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Reed as gasification fuel compared to woody fuels

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International conference on the utilization of wetland plants
Reed as Renewable Resource, February 14th-16th, Greifswald, Germany

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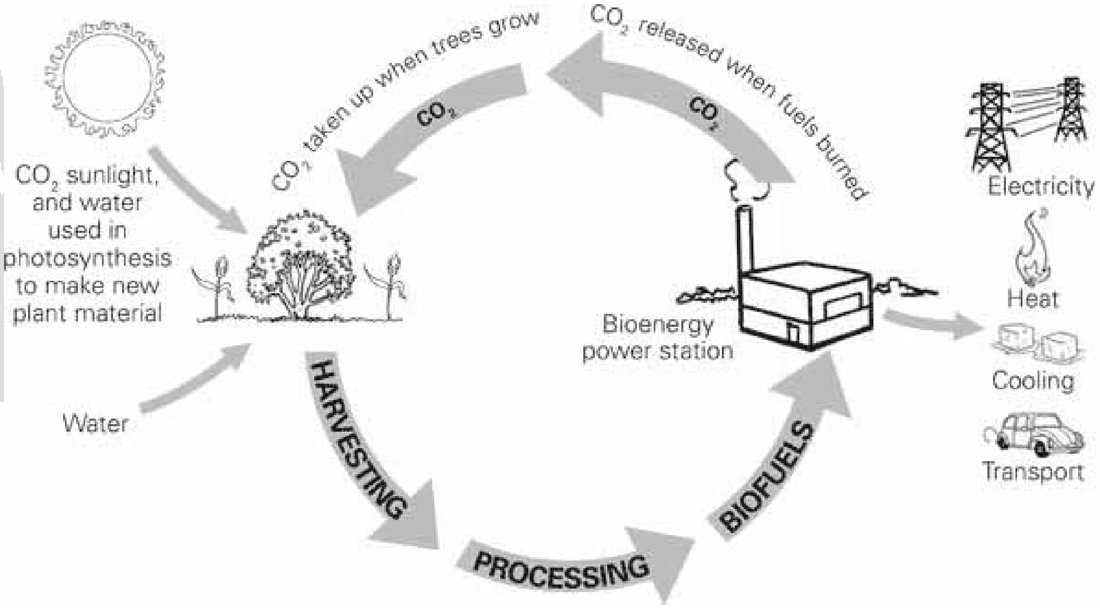
Reed and wood

- renewable energy sources
- considered to be CO_2 neutral
- can be used for energy purposes.



http://www.nicholas.duke.edu)

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Selected fuels - Reed

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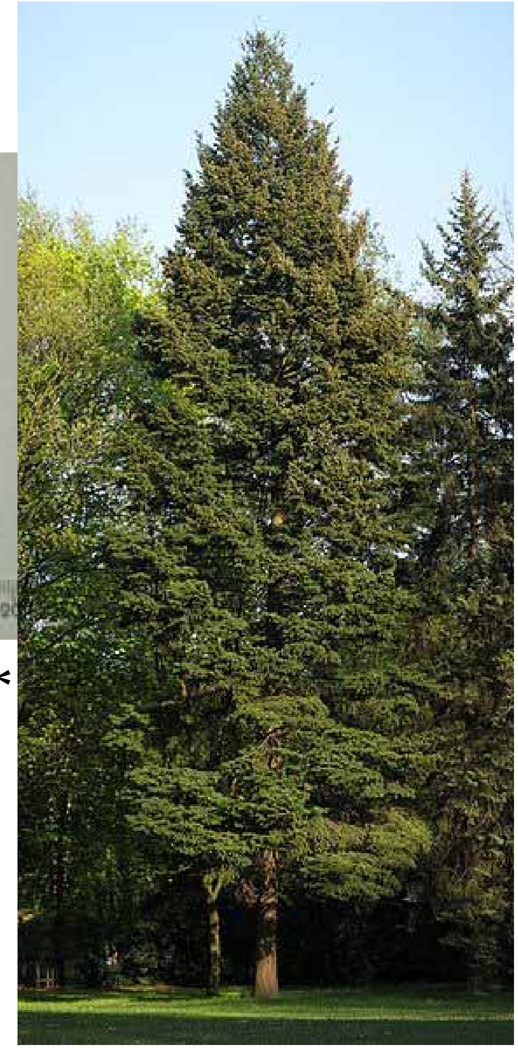
Selected fuels- wood



PINE PELLET

*DOUGLAS FIR**

http://et.wikipedia.org/wiki/Harilik_ebatsuuga

Introduction – reactivity

Char reactivity in the char conversion stage, following the pyrolysis/devolatilisation step in the gasification process, is generally much slower than the pyrolysis itself and is therefore **the rate-determining step**.

