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CLASSIFICATION AND COMPARISON OF FLUIDIZED BED USED IN THE OXI – COMBUSTION PROCESS OF MINERAL COAL

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Abstract. *Fluidized bed technology, together with oxy-combustion, significantly reduces pollutant emissions in the coal burning process for power generation, as well as providing a higher heat output and enabling the use of low calorific power, as it is the case of Brazilian coal. By reducing levels of pollution, it is possible to use coal more sustainably as a source of energy, thus benefiting from its abundant existing reserve. The objective of the project is to classify and compare the fluidized beds used in the oxy-combustion process of coal, showing how they work, pointing out the characteristics of each model, seeking to achieve the conditions for maximum emission reduction and a higher calorific efficiency. The methods used are based on the literature review of published scientific articles on the subject, in order to carry out the survey of the necessary experimental data for the analysis and comparisons. Regarding the results, a complete study of the fluidized bed technology was carried out; an analysis of the operation of different types of bed was obtained, as well as a comparison between them, indicating the advantages and disadvantages and the one that presents the best efficiency for a certain operating condition; the combustion efficiency and the reduction of the pollutant emissions in the burning process were also analyzed, identifying the parameters that influence the satisfactory yield of these factors.*

Keywords: *fluidized bed, oxy-combustion, mineral coal.*

1. INTRODUCTION

One of the current issues is the need for a change in the world energy matrix, in order to reduce the use of fossil fuels and increase the exploitation of renewable resources, so that there is a reduction in the emission levels of polluting gases in the atmosphere, in order to mitigate the impacts of the greenhouse effect. However, this transition from one energy model to another is not as easy to perform as it is related to several factors, especially in relation to the dependence on some current sources of energy, which have a large participation in the supply of energy global demand. Coal is one of the energy sources that the world currently depends on, and it is one of the types of fossil fuel that emits harmful gases when burned, which does not give it much acceptance and confidence in the sustainable energy scenario. However, it has advantages on the world stage for the generation of energy that makes its use difficult to put aside so quickly. In addition to being an inexpensive source of energy when compared to other sources, coal has an abundant natural reserve, about 860 billion life-span of 109 years, according to studies made by Araújo (2014), which would guarantee its participation in the global energy matrix for many years yet. About the existing deposits, 75% are concentrated in five countries: the United States, China, Russia, Australia and India, which are also the largest producers of coal. Brazil presented an 11.7% increase in its production in 2013, reflecting water scarcity in the regions

producing hydroelectric energy, which shows that, despite the existing environmental pressures, dependence on coal continues and increases in the course of time (Araújo, 2014). However, the major problem with coal is its burning, which is necessary for the generation of electricity through steam, which releases polluting gases into the atmosphere, where the main one is carbon dioxide (CO₂), the largest responsible for the greenhouse effect. One of the solutions found to reduce emissions of pollutants without breaking this huge dependence on power generation is the development of new technologies that allow the use of coal and at the same time reduce the generation of pollutants. In this context, techniques such as oxy-combustion and fluidized beds have grown.

Oxy-combustion is a process that consists in the elimination of the N₂ present in the oxidant used to burn coal in the boiler. For this, an air separator system is added to the thermolectric plant, which eliminates the non-combustion gases for combustion, leaving the oxidant with a higher concentration of oxygen. As result, an increase in the efficiency of the burning of the coal is achieved and the emission of pollutants decreases, because with the oxidant more pure in oxygen, the product of the combustion consists only in water and carbon dioxide, which can be collected and stored before being released into the atmosphere. Fluidized bed technology is based on different types of boilers which, through the use of a fluidization system in the burning of coal, are able to work at lower temperatures than conventional boilers, increasing the efficiency of the combustion process of coal, besides reducing levels of pollution and allowing the use of low-calorie coals. According to ANEEL (National Agency of Electric Energy), the reduction of gases derived from sulfur and NO_x gases is quite significant in the fluidized beds, and can reach the 80% range using the desulfurization process, which consists in the addition of calcium in the atmosphere of oxy-combustion to realize the absorption of the gas sulfur produced during the coal burning.

This work will deal with two types of fluidized beds used in the oxy-combustion of coal, circulating beds and bubbling beds, in order to show their respective advantages, disadvantages and functions. The objective is to make a comparison between each type of bed and classify them according to their efficiencies and yields. The research method used was a literature review of the main articles published in the area of oxy-combustion applied in fluidized beds, which covered several studies carried out on the subject in recent years.

