control methods are expensive and therefore increase production costs. Among the less expensive alternatives, co-firing has gained popularity with the electric utility producers (NARAYANAN, NATARAJANB 2007).

The future of coal and biomass blend co-firing in utility boilers looks very bright. Based on the positive results of recent co-firing studies conducted

across the globe, coupled with more strict environmental regulations and associated penalties, utilities are seriously considering co-firing of locally available biomass fuels with coal in their boilers. Co-firing biomass fuels with coal has the capability to reduce both  $\text{NO}_x$  and  $\text{SO}_2$  levels from existing pulverized coal-fired power plants. In addition, overall  $\text{CO}_2$  emissions can be reduced because biomass is a  $\text{CO}_2$  neutral fuel. However, co-firing technology faces some technological problems (KUDELOVÁ et al. 2009).

The aim of this project was to test the possibility of co-firing of cutting oils together with coal in fluidized-bed boiler. With regard to the type of installed boilers – atmospheric boiler with circulating fluidized bed combustion - it is possible to combust coal, pellets and technological wastes (commonly combustible materials, waste sludge, oily water with content up to 50% of oil etc.) in the boilers (VOŠTOVÁ, FRIES 2003; KUDELOVÁ et al. 2009). The combustion temperature in the operating area of the boilers is  $850^\circ\text{C}$ ; it is not possible to combust materials producing escape of chlorine, due to the lack of trapping appliances.

## MATERIAL AND METHODS

For the testing purposes samples (Table 1) of brown and black coal and of the cutting materials employed in regular operation of engineering industry were presented. For an appropriate evaluation, it is necessary to examine the composition of the samples (Table 2) according to their individual fractions, calorific value (Table 3) and the effect of the solid phase and the ash produced out of it upon the properties of the coal (Table 4), and/or upon properties of the mixture of these ashes. All

Table 2. Weight composition of the sample

	Solid residue, insoluble in acetone and xylene (% wt.)	Extracted fraction (water, oil, emulsifying agent) (% wt.)
AR	37.7	62.3
AE	26.7	73.3
RR	50.6	49.4

Table 3. Composition of the waste samples in dehydrated and degreased state

Sample	Ash (%)	Hydrogen (%)	Carbon (%)	Gross calorific value (MJ/kg)	Net calorific value (MJ/kg)
AR	lim. 100 <sup>1</sup>	0.20	2.24	7.07	7.00
AE	8.89	5.85	17.36	17.36	16.08
RR	11.02	5.59	19.28	19.28	18.06

<sup>1</sup>with highly mineralised samples, the assessment of ash in degreased and dehydrated samples can be misleading; at high contents of metals in the solid residue, the resulting contents of ash can be even higher than 100% wt. of the sample (oxidation), as has been the case of the sample AR, where the fraction of non-extractable organic matter has constituted 3% wt. only

Table 4. Composition of the samples of coal (original state)

	CU	HU
Water (% wt.)	25.72	6.61
Ash (% wt.)	6.00	6.35
Hydrogen (% wt.)	3.85	4.31
Carbon (% wt.)	52.75	78.02
Sulphur (% wt.)	0.70	0.53
Nitrogen (% wt.)	0.94	1.42
Oxygen (% wt.)	10.04	2.76
Heat output (MJ/kg)	21.74	31.86
Calorific value (MJ/kg)	20.90	30.91

measurement were done by authorized body with application of mandatory standards ČSN EN 14918 (2010) and ČSN EN 14778 (2011).

In the pre-treatment of all the three presented filtration residues by double acetone extraction and subsequent extraction of water from the liquid samples, solid residues of individual samples were obtained. This procedure allows obtaining dehydrated and degreased samples that can be subject to further treatment. The samples AR (Arbocel BC1000, Arbocel BC200 + cutting oils) and AE (Arbocel BC1000 + cutting emulsions) (Arbocel BC – Kremer Pigmente GmbH & Co. KG, Aichstetten, Germany; cutting oil – Paramo a.s., Pardubice, Czech

Republic) maintained their clotty structure even after the extraction, when they were already completely homogeneous and of grey-white colour. These samples were torn to fibres partly, employing a high-speed cutting homogenizer (HO-Turbo; MAVET CZ s.r.o., Králíky, Czech Republic). The RR sample (Reofix + cutting oil; BP Oil New Zealand Ltd., Wellington, New Zealand) was completely uniform, of fine-grained nature, and it was employed for further tests without any additional treatment.

## RESULTS

The percentages of extractable fractions and non-extractable residues in the individual samples subjected to treatment were found as follows.