Char reactivity is affected by number of factors:

- char formation conditions: temperature, heating rate, pressure
- particle size and size distribution
- composition and content of the inorganic matter
- char porosity, active sites
- pretreatment, for instance leaching
- temperature and partial pressures of the gasifying agent

High char reactivity is needed in order to obtain higher energy outputs from the reactors.

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Analysis and characterization of the biomass samples

	Proximate analysis, dry basis (wt%)				Ultimate analysis, dry basis (wt%)					
	Moisture	Ash	Volatile matter	Fixed carbon	N	C	H	S	Cl	O
R1	5.4	3.2	80.3	16.5	0.4	47.4	5.7	0.2	n.d.	43.1
DF	7.7	6.7	72.3	21.0	0.6	48.5	4.9	0.05	n.d.	39.3
PP	5.9	0.2	83.3	16.5	0.3	50.5	5.9	0.2	n.d.	43.0
R800	6.9	16.0	6.7	77.3	1.7	59.2	1.2	n.d.	n.d.	21.9
DF800	6.5	20.8	9.5	69.7	1.5	56.7	0.9	n.d.	n.d.	20.1
PP800	8.6	4.1	7.1	88.8	1.0	64.1	1.2	n.d.	n.d.	30.6
R2	5.4	3.5	82.1	14.4	0.3	47.1	7.4	0.02	0.04	41.7
CW	32.3	0.6	83.5	15.9	0.3	50.0	5.9	0.02	0.01	42.7

n.d. – not determined

R1 – reed for reactivity analysis
R2 – reed for ash fusion analysis together with CW
DF – Douglas fir
PP – Pine pellet
CW – coniferous wood residue for ash fusion analysis together with R2
R800 – char sample of R1
F800 – Douglas fir char sample
PP800 – pine pellet char sample

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Ash chemical analysis

	R1	DF	PP	R800	DF800	R2	CW
K_2O	5.9	4.1	7.7	3.3	4.7	2.5	20.4
Na_2O	8.4	1.5	1.3	2.8	1.4	2.4	0.3
CaO	2.9	10.9	37.3	4.1	9.6	4.5	41.5
MgO	1.4	4.9	9.1	1.5	7.7	2.2	12.9
SiO_2	73.7	55.5	11.2	83.4	51.9	81.9	1.1
Al_2O_3	0	11.6	5.0	0.9	13.7	1.1	2.2
Fe_2O_3	1.1	7.2	4.8	1.4	6.6	0.4	0.16
SO_3	n.d.	n.d.	n.d.	n.d.	n.d.	2.0	3.2
Cl	0.6	0.7	1.0	0.2	0.4	0.6	0.1

