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MİCROWAVE PYROLYSİS OF COAL SLİME AND WOOD STRAW BY PYRİTE FOR ACTİVE CARBON PRODUCT

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ABSTRACT

In the Southeastern Anatolian Region of Turkey, in Ergani Elazığ and Siirt Şirvan copper ore concentrators, containing the pyrite and the high pyrite content discarded is received as pyrite concentrate from concentrating copper by flotation swept and waste products. Ergani Concentrator produce the pyrite concentrate by product about 350 thousand tons for sulfuric acid production and about 1,700 thousand tons of pyrite waste sent to dispose, Siirt Şirvan copper pyrite is not also evaluated. These pyrite waste products both should be evaluated by the microwave pyrolysis of Turkish Lignites and Şırnak Asphaltite which contains aproximately 8% coal pyrite at seperately disseminated micron and macro sized. The shale and clay content was also separated sellectively in this microwave processing in terms of high carbon contents.

In this study, samples are subjected to microwave pyrolysis by roasting of pyrite waste and subsequently pelletized slime mixtures with wood straw samples were subjected to microwave pyrolysis by pyrite at varied power under the temperature 500^{o}C. Active carbon and char matter at the end of microwave pyrolysis were tested. The carbon, ash and moisture volatıle matter improves physical pore types for active carbon at certain degree. The energy need was also minimised at 73% for Şırnak Asphaltite slime by microwave pyrolysis.

Keywords: coalslime,active char, carbon, wood straw, microwave cleaning, asphaltiteslime

INTRODUCTION

Lignite consumption in energy production is increasing in parallel with growing energy needs today. In terms of reserve and production quantities of high quality lignite, natural resources are limited. The significant amount of electricity is produced primarily from coal in the world [1, 2].

The almost 211TWh total electricity in 2011, Turkey were produced primarily from imported natural gas and domestic coal [3,4]. The total amount of asphaltite resource in reserves and production in Şırnak City are over 82 million tons of available asphaltite reserve and 500 thousand tons per year, respectively [5]. The most effective and cost-effective technologies are needed for clean coal products in today's modern technologies [5-9]. Turkish coal industry needs noble gasification technologies and high gasification performances at lower cost with various types of local coals regarding researches.

The most effective and cost-effective technologies are needed for clean coal products in today's modern technologies [5-9]. Turkish coal industry needs specific tests in order to measure gasification performances of various types of local coals regarding standard qualification tests. There are lots of signs for the production of bio-masses and lignite in industrial many fields even using regular high capacity wood and maize slush or cellulosic biomass wastes. Processing technologies using wood and maize slush manure should be under contribution to the fuel side [9]. On the nature and characteristics of the medium as base lignite are distinctly determined. In the view producing high value cleaned products, pyrolysis and gasification of lignite are managed for this purpose.