For the mixed melting points, there the mixing ratios were calculated for the same relative states in dry matters or dry extracts, corresponding to the ratio of dry matters 95% coal + 5% tested sample. The proportions in the original mixtures (wet coal + tested sample not dried and not extracted) are shown in Table 5. All the samples of filtration residues as they were presented are not homogeneous and it is not possible to use them for the analysis practically. Moreover, it is to be expected that their contents in the actual operation will be variable, which can ex-

Table 5. Proportions of solid residues (%) in original states (wet coal + not treated sample) and in dry matters

Sample	Brown coal		Black coal	
	original state	extracted d.m.	original state	extracted d.m.
AR	9.40	5.00	11.53	5.00
AE	12.77	5.00	15.55	5.00
RR	7.17	5.00	8.85	5.00

d.m. – dry matter

Table 6. Parameters of the ash fusibility (°C)

Sample		$t_S$	$t_A$	$t_B$	$t_C$
AR		1,391	1,479	> 1,550	> 1,550
CU		1,232	1,238	1,296	1,371
HU		1,255	1,280	1,335	1,348
AR + CU	mixture 5:95	1,246	1,271	1,384	1,422
AR + HU	mixture 5:95	1,215	1,261	1,349	1,380
AE		1,357	1,412	1,547	1,570
AE + CU	mixture 5:95	1,220	1,241	1,291	1,316
AE + HU	mixture 5:95	1,201	1,241	1,305	1,324
RR		1,440	1,568	> 1,550	> 1,550
RR + HU	mixture 5:95	1,210	1,234	1,281	1,302
RR + CU	mixture 5:95	1,230	1,246	1,298	1,319

$t_S$  – deformation temperature;  $t_A$  – sphere temperature;  $t_B$  – hemisphere temperature;  $t_C$  – flow temperature

ert influence upon the overall calorific value of the combusted substance; however, the effects upon emission parameters and ash fusibility will be determined by solid fractions predominantly.

## DISCUSSION

By an analysis of the samples of employed auxiliary filtration materials it was ascertained that the samples AR, AE and RR are significantly inhomogeneous by their nature, with varying extractable fractions (oil, water, emulsion) and varying composition of the solid fraction (Table 2).

With the samples AE and RR the calorific value of the solid phase of 16–18 MJ/kg was ascertained. However, the overall calorific values of these samples were different, owing to higher contents of water in the AE sample. The calorific value of AE ranged from 10 to 15 MJ/kg, depending on the contents of water. The calorific value of RR was on the level of 30 MJ/kg.

With the AR sample a min. calorific value of the solid phase was found 7 MJ/kg merely (Table 3); the reason is a min. content of the auxiliary filtration material whereas 90% of the contents are constituted by entrapped iron. The calorific value of the whole sample ranged from 25 to 30 MJ/kg, because 63% of contents of extractable substances were constituted by cutting oil, of a calorific value about 40 MJ/kg.

Moreover, the effects of the solid phase and the ash produced out of it upon the properties of the

coal ashes and/or upon the properties of the mixture of these ashes were examined. The lowest softening temperature of the mixture of ashes was 1,200°C, i.e. by 54°C less than that of the brown coal (Table 6).

As far as a chemical composition of solid residues of wastes is concerned, there is a major proportion of iron; in the RR sample, of aluminium and potassium. The metal contaminants under close observation were As, Cd and Hg; they were present at the detection level only or below it.

## CONCLUSION

The formation of mixed eutectics with lower melting point was more distinguished with the mixtures of wastes with brown coal, where the fusibility points can be lowered by as much as 50 to 55°C. With the mixtures of wastes with black coal, the melting points were not practically altered in two cases (AE, RR); with the AR sample, they were even slightly higher. From the results of measurements it can be inferred that the chosen mixing ratio is the max. usable one, in particular with brown coals. The weight ratio of the dry matter extracted out of the waste (1:20) corresponds to the mixing of fuel charge with moist waste in a ratio not exceeding 10% wt. approximately. For the mixing, it is very important how heavily the filtration matter is clogged with waste sludge, or what the proportion of the ash and organic (cellulose) matter is in the obtained solid residue.

The heat output and the calorific value of extracted samples are of rather an informative value; it is both the heat obtainable of the organic insoluble matter and the portion of heat generated by the oxidation of metals. The actual calorific value of the waste can be established, yet, it will vary very considerably depending upon the momentary proportion of oil-water in the mixture. The oil increases the calorific value considerably (by about 40 MJ/kg); meanwhile the content of water considerably decreases it.

In order to achieve a reliable combustion without excessive slugging of the boiler, the admixture of waste must be homogenized in the charge very carefully, and the admixtures of moist material ought not to exceed 10% wt. of the overall charge in any case. For a safe operation, admixtures up to 5% wt. should be considered, in particular with brown coal, where eutectic effects play a more important role. The charge of the waste should be mixed with coal in the proportion 1:3 at least before loading it into the boiler still, in order to avoid local increases of its concentration in the combusted mixture. It is not advisable to mix both types of coal either, because other eutectic effects could operate there. Higher proportions of filtration matter in the waste should not be obstacle, because the calorific value of cellulose materials is low, and the aim is to thin the metal components as much as possible, which will play always an active role in the formation of melts at lower temperatures.

At the same time, the project also examined the possibility to pelletize the waste. The AR waste sample was subject to a test on equipment serving for production of biomass pellets produced by Eko-ver (Březovice, Czech Republic). The design of the equipment and the character of the AR waste sam-

ple were not compatible and the resulting product was not compact; moreover, during the production of pellets oil leaked into the surroundings of the equipment.

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