Calculation and modelling to the Brown coal drying fluidized bed specialized for Greek lignite of West Macedonia

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Abstract: - Brown coal is considered to be a competitive primary energy source for power generation in parts of Central and Eastern Europe due to the economically recoverable reserves of this fuel in these regions. Specifically for Greece lignites is the main fuel and contributes at 60 % in the production of electric energy. On the other side, it is well known that coal brown contains significant amounts of moisture whish decreases the overall plant thermal efficiency due to the increased flu gas thermal loses. In order to keep the competitive edge of brown coal, an improvement of the power plant efficiency is required. In the previous paper a computing program was developed for the brown coal fluidized bed calculation in a matlab code. Model studies of fluidized bed show the best parametric a brown coal fluidized bed should have in order to dry the Greek lignite.

Key-Words: - Energy Source, Lignites, Electric Energy, Brown Coal, Fluidized Bed.

1 Introduction

Lignites contributes to the safety of Europe's energy supply and can be considered European fuel. For many countries it is the main domestic energy raw material.
The prospect of lignite's industry is associated with the maintenance of the competitiveness and common acceptance of activities. Their guarantee in the future, imposes careful planning of exploitations, the modernisation of technology and the improvement of organisational structures of enterprises.
The social acceptance of this sector that influences seriously the environment and the social balances, requires particular concern as long as complex and diachronic adaptation in each condition.
With the social acceptance and the competitiveness of lignites as an energy fuel the conditions for the continuation of activities will be ensured and the exploitation of important advantages of this sector, which are:

1.the enhancement of the productive sector of countries
2.the guarantee of working positions
3.the safety in the energy supply
4.the possibility of forecasting the future configuration of lignites price
5.the reliability of energy planning

The programs of growth of new efficient and "clean" technologies of solid fuels exploitation will be promoted in developed countries and mainly Germany. That also consists in essential and effective interventions for the upgrading of existing installations of exploitation of solid fuels.
Regarding the strategic analysis for the Greek lignites nowadays results to the fact that the lignitic production does not ensure smaller cost of production than the alternative fuels such as the coal and the natural gas. The lignitic production causes bigger environmental repercussions than natural gas and particularly as the emissions CO2 are concerned. It also happens with coal although in smaller degree.
Greek lignites divides into three categories:

- the turf which has intense moisture ,small amount of coal and low heat power(800 – 1.000 kcal/kg).
- lignite which has absence of wood material heat power(1.000 – 2.500 kcal/kg)
- wood-like which consists of wood and has the most heat power(1.500 – 3.000 kcal/kg).

Most Greek lignites are the regular type while turf is 25% and wood-like11%. Greece is second in the E.U. in producing lignites and fifth worldwide.

In 70 regions there are 100 beds of lignites whose size and morphology depend on the size of the bed and their product, while their economic value depends on those sectors and is influenced by tectonic reaction.

Figure 1 shows the most known beds in the country:

1. Ptolemaida-Amyntaio-Florina the Lignitic Center of West Macedonia of the National Electrical Company.
2. Megalopolis
3. Elassonas (beds of Domenico and Amouriou)
4. Drama

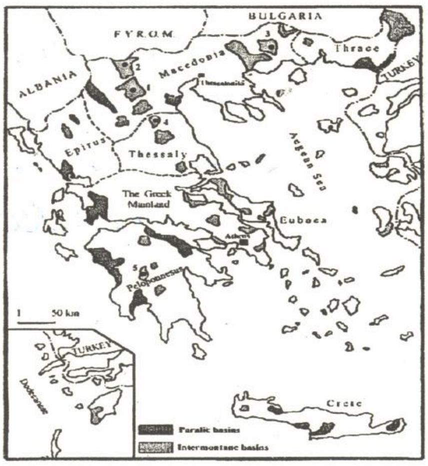

Figure 1, Lignite beds in Greece

Lignite offers safety in supply while at the same time contributes in the regional growth. Thus, the prospect of extension of life of lignitic centres of the region of Ptolemaida and Amyntaio should constitute a fundamental aspect in the policy of lignites.

Natural gas is connected with the energy dependence and consequently its use in generating electricity under the given conditions cannot exceed a certain limit of total generation of electricity. Such limits are forecasted in other countries supplied by one supplier.

The lignitic activity that was developed in the prefecture of Kozani and generally in Western Macedonia, for the energy exploitation of the extensive layer of lignites basin of Ptolemaida, is a national success, as the lignites that is exploited in the L.C.P.A, the NATIONAL ELECTRICAL COMPANY made the biggest achievement which is covering the need of electric energy in our country. With the investments made by the capital, unthinkable for private individuals investors, it has developed the most important energy institution of the country, the layer of Ptolemaida , which in the last five years has covered the 60% of the need in electric energy, that allowed the promotion of electrification up to the last village of the Greek territory and with the lowest price for the domestic use in the European Union.