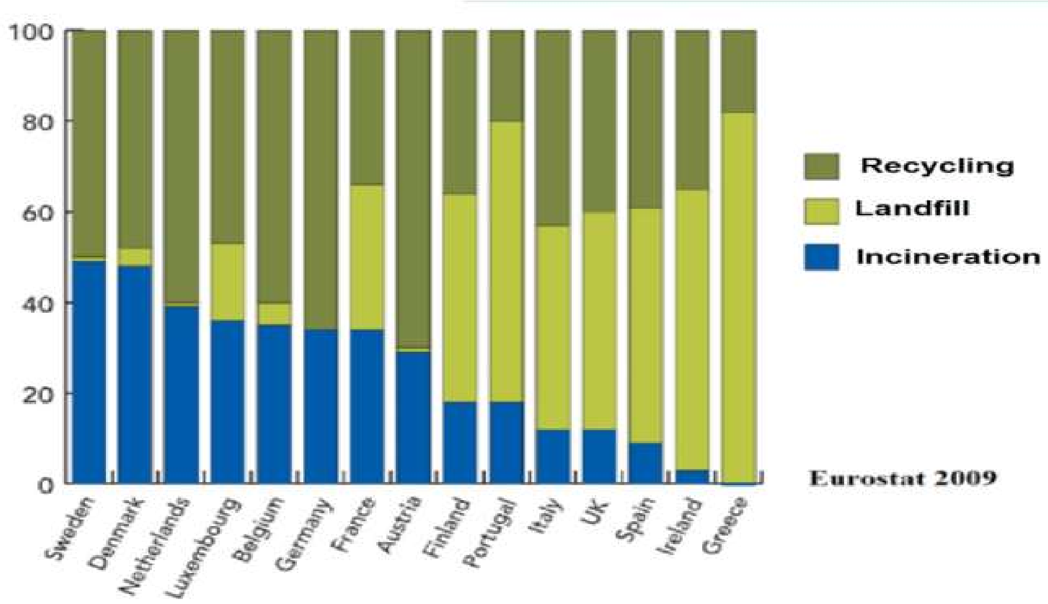


Figure. 1Waste to Energy Production and Distribution of countries according to the European Waste [2]

Depending on advanced technological developments in energy production the low quality coals needed the most economical technologies and even in order to make it possible to produce coal-derived products. Compliance with environmental norms of coal pyrolysis or gasification of various types of coals, feasible combustion systems and energy production facilities are needed in today's modern technology, also enable the production of liquid and gaseous coal fuels [10]. However, agricultural waste materials and chemical nature of them requires a variety of adaptation methods. For this purpose, alternative renewable energy resources needs to process them to provide the basic information required in laboratory and pilot scale. The methods using feasible process in gasification and methanation may produce clean derivative gas fuels in the local area. So significant design works need to obtain the derivatives from the wastes and available renewable resources.

PYROLYSIS AND GASIFICATION

Considerable research on coal pyrolysis and gasification has been conducted over the years, but the pyrolysis results are widely dispersed because of the complex chemistry of coal [11-16]. Time related coal-pyrolysis modeling assumes basically first-order kinetic equations, or less sensitive for heating rate [17, 18]. The other distributed activation model is dependent on the heating rate. The last two more advanced models need three and four constants, respectively, which basically depend on the coal properties but also cover to some extent, the effect of heat-and-mass transfer phenomena [19].

That is the reason for the different values of the activation energy and pre-exponential factor cited in the literature and the lack of generally valid data. The same situation exists in the case of coal-char gasification. The reaction rate of char is influenced mainly by chemical and physical factors, which include coal type, catalytic effect of the ash and the specific surface area of char, which changes during the reaction course with the development of internal pores, and finally, their destruction [20]. The combustion of biomass in fluidized bed was managed in plant scale for incineration energy production as illustrated in Fig 2.

