CEEC-TAC7
7th Central and Eastern European Conference on Thermal Analysis and Calorimetry

THE REACTIVITY STUDY OF FUELS FOR THE METALLURGICAL INDUSTRY USING THERMOGRAVIMETRY

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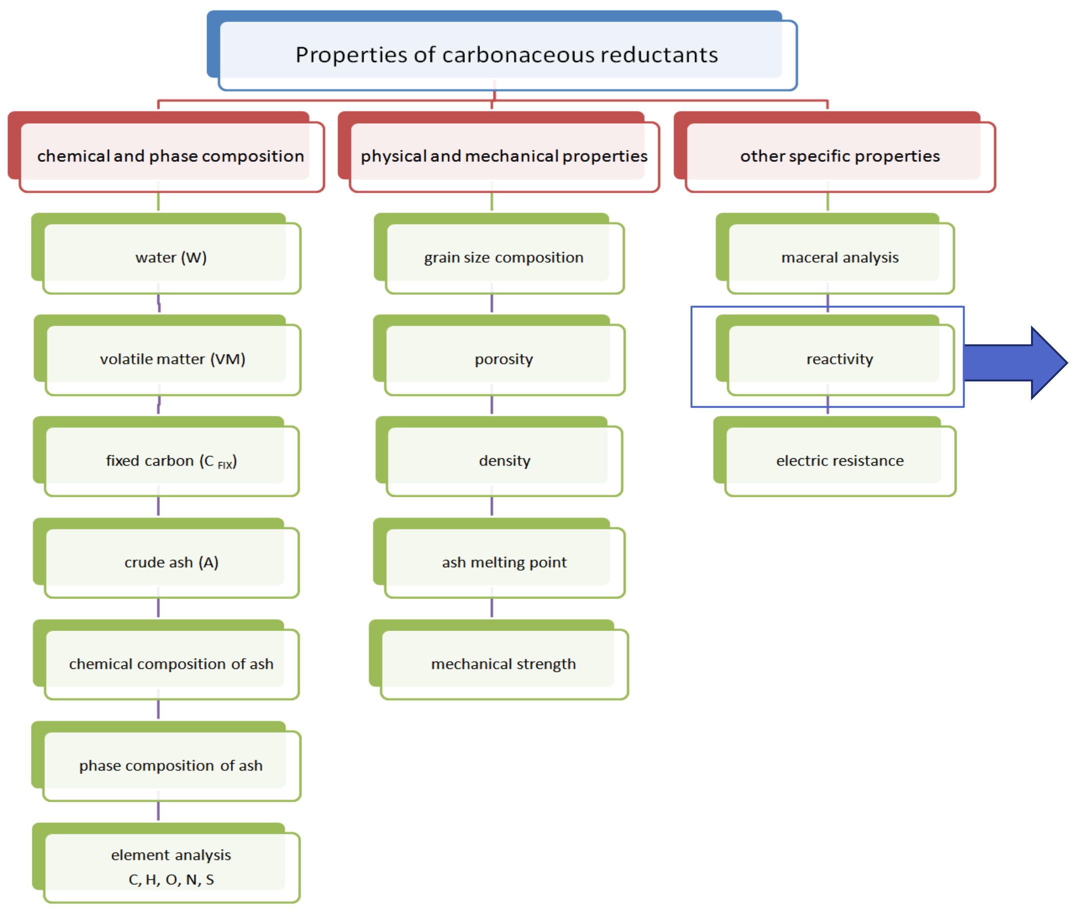
INTRODUCTION

Pyrometallurgical processing and production of metals by high-temperature methods requires the provision of oxidation-reduction processes, where fuels play an important role [1]. Fuels are generally used for the purpose of obtaining thermal energy and/or reduction work, or perform other functions such as gas permeability or carbonization ability. Due to the nature of the process and the required function of the fuel in it, various requirements are also placed on its properties, and therefore, among other things, on its reaction ability in interaction with the environment [2]. For this reason, assessment of thermal stability and quantification of fuel reactivity in the considered reaction systems is a necessary condition for defining optimal parameters.

