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Microwave ignited combustion of Coal with maize slush and waste cardboard in modified Tube furnace

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Abstract

The microwave heating applications in various fields and materials could be managed, such as contaminated soil remediation, waste processing, minerals processing and activated carbon regeneration. Microwave heating of volatile organic compounds (VOC) by synthetical heating susceptors in microwave. The microwave combustion technology could be improved for lignite and biomass in the packed bed systems. This may include few difficulties associated with the scaling up of laboratory units to industrial process depending on material dielectric properties. The combustion process by microwave may have specific advantages over conventional methods with cost of heating.

Keywords: Microwave ignition; coal combustion; packed bed; microwave heat flux.

1. INTRODUCTION

The heat values of biomass potentially recycled in the world for a renewable source bring out necessity in use by mixing or a self preference on combustion biomass wastes in the country. The total thermal values based on the products for maize, wheat and cotton are 33.4, %16.1% and 27.6%, respectively. In Table 1, the total annual production of horticultural crops in Turkey is given. The total thermal values are approximately 13,5, 14,8 and 21.5 kJ/kg, respectively. As given in Table the total calorific value of the product nut shells and olive seed were 56.3% and 25.2%. The potential calorific value of the potential amount of pitch waste and animal waste could be determined and true and theoretical values of heat for cows, sheep and poultry, which is about 36, 13 and 6.5 million tons/a in Turkey for cows. According to the number of animals in Şırnak City Province, sheep and poultry, and approximately in Şırnak City Province these amounts of annual waste capacity are 235, 141, 58 thousand tons/a, respectively. The total annual amount of forest, bush and wood waste, are 6, 0.6 and 0.49 million tones, respectively in Turkey. The total available solids content of of forest, bush and wood waste are recycled 65%, 3% and 99% as determined by the availability, respectively

The combustion process by microwave may have specific advantages over conventional methods with cost of heating.The factors influencing heat flux are

- the combustion kinetics in microwave ignition,
- coal type,
- microwave permittivity,

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- temperature difference,
- length (or thickness) coal bed,
- cross sectional area of bed, and the thermal conductivity of the air/coal bed.

Thermal conductivity is the measure of the quantity of thermal energy which flows through a conductor. In addition to form, there are a number of factors influencing thermal conductivity of coal including micro structure and amorph structure and porosity structure, and density.

2. MICROWAVE PYROLYSIS

The torrefaction and advanced applications for active carbon require further treatment. The pyrolysis process can thus be regarded as pre-treatment process. Pre-treatment of biomass via pyrolysis results in various advantages compared to the direct utilization of biomass. The energy density on volumetric basis is a factor 3–10 higher for pyrolysis oil, decreasing e.g. transportation costs. Via pyrolysis, locally available biomass streams can be exploited as renewable material which could otherwise not be processed economically. Besides economic and ecologic advantages, pre-treatment via pyrolysis also creates technical advantages. The pyrolysis oil is much easier and cheaper than char, solid carbon mass. Also, ash forming elements are reduced by an order of magnitude. The decision to include fast pyrolysis as pre-treatment or gasify the powdered biomass in an entrained flow gasifier directly will ultimately depend on biomass properties and the specific scenario.

2.1. Coal Pyrolysis for Char

One of the most common method to convert biomass into biofuels is believed to be pyrolysis and entrained flow gasification. Pyrolysis of biomass has been studied extensively and several reactor technology have used at commercial scale. In the fast pyrolysis process, biomass is rapidly heated in an oxygen free environment to form condensable vapours, permanent gases and a solid residue often referred to as char. After rapid cooling of the condensable vapours, up to 700g/kg of biomass can be converted into a liquid product called pyrolysis oil. With comparable heating values, the overall energy yield from biomass to pyrolysis oil is in the same range (0.7J/biomassJ).

A slightly different approach is followed in the pyrolysis cracking of fast reactions and th following oxidation od carbon matter with oxygen and steam forming process,

$$C + O_2 \rightarrow CO_2 \ \Delta\text{G=-RTlnKp=-96500kj/kmol}$$

$$2C + O_2 \rightarrow 2CO \ \Delta\text{G=-RTlnKp=-112600kj/kmol}$$

$$C + CO_2 \rightarrow 2CO \ \Delta\text{G=-RTlnKp=-56500kj/kmol}$$

$$C + 2H_2 \rightarrow CH_4 \ \Delta\text{G=-RTlnKp=+76500kj/kmol}$$

$$2C + 2H_2O \rightarrow CH_4 + CO_2 \ \Delta\text{G=-RTlnKp=-46500kj/kmol}$$

$$C + O_2 \rightarrow CO_2 \ \Delta\text{G=-RTlnKp=-96500kj/kmol}$$

3. METHOD

The chemical analysis of fuel resources used in the experimentation are given in Table I.

Table I. Coal and Biomass feedstock properties.

