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COMPOSITION OF REED MINERAL MATTER AND ITS BEHAVIOR AT COMBUSTION

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INTRODUCTION

The purpose of this study was to increase our knowledge of chemical composition and melting behaviour of summer and winter harvested reed ash. In order to do this, we studied chemical composition of different sample ash (ashed in temperature 550°C) using conventional liquid phase chemistry method, elementary analyses in ENAS OY Jyväskyla Finland and determined the ash melting temperatures.

Ash melting temperatures was done according to technical specification CEN/TS 15370-1 (ISO 540) and by extracting melting behaviours from the ternary phase diagram K_2O -

REED AS SOLID FUEL

Ultimate analysis of reed

The elemental composition of organic mater of winter reed is analyzed in Vario EL CHNOS elementary analyzer and results are given in Table 3 and Table 4.

Table 3. Elemental composition of winter reed, %

Element	Ranges		Average
C	46.96	48.34	47.5
H	5.50	5.60	5.6
O	42.75	43.84	43.3
N	0.23	0.34	0.3
S	0.03	0.09	0.04
Cl	0.05	0.18	0.1

Table 4. Elemental composition of summer reed, %

Element	Ranges		Average
C	46.13	47.11	46.5
H	5.93	6.42	6.2
O	39.7	42.2	40.7
N	0.57	1.17	1.0
S	0.12	0.45	0.2
Cl	0.28	0.48	0.4

Moisture

Figure 2 illustrates the reed moisture content dynamics on years 2002 2005.

As solid fuel reed is rather specific, in natural condition suitable moisture content 18-20% for combustion facility is achieved not before March-April on some years even earlier.

Table 5. Content of some elements of ash winter reed, mg/kg (analyzed by ENAS Oy Jyväskyla, Finland)

Element	Ranges		Average
Ca	22 300	22 800	22 500
Mg	5 600	15 500	9 700
Na	14 300	70 700	36 633
K	35 700	80 200	57 300
Mn	1 200	3 700	2 033
Cd	0,30	0,73	0,47
Cr	30	76	46
Cu	30	89	55
Pb	33 - 39		36
Ni	9	11	10
Zn	140	490	297
S	12 400	31 800	19 067
Fe	1 500	2 300	1 967
Al	1 200	1 900	1 467
P	5 400	8 600	6 867
Cl*	0.05	0,18	0,14

*, % on dry bases

Ash melting behaviors

The method used for the determination melting of ash was done according to technical specification CEN/TS 15370-1. The fuel reed was ashed at the temperature of 550 °C. In the ash-melting test, the external shapes (shrinkage, deformation, hemisphere and flow of cylindrical pellets with height 3 mm and diameter equal to the height) were identified using high temperature microscope MOD 2 (Carl Zeiss), operated at temperature 200-1 500 °C. The temperature increase in the furnace was 10 °C/min. The four temperatures are identified as shrinkage starting temperature SST, deformation temperature DT, hemisphere HT and flow temperatures FT (Table 6). Test atmosphere oxidizing.

Figure 1: Moisture content of reed as received basis M_{ar} =18 20%, low calorific value as received basis

$q_{net,ar}$ = 14-15 MJ/kg, ash content dry basis A_d = 2-4%

Calorific value

The heat related during the combustion of fuel samples is measured in adiabatic calorimetric bomb in standard condition (CEN/TS 14918:2005).
Winter and summer reed calorific values and energy density on 20% moisture E_{20} are given in Table 1 and Table 2.

Table 1. Calorific values of winter reed, MJ/kg

Calorific value MJ/kg	Ranges		Average
q_b	18.62	19.16	18.92
$q_{gr,d}$ (dry matter)	18.62	19.16	18.91
$q_{net,d}$ (dry matter)	17.48	18.01	17.77
$q_{net,20}$ (20% moisture)	13.68	14.86	14.17
E_{20}, MWh/t	3.80	4.13	3.94

Table 2. Calorific values of summer reed, MJ/kg

Calorific value MJ/kg	Ranges		Average
q_b	18.33	18.77	18.51
$q_{gr,d}$ (dry matter)	18.31	18.75	18.49
$q_{net,d}$ (dray matter)	17.02	17.44	17.21
$q_{net,20}$ (20% moisture)	13.16	13.49	13.31
E_{20}, MWh/t	3.65	3.75	3.70