Our research is focused on the evaluation of the reactivity of selected fuels that are used in the production processes of ferrous and non-ferrous metals obtained by reduction using thermogravimetric analysis. Thermogravimetry is one of the universal techniques for monitoring the influence of temperature, time and atmosphere on physico-chemical changes in the monitored material. The aim of the work was to use the acquired knowledge for the replacement of fossil fuels and reducing agents in the metallurgical industry and their substitution with hydrogen. The obtained thermogravimetric records provide a comprehensive picture of the thermal stability, reaction kinetics and thermal effects in the temperature range of the tested fuels. The measurement results confirmed the expected differences in mass degradation due to their structural composition. The use of the proposed methodology can be applied to various types of traditional as well as alternative fuels, such as various types of biomass, which are considered to reduce the environmental burden of production processes. From the obtained experimental results, it is evident that thermogravimetry has a great application in the field of investigating the properties of fuels.

METHODOLOGY



TGA conditions for reactivity determination

- Sample grains 1-3mm
- Linear heating (5-15K/min) up to 1070°C (or 1170°C) in Ar or N_2
- Quasi isothermal (0.5K/min) up to 1100°C (or 1200°C) in CO_2

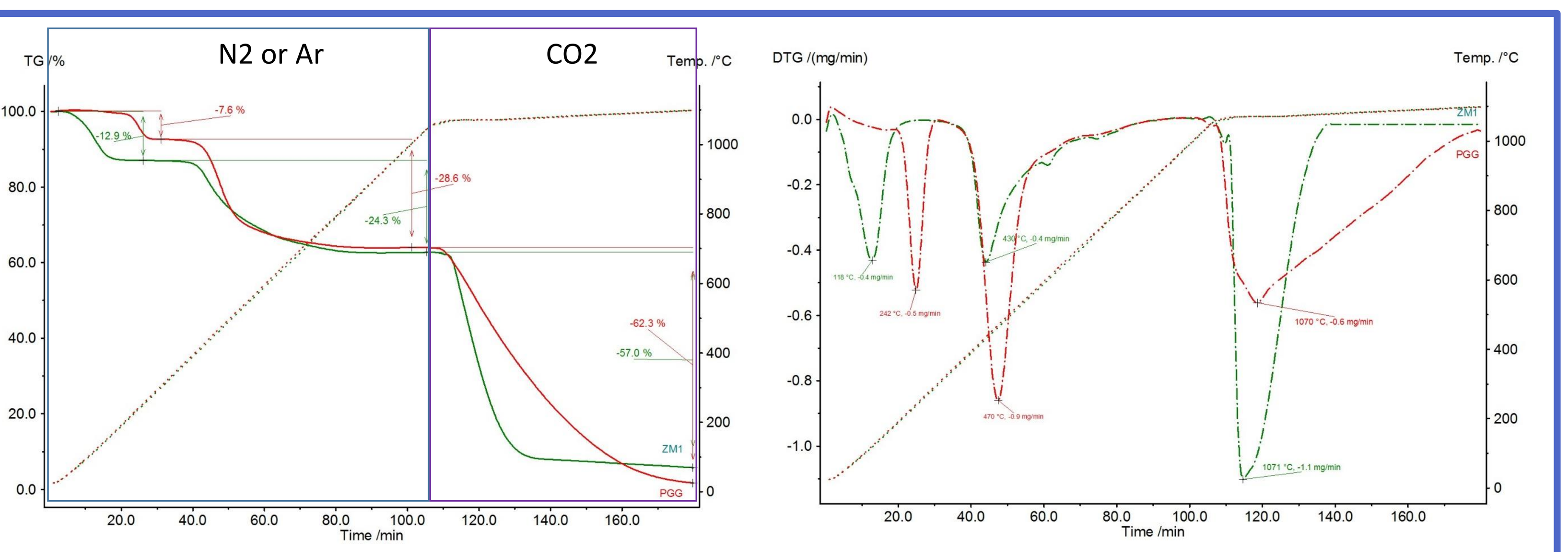


Fig.1 TGA plots of samples degradation

The assessing parameters for the reactivity:

- maximum reaction rate (r_A)
- time to reach r_A (with the isothermal heating in CO_2)
- degree of conversion (X)
- time to reach the 50 % conversion during reactivity

$$r_A = \frac{1}{W_0} \cdot \frac{dW}{dt}$$

$$X = 1 - (W/W_0)$$

Where:
W- char weight of fixed carbon loss
W_0- initial char weight
dW/dt- the maximum rate of fixed carbon loss

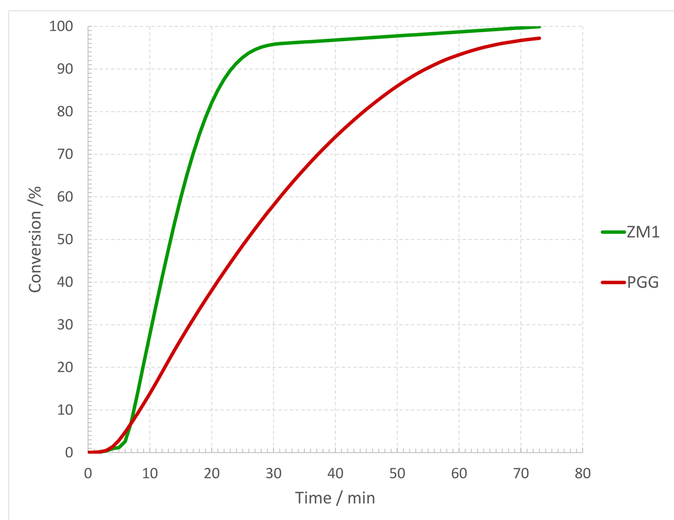


Fig.2 Calculated conversion curves of coals

Tab.1 Calculated parameters of coal

Identification	Sample	r_A / °.min^{-1}	t_{rA} / min	t_{X50} / min
ZM1	Zenmar č.1 EKO I	0,072	9	13,5
PGG	Murcki-čierne uhlie, 62008	0,027	12	26

