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Review article

Report on comparison among current industrial scale lignite drying technologies (A critical review of current technologies)

Nikolaos Nikolopoulos [a], Ioannis Violidakis [a,*], Emmanouil Karampinis [a], Michalis Agraniotis [b], Christian Bergins [b], Panagiotis Grammelis [a], Emmanouil Kakaras [a,b,c,1]

[a] Centre for Research & Technology Hellas/Chemical Process and Energy Resources Institute (CERTH/CPERI), 4th km. N.R. Ptolemais-Mpodosakeio, GR-50200 Ptolemais, Greece
[b] Mitsubishi Hitachi Power Systems Europe GmbH, Schifferstraße 80, 47059 Duisburg, Germany
[c] Laboratory of Steam Boilers and Thermal Plants, Thermal Engineering Sector, School of Mechanical Engineering, NTUA, 9th Heroon Polytechniou Str., Zografou Campus, GR-15780 Athens, Greece

HIGHLIGHTS

- Report of different types of dryers, both evaporative and non-evaporative.
- Comparison of technical characteristics of main dryer types.
- Report of existing drying applications in large power plants.

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ABSTRACT

Lignite constitutes a major energy source and has long been used for energy production despite its contribution in greenhouse gas (GHG) emissions, as a fossil fuel. For example, 27.4% of Germany's electricity originates from lignite power plants, while in Greece more than 55% of its electric energy consumption is provided by lignite. 45% of the total global coal reserves consist of low-rank coals (LRCs) such as lignite. With this background, the utilization of lignite for energy production is expected to remain a common practice in the decades to come since the availability of lignite is considerable in many countries of Europe and the world (e.g. Germany, Poland, Greece, USA, and Australia). Therefore, problems regarding the combustion and use of lignite should be addressed in a more efficient and environmentally friendly way. One of the main existing problems is the high moisture contained in raw lignite as received from the mine. The high moisture content results in higher CO_2 emissions per unit of energy produced and is responsible for high capital and transport costs as well as other technical problems such as reduction in coal friability and difficulties in its blending and pneumatic transportation. Therefore, processing of lignite through drying is considered of great interest in the implementation of energy production in lignite power plants. Taking into account the significance of the subject and the usefulness of such an attempt, an overview of the currently existing drying technologies, including both evaporative and non-evaporative drying methods is reported in the present paper.

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* Corresponding author at: 52, Egialias Str., GR-15235 Maroussi, Greece.
E-mail address: violidakis@certh.gr (I. Violidakis).
[1] Tel.: +30 210 7723604.

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1. Introduction

Lignite is considered the lowest rank of coal due to its high moisture and ash content and its low carbon content. Low-rank coals (LRCs) constitute about 45% of the total global coal reserves [1]. The combustion of lignite in power plants is widespread in many countries (Australia, the United States, Canada, India, Germany, Greece, Poland, Serbia, Russia, and many other parts of Europe). 27.4% of Germany's electricity originates from lignite power plants [2], while in Greece more than 55% of its electric energy consumption is provided by lignite (Fig. 1) [3].

The high moisture content of lignite is a major issue in terms of its commercial utilization. High moisture means a decreased heating value and, as a result a lower energy density. Therefore, the high moisture content of lignite lowers the plant efficiency, leads to higher CO_2 emissions per unit of energy output and increases the capital costs due to larger size of lignite boilers compared with the current state of the art hard coal fired boilers. Moreover, due to the high moisture content, it is economically not feasible to transport lignite over larger distances, as is the case with hard coal, and for this reason lignite power plants are typically located at or very close to lignite mines. Drying and pulverization is therefore required in the large scale applications, in order to assure efficient ignition and stable combustion of lignite. The impact of moisture content on the efficiency of coal fired power plants is depicted in Fig. 2. In addition, the presence of moisture also causes reduction in coal friability and impose serious difficulties in its feeding behavior, blending and pneumatic transportation.

On the other hand, lignite can offer many advantages such as low mining cost, high reactivity, high amount of volatiles and low pollution-forming impurities such as sulfur, nitrogen and heavy metals. For these reasons, the utilization of lignite in the power sector is still relevant and is expected to grow in the coming decades in a global level.

The lignite pre-drying concept is a step toward optimal lignite utilization and upgrade. Decreasing the amount of moisture in LRC leads to lower energy losses during combustion, lower flue gas mass flow, higher plant efficiency, low transportation cost, but increases the safety measures for their transportation and storage, etc. [1], owed to their higher risk for self-ignition.

2. Drying process

For each material, there is a representative curve, the drying curve, which describes the drying characteristics for that material at specific temperature, velocity and pressure conditions. The drying curve can be derived if the rate of moisture loss is plotted against time, for a sample of the material exposed to the drying medium at controlled constant conditions. The exact curve shape and values representing the drying rate always varies with (a) the velocity of the drying medium, (b) the heating medium temperature, (c) the particles size distribution (PSD), and the (d) the particles' own structure characteristics (e.g. pore size and distribution).

There is an initial period during which the material heats up and the drying rate increases. This is followed by a period of constant drying rate, the constant rate period, during which diffusion