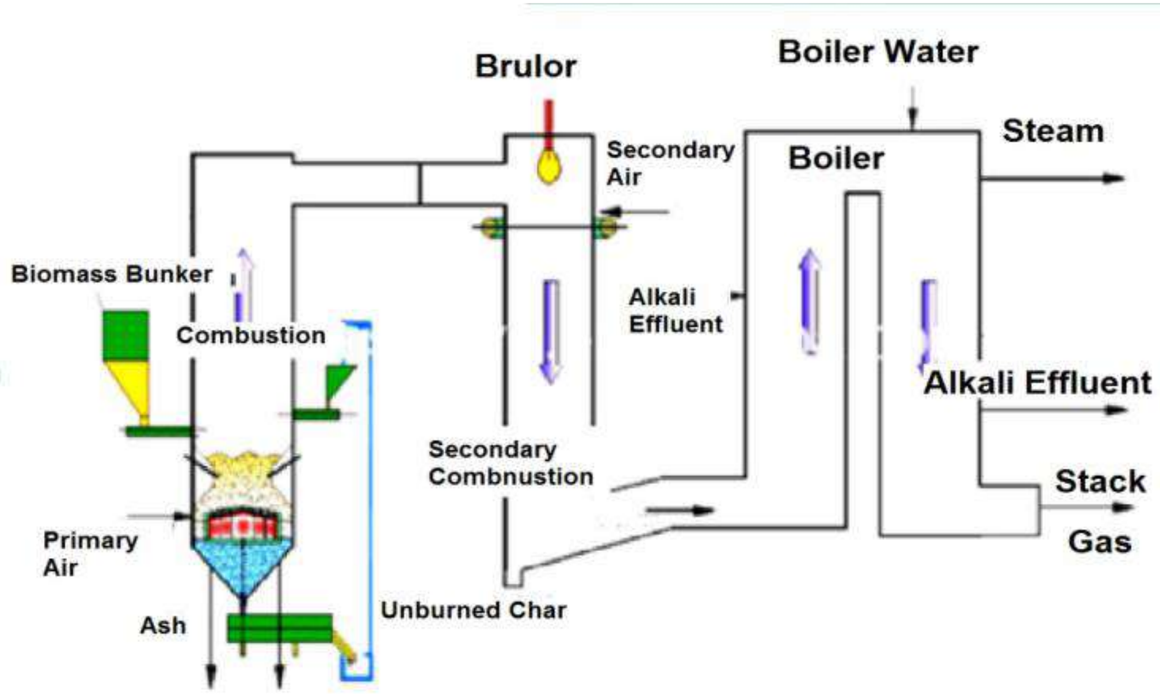


Figure2 The fluidized bed combustion of biogas and solid waste [3]

The particles are assumed to be spherical, and the reaction order n = 1. It should be noted that the equations in the model refer to the evolution of 1 kg of particles (as indicated through the parameter N, number of particles per kg of coal). A single film model with CO_2 as the only product of char oxidation is applied. CO_2 oxidation is assumed to occur far away from the particle. The flow of oxygen towards the particle and its partial pressure at the particle's surface are calculated following e.g. Bird et al. [37]. Both diffusion (Fick's law) and Stefan flow (due to the net outwards convective flow) are considered to calculate these two parameters. Then, the identity of oxygen consumption and transport leads to:

$$m = \frac{-dO_2}{dt} \qquad 1$$

$$k = Ap_{O_2} e^{-\frac{E}{RT^2}} \qquad 2$$

The gasification submodel is similar to the one just presented for coal devolatization and gasification, with the mass and energy balances adapted to the simulation of that process. Again, a single step model is used for devolatilization and apparent kinetics for char gasification in CO_2. However, now the order of reaction with respect to CO_2 partial pressure at the surface, m, is not fixed at period t and will be derived from the experimental data:

$$m = \frac{-dC}{dt} \quad 3$$

$$m_{CO_2} = \frac{mC_0 - mC_t}{mC_0} \quad 4$$

As in the combustion model, both diffusion and Stefan flow are considered in order to calculate p_{CO2};s and the Dufour effect is included in the calculation of the convective heat flux (Eq. (9)), with K in this case

$$k = Ap_{CO_2} e^{-\frac{E}{RT^2}} \quad 5$$

In the case of the scaling-up procedure, the uncertainty of a complex model of the reacting system may be very high and it is reasonable under some conditions to use a methodology based on quasi-equilibrium conditions, which can be reflected at a larger scale.

The country needs the cleanest fuel to be produced providing the essential oils and gases. For this reason, gasification of KütahyaGediz, Soma lignite, Şırnak asphaltite and lignite may be so feasible at the side of cost and production high amount of gaseous fuels instead of importing natural gas. Advanced coal washing of Turkish lignite may not be feasible. However, pyrolysis and following gasification of clean Turkish lignite can be managed [16]. This project approach assumes basically that the process itself, with all specific features, is a decisive factor for the path of the reactions of coal decomposition. Therefore a static model of char gasification and coal pyrolysis was developed. It is based on the assumption that the final process temperature is a decisive factor for the required volatile-matter content in the char being in a quasi equilibrium state with respect to the gas temperature. Instead of fluid bed gasification, packed bed gasification of coarse size coals is governed by chemical reactions on particle gas reactions. Gasification rates were lower so that mass diffusion rates of gaseous materials to coal particle fundamentally control reaction kinetics. A modified model of kiln gasification for Turkish lignite and asphaltite used in coal gasification-pyrolysis process was found to be efficient.