RESULTS

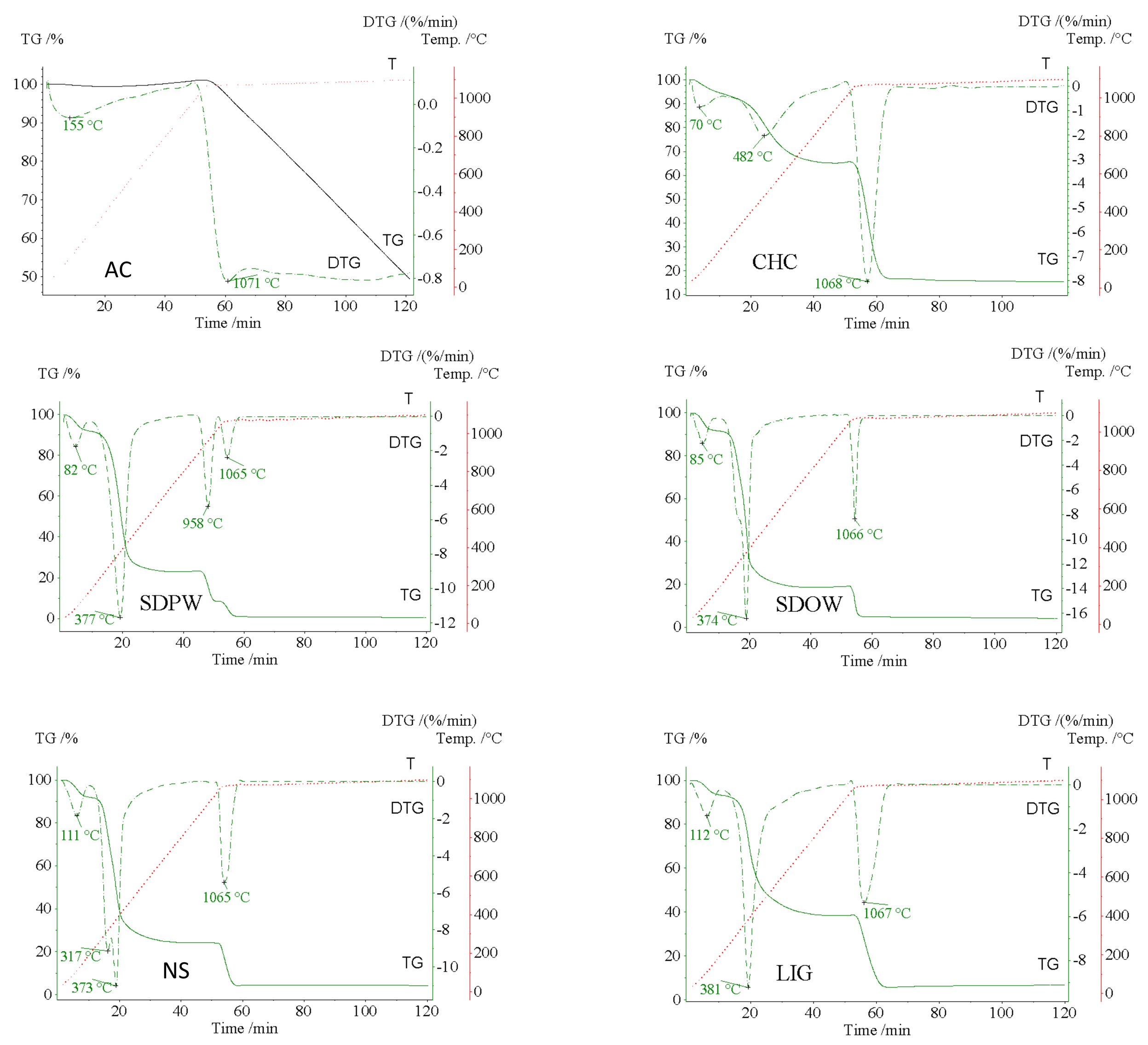


Fig.3 TGA plots of biomass samples and BF.coke

Tab.2 Calculated parameters of coke and biomass

sample	r_A / min^{-1}	t_{rA} / min	t_{X50} / min
AC	0.0156	7.5	68.08*
CHC	0.1643	4.0	5.03
LIG	0.1688	3.0	5.18
NS	0.3086	1.0	2.09
SDPW	0.3302	1.5	1.83
SDOW	0.5364	1.5	1.57