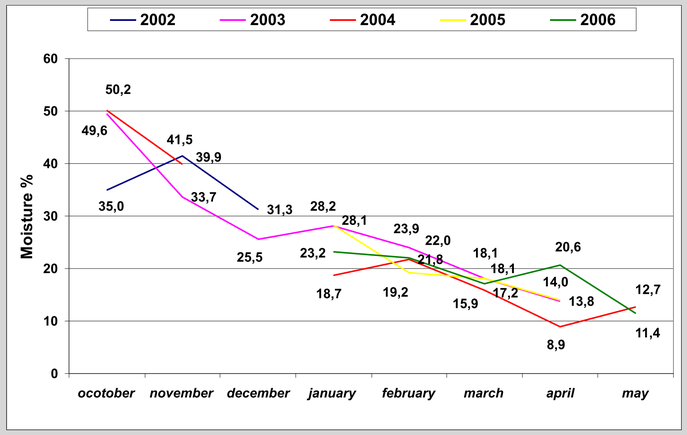

Figure 2: Reed moisture content dynamics 2002-2005

Ash, ash chemical composition.

Ash is formed from the minerals present in the fuel: but also a portion of the organic matter can be converted to ash and a portion of the mineral matter can volatilize.
The reed was ashed at 550±10 °C and chemical composition was determined using conventional liquid phase chemistry and detected by flame photometry. Ash content of the winter reed is within the range 2.1 4.4% average 3.2% and for summer reed essentially higher 4.1- 6.2% average 5.4% (Figure 3 and 4, Table 5).

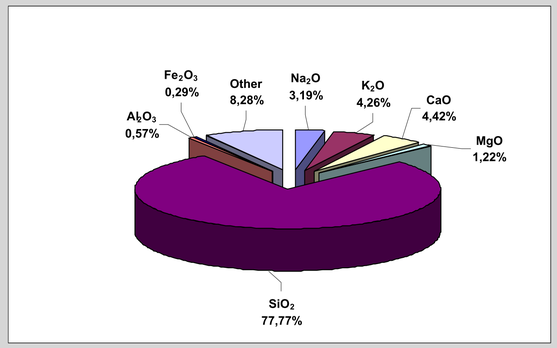

Figure 3: Chemical composition of winter reed ash, %

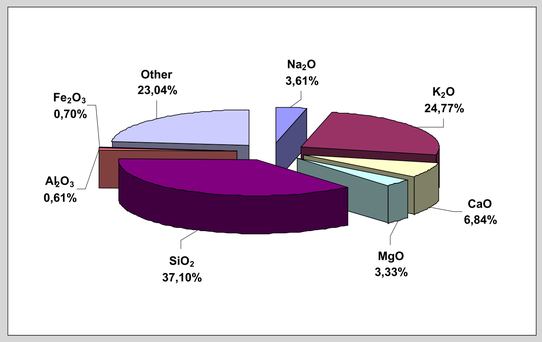

Figure 4: Chemical composition of summer reed ash, %

Table 6. Fusion and melting temperatures of ash of winter and summer reed, °C.

Temperatures	Winter reed Ranges	Summer reed Ranges
SST	790 1 270	580 - 730
DT	1 040 1 380	760 -1 030
HT	1 230 1 400	910 1 150
FT	1 270 1 450	990 -1 170

COMBUSTION TESTS

The first combustion tests were carried out in the boiler laboratory of Tallinn University of Technology (TUT). Small boiler with screw-feed equipment, mechanical fuel mixing hopper and stocker burner with nominal capacity of 250 kW was used. The first industrial test was made in district heating company Kuressaare Soojus Ltd where reed (waste from thatch building material) mixed with waste wood and successfully burned in the wood fuel boiler.

Reed as a fuel is very specific and therefore needs special furnaces and burning techniques. Burning

Crushed (refined) reed in a furnace, the volume of ash heap (residue) rather big, with loose structure, which prevents falling without mechanical stirring.

CONCLUSIONS

Reed as solid fuel for boilers is necessary to harvest certainly in winter, when the nutrients and minerals are leaved to the roots and leaves are fallen town. The winter harvested reed in this study showed low moisture and ash content compare with summer reed. The summer reed ash more melting occurred in the lower temperature range (<1 200°C) and for winter reed more melting occurred in the higher temperature range (>1 300°C). The most dominating ash forming elements in reeds are SiO_2, K_2O and CaO.

The K_2O-CaO-SiO_2 ternary diagram could therefore be useful for predicting melting behaviors of reed from different growing sites and seasons. Reed fuel properties and combustion tests showed that reed is promising renewable energy source.

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