METHOD

The total amount of asphaltite resource in reserves and production in Şırnak City are over 120 million tons of available asphaltite reserve and about 600 thousand tons per year, respectively. The asphaltite is used in mainly coal boilers for direct heating, and also in industrial furnaces as coal fine. The coal power plants use asphaltite about 400.000 tons per annum in the boiler. The most effective and cost-effective technologies are needed for clean asphaltite production in today's modern technologies.

The carbon, hydrogen and nitrogen contents were determined by LECO CHN-600 elemental analyzer. Total sulfur contents were determined by LECO sulfur analyzer. The proximate analyses of the original samples were carried out carried according to ASTM D-3173, D-3174 and D-3175 standards. Total sulfur contents were determined by LECO sulfur analyzer. The proximate and ultimate analyses of the original asphaltite and wood and maize slush manures are given in Table 1 and Table 2.

A kiln reactor was used in coal pyrolysis heated till 600 ^{o}C with a rate 7-10^{o}C/min by fuel. The process was tested at a scale of 2–3 kg/h; collecting operational and design data to build an industrial installation. A technological diagram of the coal gasification-pyrolysis process developed unit is made. Thermal destruction almost observed at temperature increase from 350 °C to 400°C with a desulfurization rate of 60-70% and with simultaneous dilution of oil products by condenser distillate.

To achieve this, it is necessary to create conditions of internal circulation without the transported coal and char in rotary kiln, where the average concentration of solids amounts to 0.2- 0.3 m^3/m^3, i.e. the conditions for residence time are long enough for the thermal decomposition of coal and intensive gas mixing so enhancing mass and heat transfers.

Table1.Proximate Analysis of Turkish Lignite and Asphaltite. (ADB:Air dried base. DB:Dried base, DAB:Driedashless base).

Coal Type	**Ash,% ADB**	**Moisture,% ADB**	**TotalS,% DB**	**Volatile Matter,% DAB**
Şırnak Asphaltite	46.3	0.1	7.1	62.6
Şırnak Lignite	29.3	18.1	3.1	52.6
KütahyaGediz	22.0	1.7	3.6	42.7
Soma Kısrakdere	13.8	14.0	2.2	40.4

Table2.Proximate Analysis of Biomass Waste. (ADB:Air dried base. DB:Dried base, DAB:Driedashless base).

Biomass Waste Type	**Ash,% ADB**	**Moisture,% ADB**	**TotalS,% DB**	**Volatile Matter,% DAB**
Maize Slush	46.3	0.1	7.1	62.6
Wood	29.3	18.1	3.1	52.6

Laboratory scale pyrolysis was made to create gaseous conditions of internal circulation without the transported coal and char in fluidized bed, where the average concentration of solids amounts to 0.2- 0.3 m^3/m^3, i.e. the conditions for residence time are long enough for the thermal decomposition of coal and intensive gas mixing so enhancing mass and heat transfers.(Figure 3)

Gasification commenced by fuel burning into the fluidized bed firstly and then CO_2 gas evolution followed and circulated into the auger bed for three hours. When it is observed a temperature increase from 800 to 900°C without fuel addition, injected steam at a volume rate of 2/1 and air with 3lt/min. Gaseous products with simultaneous dilution of oil products by condenser distillate are collected. To achieve this, it is necessary to create conditions of internal circulation without the transported coal and char in the reactor, 50-60% conversion yield recoveries were observed at the end of gasification.