	Pinewood waste	**Maize slush**	**Şırnak Asphaltite**
Moisture (a.d.)	98	68	(g/kg)
Ash (dried)	34	24	(g/kg)
LHV (a.d.)	18.8	14.2	(MJ/kg)
Elements (Dried)			
C	515	437	(g/kg)
H	63.0	57.5	(g/kg)
N	<0.1	8.9	(g/kg)
O	419	433	(g/kg)
S	62	894	(mg/kg)
P	59	695	(mg/kg)
Ni	0.9	1.2	(mg/kg)
Pb	1.5	<1	(mg/kg)
Mn	96	19	(mg/kg)
Ca	1143	2223	(mg/kg)
Mg	222	488	(mg/kg)
Fe	149	66	(mg/kg)
Na	18	62	(mg/kg)
Al	117	35	(mg/kg)
K	465	11,850	(mg/kg)
Zn	11	10	(mg/kg)

The moisture content of wheat straw before pyrolysis was relatively high at 98g/kg. Comparing the wood and straw shows a significantly higher ash content in the wood waste.

In Figure 1 photographs of the laboratory equipment used in this work are presented. The produced pyrolysis oil and the asphaltite feed was integrated with the control system in the gasifier.

In the pyrolysis experiments with addition hydrated lime, reactor temperature changed between 400^{o}C and 650^{o}C and lignite samples mixed only by %10 lime. Products received from pyrolysis of coal specimens were subjected to analysis for sulfur hold-up determination. Test results of pyrolysis by lime and other alkali at 600 ^{o}C are seen in Figure 1.

From the point of view of gasification experimentation, the resulted chars quality and quantity in the pyrolysis chambers for biomass, lignite and coal samples were determined for different source evaluation and so we may reduce the effect of ash content of coal samples in order to optimize pyrolysis a gasification rates of lignite samples. As given in Figure 3 gas and oil yields for lignite and coal samples were slightly similar, oil yield was lower for coal. In the gasification experiments with different particle size fractions of coal specimens, at reactor temperature changed to 600^{o}C and lignite samples mixed only by lime at 10% weight rate. Products gasification of coal specimens were subjected to analysis for yield determination.

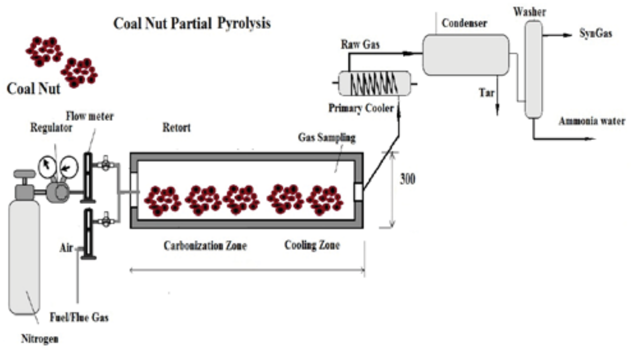

Fig. 1. Kiln pyrolyzer of Turkish Lignites used in coal pyrolysis process at 600 ºC

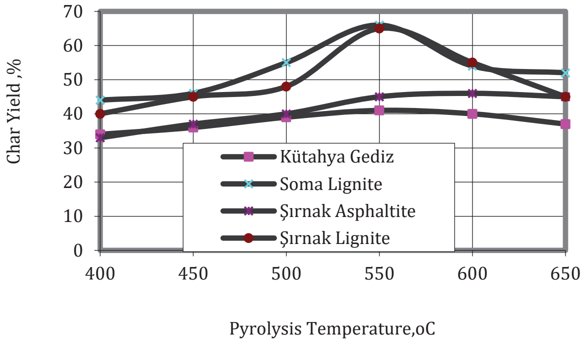

Fig. 2. Comparison of desulfurization %10 lime addition at equal rates to pyrolysis chamber with lignite

Test results of gasification of Turkish lignite are seen in Figure 4. Comparison of particle size at 3-10mm additions at equal rates into the pyrolysis chamber with finer lignite showed that Gediz lignite was showed higher oil yield at near 26 % weight rate. In the gasification experiments, the experimental condition is calculated on the basis of the gas composition in the ambient state. So neither the contained water vapour nor the condensing hydrocarbons are taken into account. However, these components increased by decrease the particle size to 100 micron and oil yield was remained low 12% weight.

4. CONCLUSIONS

The microwave pyrolysis products can be used as humate mud as carbon source or char from a biomass and coal mixture feed in pyrolysis. This microwave heating by iron susceptor can have certain advantages over direct biomass pyrolysis. The tests were performed to investigate the effect of microwave on char quality from biomass via the pyrolysis and in packed flow to syngas. The maize slush, forestry waste pine wood were used as feedstocks; both were converted into homogeneous pyrolysis oils and syngas with very similar gasification measured for waste pine wood waste- and waste maize slush derived pyrolysis syngas, respectively. A continuous 2-day process run with wood and coal pyrolysis char was under full steady state operation.

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