Our main strategy should be that the lignites is the main fuel that might ensure the electric sufficiency of the country and there should be developed such politics that offer availability in the mining resource, as to achieve the elongation of exhaustion.

All industrial uses of lignite require upstream fuel drying. Owing to the high amount of water to be removed, lignite drying is a process that needs a lot of energy. This is why energy efficiency is of great significance here. In Creek's conventional lignite-fired power plants , lignite is dried by hot flue gases which are recirculated from the steam boiler at temperatures between 900 and 1,000° C. Decoupling of the combined milldrying process applied so far allows drying at low temperature levels in an exergetically more efficient way and, hence, helps to achieve a substantial

increase in overall power plant process efficiency.

For so-called low-rank coals, which are not only characterized by high moisture contents but also have high ash contents, the calorific value can be raised by predrying to such an extent that these coals can be used for combustion in conventional steam boillers without needing back-up fuels.

2 Process fundamentals

The WTA (Wirbelschicht Trocknung mit interner Abwarmenutzung) technology is based on the principle of a stationary fluidized bed with low expansion. The energy required for drying is supplied via heat exchangers that are integrated in the fluidized-bed drier and heated with steam. Drying takes place in quasi 100% pure steam which is slightly superheated. At constant pressure, equilibrium is reached –depending on the steam temperature – between the steam temperature and the residual moisture of