n.d. – not determined

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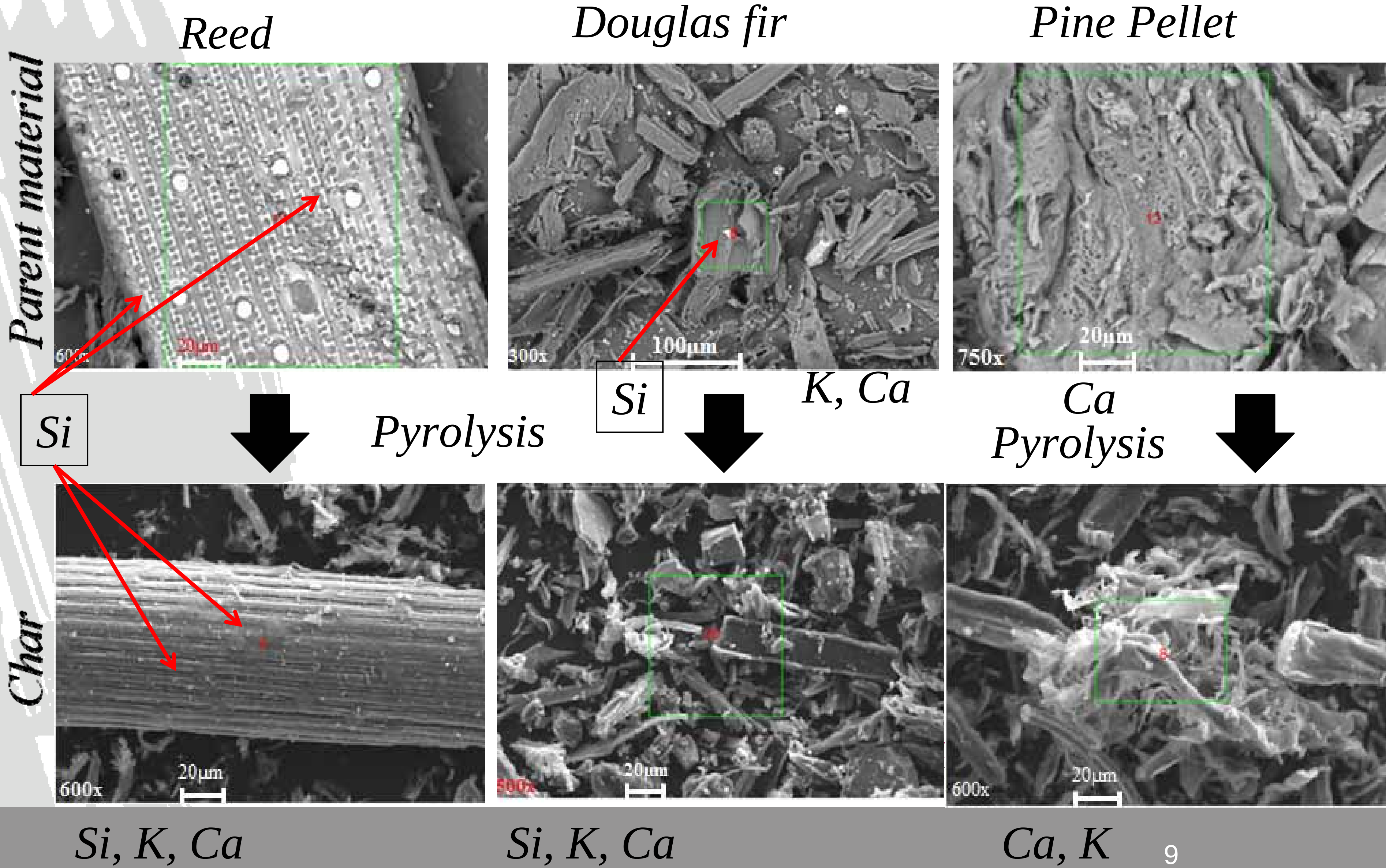
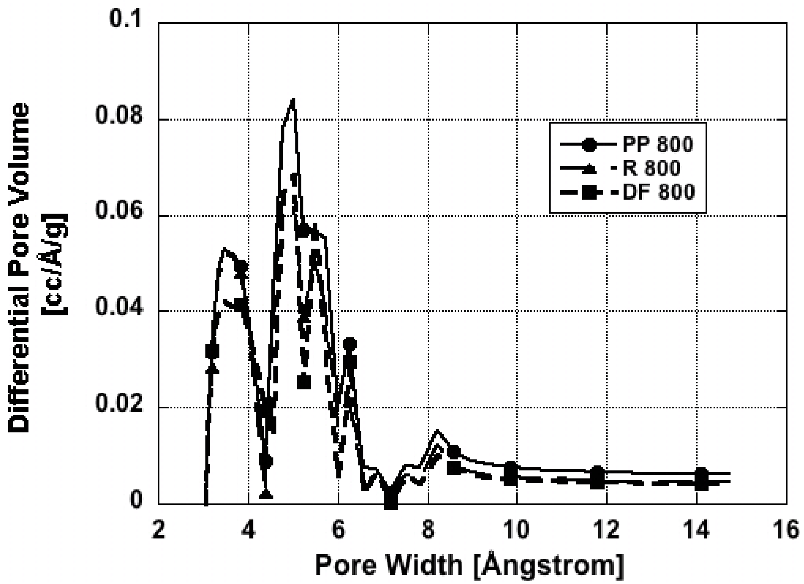
SEM images – reed and wood



Specific Surface Areas ($m^2\,g^{-1}$)