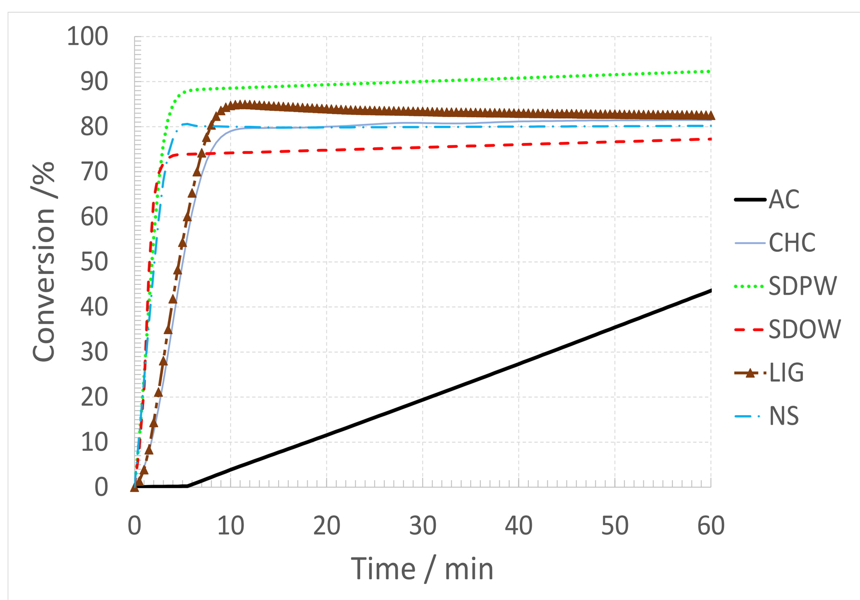


Fig.4 Conversion plot for biomass samples and BF.coke

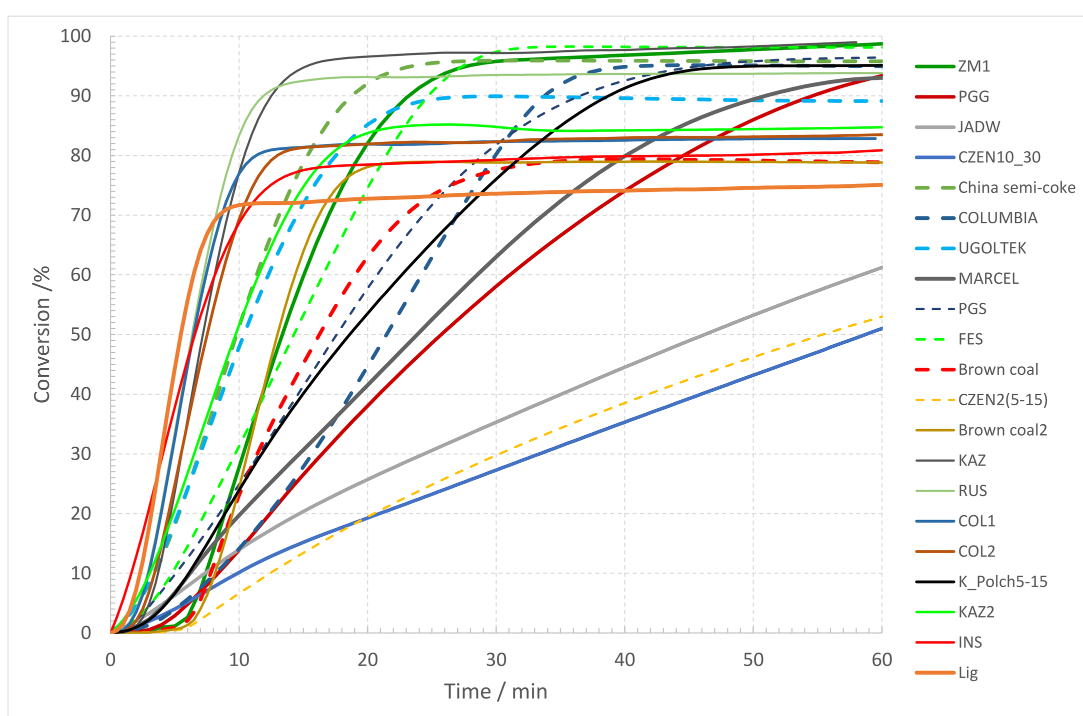


Fig.5 Conversion plot for ferroalloys reducing agents

CONCLUSIONS

- Determination of different rate of mass loss (defines the kinetics of decomposition)
- Conversion maxima indirectly show the proportion of unreacted mass
- Measuring the thermal stability and reactivity of biomass such as sawdust, walnut shells, lignin compared to blast furnace coke indicates significant differences in the observed parameters and can be used in their application as a substitute fuel or reductant
- TGA analyse gives more complex information about thermal stability and reactivity

REFERENCES AND ACKNOWLEDGMENETS

[1] M. Laputka, WG. XieA, “Review of Recent Advances in Pyrometallurgical Process Measurement and Modeling, and Their Applications to Process Improvement”, Mining. Metal. Explor., 38, (2021) 1165
[2] S. Blakey, B. Rauch,A. Oldani, T. Lee, ”Advanced Fuel Property Data Platform: Overview and Potential Applications”,Front. Energy Res., (2022), DOI10.3389/fenrg.2022.771325

The work was supported by the Research and Development Support Agency No. APVV-21-0142.