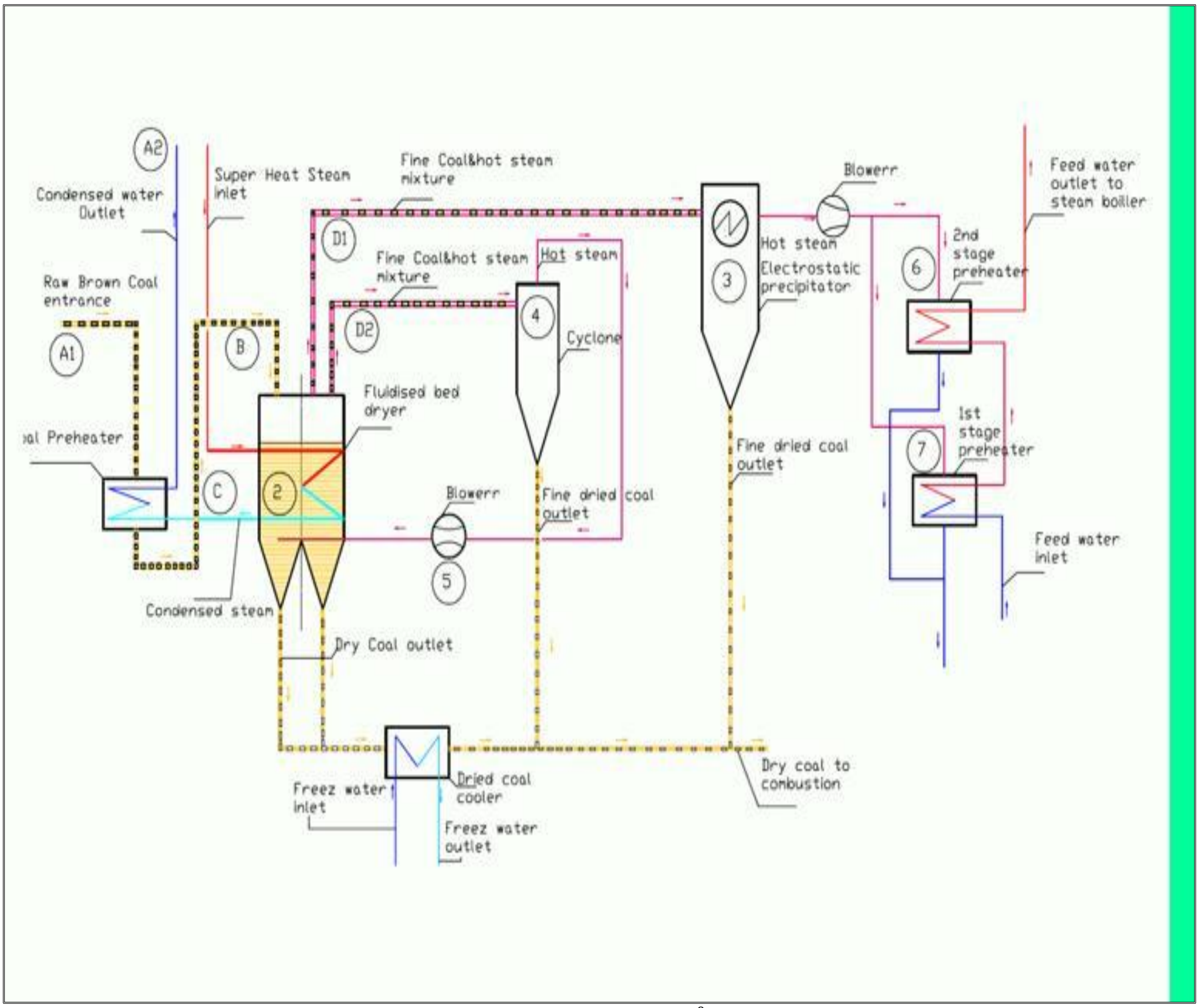

Figure 2, WTA-dryer especially in a Greek lignites power plants general description

the dried lignite. By controlling the fluidized-bed temperature, the moisture content can be adjusted andmaintained constant at the desired value.

2.1 Fluidized bed drying with internal waste heat utilization and feed-water preheating

The operation concept of this technique, whish has been developed by Rheinbraun and is originally called WTA (Wirbelschicht Trocknung mit interner Abwarmenutzung) , one variation whish can be use in the Greek lignites power plants can be see in fig.1.

After the raw brown coal (A1) has been preheated at 65^{0}C in a heat exchanger (coal preheater 1) with the help of condensed water (C) from the drying process of the previous charge, it is inserted into the dryer (2). It is fluidised at 100 ^{0}C under the influence of lightly superheat (about p=1.3 bar and ts=130 ^{0}C .This is the data of present calculations) steam (A_2). The main part of heat needed for the moisture heating and evaporation is provided by pressurized steam from the drying of the previous charge in a heat exchanger. The steam, whish is used for the fluidization, also contributes to the evaporation of fuel moisture. After being cleaned in an E-precipitator (D_1) and in an cyclone (D_2). The evaporated moisture of the cyclone is fed into the steam compressor (5), where its temperature is increased from 100 up 150 ^{0}C (130 ^{0}C in the dada calculations) by compression up to 0.4-0.5 MPa. A small part of this evaporated moisture is used as a fluidization medium. In the present variation of WTA technology, the compressed vapor whish come out of the E-precipitator condensing into the 1st stage (6) and the 2nd stage (7) heat exchanger to preheat the steam boiler feet-water.

2.2 Nomeclature-Operation Tables

In a pilot plant, whish has been in operation since 1993 over 1300 h in Frechen, Germany, 50,000t of raw brown coal have been successfully dried. This confirms the operation suitability and integration capability of the dryer to a power plant process. The operation data of this pilot plant are given in table 1

Nomenclature

dpi middle diameter Brown coal μm
pg Brown coal density kg.m^{-3}
$\dot{m}k$ Raw brown coal capacity kg.m^{-3}
V_{coal} Volume of brown coal m^3
e Bead porous
V_{bead} Bead volume m^3
e_{mf} minimum bead porous
ps Steam pressure bar
ts Steam temperature ^0C
$\dot{m}$ mass of steam kg.s^{-1}
psh Super heat steam density kg.m^{-3}
$\dot{V}$ Super heat steam volume $m^3.s^{-1}$
h_{sh} Super heat steam enthalpy KJ.kg^{-1}
n_{sh} Dynamic viscosity of super heat steam kg.$m^{-1}.s^{-1}$
L.C.P.A Lignite Centre of Ptolemaida Aminteo

Greek symbols
v_{sh} kinematic viscosity of super heat steam $m^2.s^{-1}$
Φ sphericity

Figure 3, Nomeclature

Particle size of raw brown coal	0-6mm
Raw brown coal capacity	53 t/h
Drying capacity	27 t/h
Moisture removed	26 t/h
Specified consumption of	110 kWh/t H_20
Electric power	

Table 1 Operation dada of the WTA drying pilot plant

The operation data which can be use in the Greek lignites power plants of the present application are given in table 2.