	BET N_2	BET CO_2	DR CO_2
R800	357	435	583
DF800	316	398	545
PP800	485	536	736



DFT/Monte-Carlo differential pore volume distribution. DFT Kernel used: CO_2 at 0 °C on carbon

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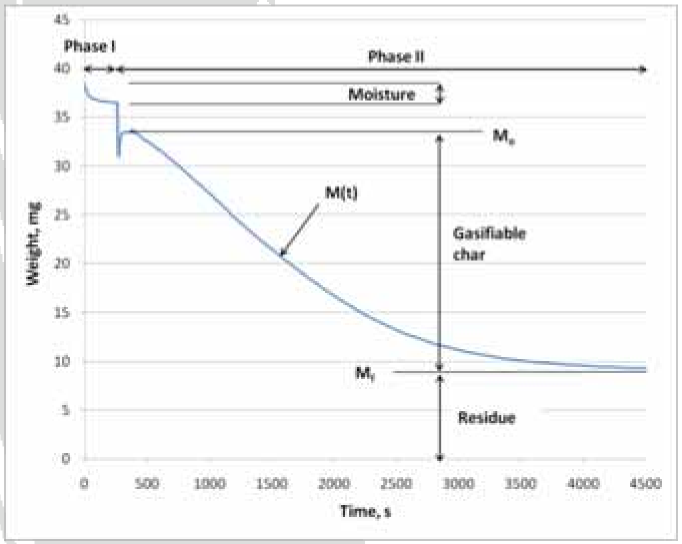
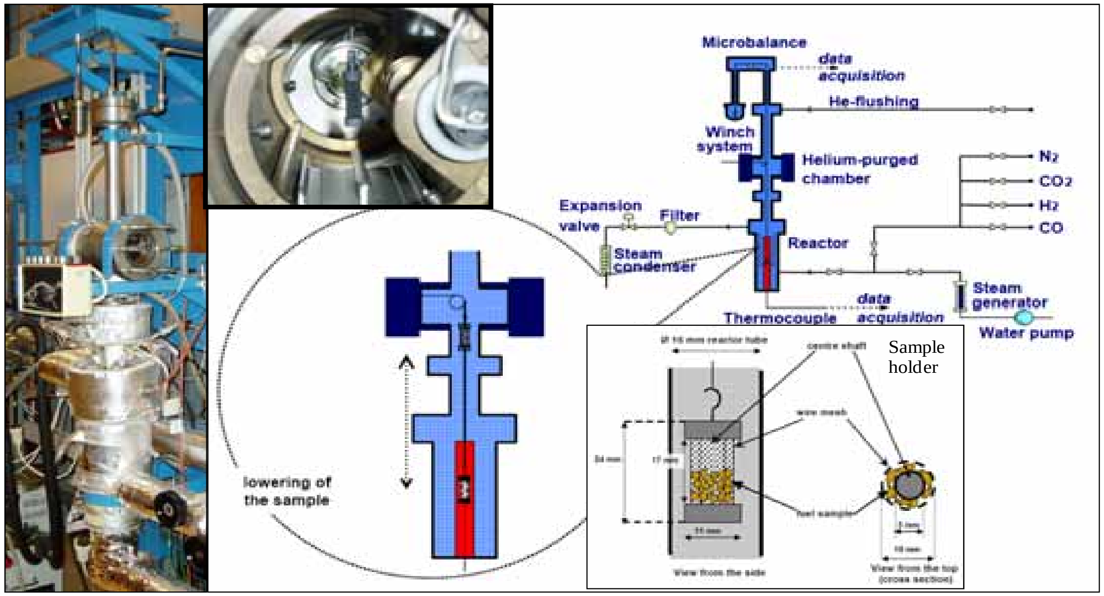
High-Pressure Thermogravimetric Apparatus (HPTGA) and reactivity calculation