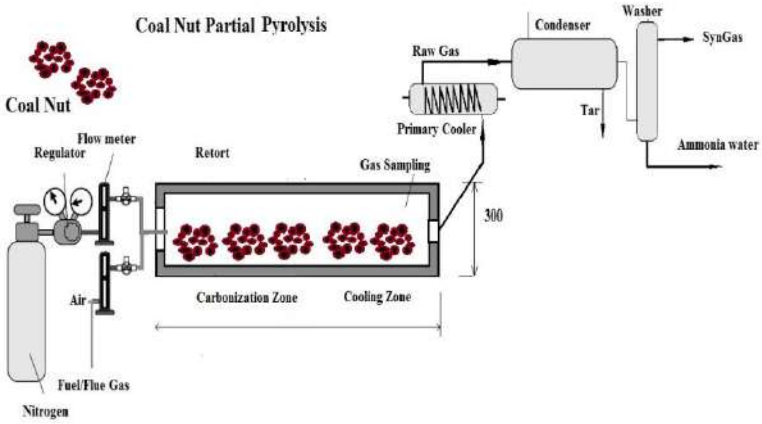
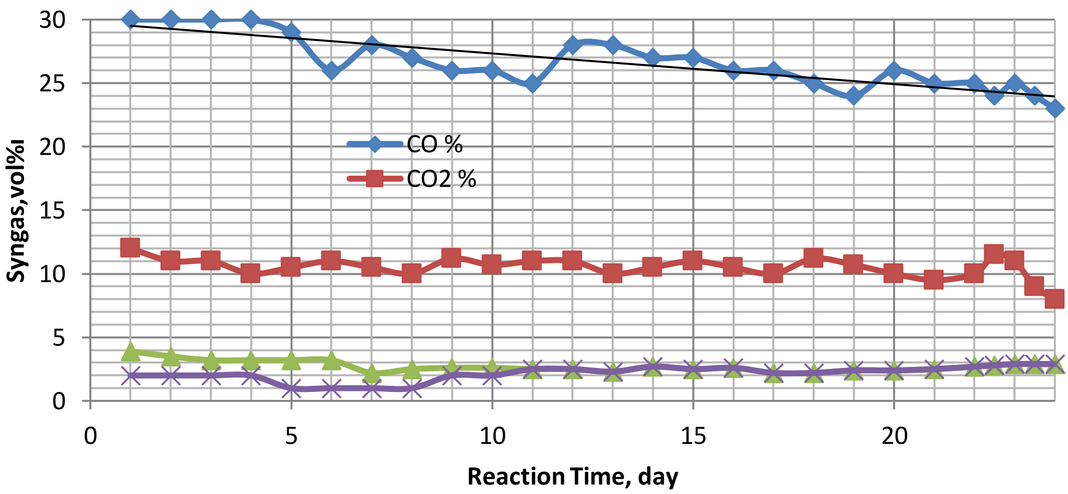


Figure3 AugerPyrolysis of Turkish Lignites and Asphaltite used in coal gasification-pyrolysis process.

RESULTS AND DISCUSSION

Gasification commenced by fuel burning into the fluidized bed firstly and then CO_2 gas evolution followed and circulated into the methanation pressurized bed for three hours. When it is observed a temperature increase from 800 to 900°C without fuel addition, injected steam at a volume rate of 2/1 and air with 3lt/min. Gaseous products with simultaneous dilution of oil products by condenser distillate are collected. To achieve this, it is necessary to create conditions of internal circulation without the transported coal and char in the reactor, 50-60% conversion yield recoveries were observed at the end of gasification, as shown in Figure 4.



Figue. 4 Effect of Pyrolysis Temperature over Char Yield rate

CONCLUSIONS

In the auger experiments with addition hydrated lime, reactor temperature changed between 1200°C and 1350°C and lignite samples mixed only by %10 lime. Products received from gasification of coal specimens were subjected to analysis for sulfur hold-up determination. Test results of gasification by lime showed extreme sulfur hold-up.

This work demonstrates the feedstock flexible nature of the fast pyrolysis – packed flow gasification process chain. The pyrolysis process deals with variable wood and maize slush manure properties and the non-slagging gasifier is able to convert the pyrolysis oils into good quality syngas.

This study examined the high sulfur and ash types of KütahyaGediz lignite, Soma lignite, Şırnak asphaltite and lignite. The representative samples were taken from local areas of the lignite. Fundamentally, the conditions regarding better desulfurization way, high quality lignite oil production, high value light oil, coal tar and gas products were determined at the goal of high fuel producing yield.

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