Middle diameter of brown coal 1000X10^{-6} μm
Brown coal density 840 kgm-^{3}
Brown coal sphericity 0.73
Raw brown coal capacity 133 kg.s^{-1}
Mass of brown coal 718,200 kg
Volume of brown coal 855 m^3

Table 2 Operation dada of WTA especially in a Greek lignites power plants

3 Flue-dynamics procedures and modeling calculations

Input data of present calculations	values	units
Middle diameter of brown coal d_{pi}	1000.10^{-6}	mm
Brown coal density ρ_g	840	$m^3.kg^{-1}$
Brown coal sphericity Φ	0.73	
Raw brown coal capacity $\dot{m}_k$	133	kg.s^{-1}
Bead porous e	0.4	
Fluid fluidization	Lightly superheat steam	
Superheat steam pressure p_s	1.3	bar
Superheat steam temperature t_s	130	^0C
mass of superheat steam $\dot{m}$	62.36	Kg.s^{-1}

Table 4, Input data of present calculations

Data of Brown coal drying fluidized bed specialized for Greek power plants

Output results of present calculations	values	units
Bead volume V_{bead}	1,425	m^3
Minimum bead porous e_{mf}	0.2880	
Superheat density ρ_{sh}	0.7080	$kg.m^{-3}$
Super heat steam volume $\dot{V}$	88.08	$m^3.s^{-1}$
Especially enthalpy Superheat steam h_{sh}	2,734	$KJ.kg^{-1}$
Dynamic viscosity Superheat steam $_{nsh}$	$1.4640.10^{-5}$	$kg.m^{-1}.s^{-1}$
Kinematic viscosity Superheat steam v_{sh}	$2.0679.10^{-5}$	$m^2.s^{-1}$
Start fluidized velocity u_{mf}	0.0918	$m.s^{-1}$
Characteristic bed length m	$4.0449.10^{-4}$	m
Visible bead velocity u	0.3188	$m.s^{-1}$
Reynolds number Re	4.4406	
Bubbling fluidization Start velocity u_{mb}	0.0970	$m.s^{-1}$
Sweep away velocity u_t	31.244	$m.s^{-1}$
Operation velocity bead u_f	0.4591	$m.s^{-1}$
Fluidized bead area S	191.84	m^2
Bead height L_{bead}	7.4278	m
Bead height for the minimum Bead porous L_{mf}	6.2594	m
Minimum fluidization Pressure drop Δp_{mf}	0.3674	bar

Table 5 Results of Brown coal drying fluidized bed specialized for Greek power plants

3. Discussion

According to the results of table 5 we observe that the bed which is discussed ,doesn't work as a steady bed because u_{mf} isn't bigger than u [Peters and Fan, Design of Gas-Solid Catalytic Fluidized Bed Reactors, CACHE Corp. Module DES59i ,1983], and because $u_{mf} \neq u$. We observe that it functions as a Fluidized bed with bubbling because $u > u_{mb}$. Also we don't have mental convection because u isn't bigger than u_t u [Peters and Fan, Design of Gas-Solid Catalytic Fluidized Bed Reactors, CACHE Corp. Module DES59i ,1983 and Yerushalmi and Avidan in fluidization, 2d ed]

The minimum price of bead porous e_{mf} seems little. The effect of pressure concludes in the light raise of e_{mf} . As for the u_{mf} it seems small too, but u_{mf} is the ostensible velocity that counts on the blunt column. The velocity of the gaps of those small particles will be bigger, and the width between velocities u_{mf} and u_t is great since $u_t / u_{mf} = 31.244/0.0918 = 340.34$.

We conclude that the washed beds have advantages comparing with the steady beds. The small particles used in washed beds provides a large surface for a certain amount of solid goods . As a result of a great external reaction heat and mass are transported. Also the small size reduces the opposition of the diffusion of mass in the particle.The fast mix of solid and fluid in the washed bed leads to an equal temperature in the bed and high transport of heat among fluid and wall. All the test cases characteristics, when applying fuel pre-drying a reduction of the fuel consumption of about 20% wt can be achieved. If bled steam is to be used the selected pressure should be the lowest possible one. The same conclusions for the pressure influence on the plant efficiency holds true in the case, where the evaporated moisture is exploited in the drying process itself (WTA). The WTA methods have been proven to be the most efficient drying techniques.

The dryer performance depends strongly on the feed conditions and particle properties.

Until now there has been no efficient way to draw a large scale of fluidization. The escalation of the problems in fluidization is a serious trouble.Therefore a well-organized programming is essential of the distributors of fluid that insert the gas in the solid bed.

Finally in Greece, the examined novel pre-drying technologies could also be applied in order to produce pre-drying lignite, which is then used as an alternative supportive fuel to the main lignite, thus meeting the basic fuel specifications for the thermal power plant. According to a PPC (Public Power Corporation of Greece) study, the replacement of the currently used xylitic brown coal, bituminous coal or diesel oil seems to be a technically feasible and economically viable. The conclusions are not restricted to Greek brown coal but they are extended to similar Central and Eastern European brown coals where this fuel type is obviously a competitive feedstock.

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