$$r = dX/dt$$

$$X = (M_o - M(t))/(M_o - M_f)$$

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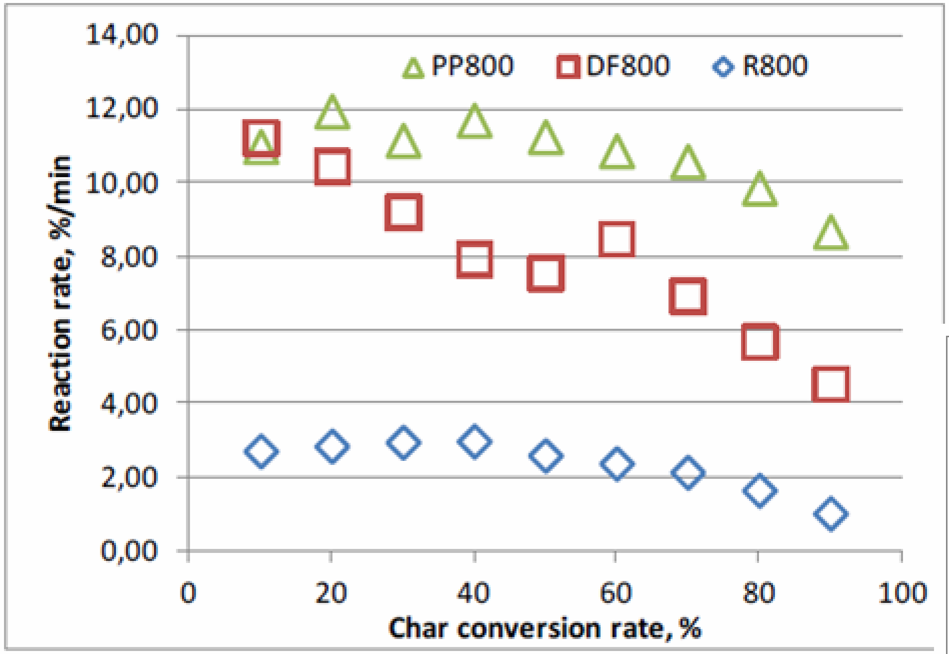
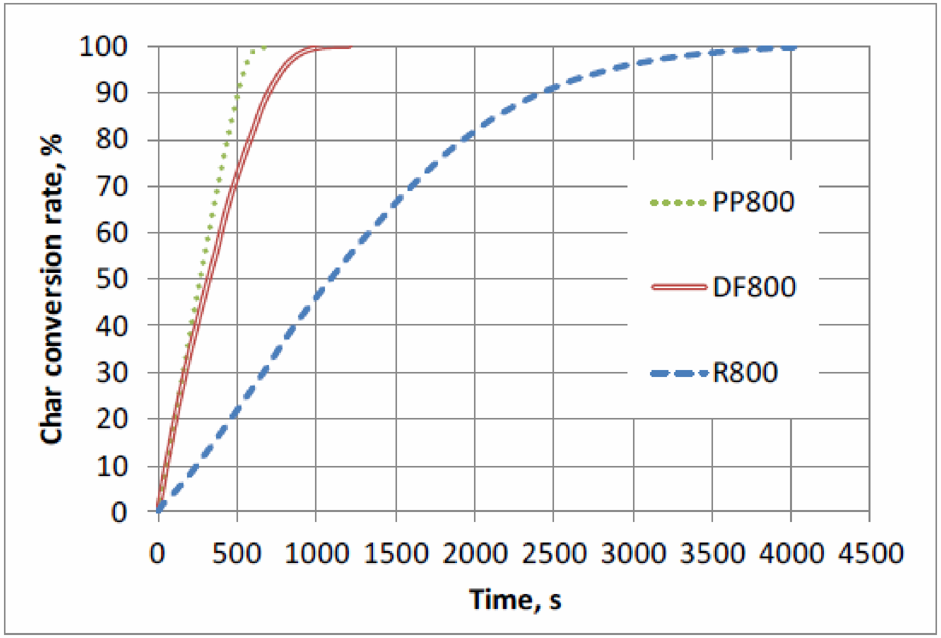
The reaction rates versus char conversion



Char gasification reactivity vs char conversion rate (850 °C)



Conversion rate vs time (850 °C)

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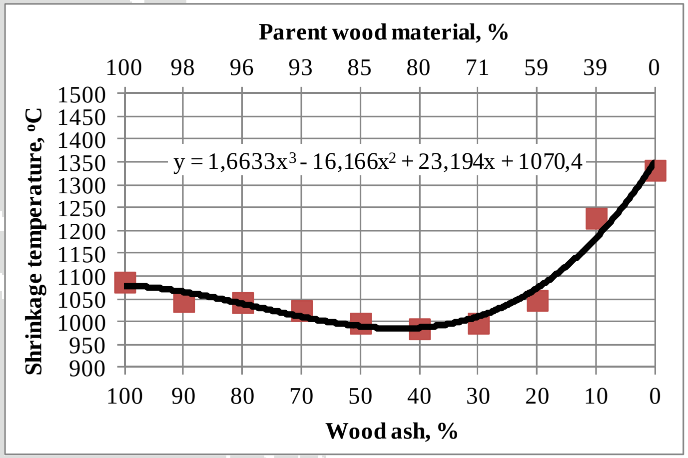
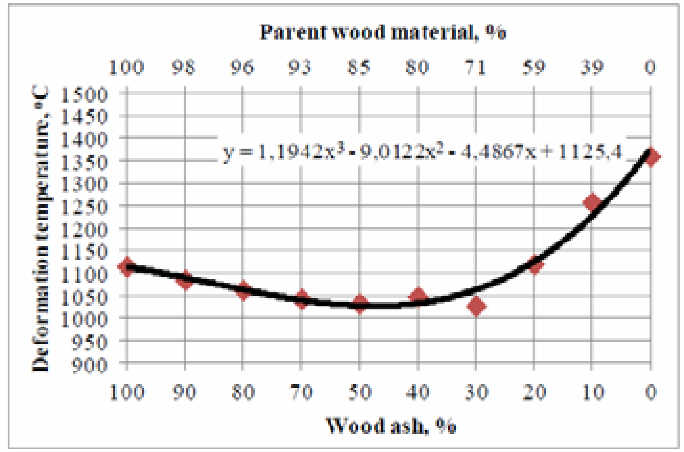
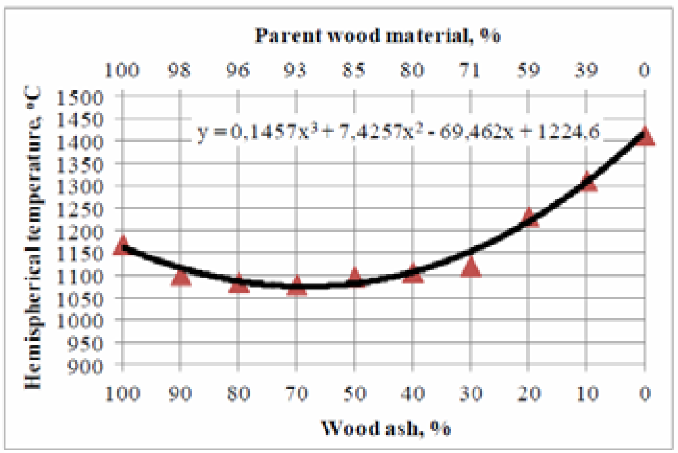
Reed and coniferous wood ash fusion



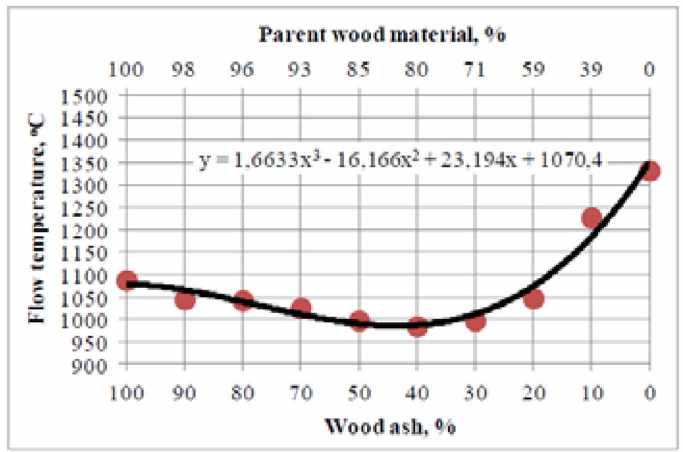
Shrinkage temperature



Deformation temperature



Hemispherical temperature



Flow temperature

Conclusions

- In general, based on this study, the order of the reactivity of chars can be seen as following: **PP800>DF800>R800**.
- The reed sample exhibited a relatively low gasification reactivity and therefore using reed as a fuel, the decrease in the reactor output could be associated, for instance, with other studied materials.
- The reed ash exhibited higher ash fusion temperatures compared to wood ash.
- Blending reed with other biomass materials, the minimum in ash fusion temperatures could be expected (10-20% of reed in blend).

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Thank You for Your attention!

Questions? Discussion.

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