By conducting tests with Victorian coal in a fluidized bed under a regime of small-scale oxy-combustion, Roy and Bhattacharya (2013) analyzed that, the concentration of CO₂ in the gases released by the combustion of the coal decreases with the increase of the concentration of O₂ in the atmosphere of burning (oxy-combustion process), as it increases with the elevation of the bed temperature. Lappalainen (2014) performed simulation modeling experiments in a supercritical fluidized bed boiler circulating with the use of oxy-combustion technology. The study evaluated operational issues in the fluidized bed with the alternation of the burning mode, where one is made with conventional atmospheric air, and the other burns in the oxy-combustion mode, in order to analyze the performance of the system. With the results obtained, it was observed that the switching mode comprehensively affects the composition capacity, the density and the heat of the flue gases, which induce changes in the heat transfer, in the operational aspects, as well as in the requirements. Lupiáñez et al. (2016) carried out a study of the burning of the coal / biomass mixture under oxy-combustion conditions in a fluidized bed, in order to analyze how this addition of biomass to coal modifies operational factors such as emission of pollutants and deposition. In the experiments, the anthracite coal and the rice straw (as biomass) were used as fuels. From the results, it was observed that the emission of SO₂ is directly linked to the amount of chlorine present in the biomass burned, the higher the chlorine emission the lower the emission, and the NO_x emission is more strongly related to the operating conditions of the bed, such as excess oxygen in the system, similar to conventional combustion. When using the oxy-combustion conditions, it is observed that the amount of chlorine in the ashes increases, and the rates of deposition suffers little change, although a more pronounced deposition is detected in the biomass burning with low chlorine content. Calcium and potassium sulphates are found in the deposition of the mixture, which minimizes the corrosion caused by chlorine. If limestone is added to the bed for desulphurisation, SO₂ emission rates can be further reduced. Balicki and Bartela (2014) proposed the analysis of the influence of the change of two primordial values for the oxy-combustion process in the circulating fluidized bed: the oxygen fraction in the oxidant produced by the air separation unit (ASU) and the oxygen oxidizing agent supplied to the bed combustion chamber, this on selected characteristics of a steam boiler. These analyzed plot values significantly affect the design and performance of the basic components that make up the oxy-combustion system. An organization of the process and the reduction of the volume of the exhaust gases would allow a reduction of the dimensions of the boiler, which would, however, cause a significant increase in the temperature of the bed. Balicki and Bartela (2014) also observed that with the increase of the oxygen percentage in the oxidant supplied to the boiler, there is an increase in temperature from 1220 to 1870 ° C and an increase in the heat output of the burning process, due to the reduction of heat losses which is a direct consequence of the reduction of the volume of exhaust gases released.

2. CIRCULATING FLUIDIZED BED

The most widely used and currently tested fluidized bed model is the circulating fluidized bed. Numerous and varied tests have been carried out in scientific studies using plants of this type of bed, and its advantages and benefits have been clearly demonstrated in order to enable its industrial application in the combustion of solid fuels. The process of operating the circulating fluidized bed is described below, being shown in sequence (numbering) in Fig. 1

below, as presented by Moura et. al (2014) in his work. Solid coal particles are introduced into the bed (1) and acquire the determined flow velocity for the fluid, which is introduced immediately after (2); the fluid then charges the particles along the riser to where they combust until they reach the top of the bed 3; at the top, the carbon particles are separated from the fluid by the cyclone (4), the gas is withdrawn from the bed through an outlet at the top (5) and those particles which have not yet been fully burned and are of sufficient diameter to suffer combustion again are redirected to the bed base 6, where they pass through the standpipe and the L-valve 7, which recirculates the particles back into the riser 8. Thus, the process functions as a cycle, withdrawing as much heat as possible from the fuel.

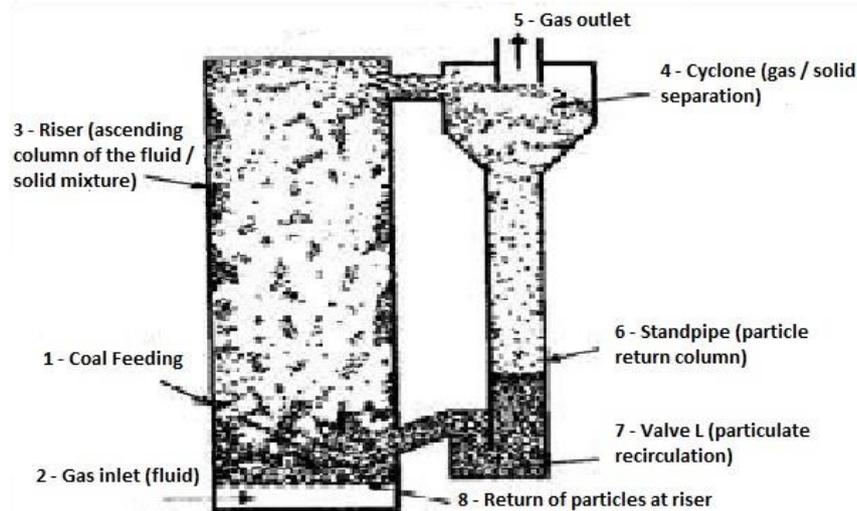


Figure 1 - Representation of the oxy-combustion process in a circulating fluidized bed plant (modified by Moura et al, 2011).

The main variable influencing the performance and proper functioning of the circulating system is the fluidization rate, which is the rate at which the fluid carrying the particles is injected into the boiler, which can be controlled according to the required conditions. For a higher speed there is a more uniform distribution of the fuel particles inside the combustion chamber, as well as a lower drop in total system pressure.

The circulating fluidized beds have the capacity to reduce between 70 and 80% of the emission of sulfur oxides (SO_x) and nitrogen oxides (NO_x) gases, which are the most harmful when released to the environment. The reduction of the emission rates of SO_x gases occurs through a specific process called desulphurisation, which consists in introducing limestone (CaCO₃) into the bed during the combustion process. This limestone has the function of absorbing the sulfur oxides formed in the burning, and at the end of the process, it is removed from the bed as solid tailings, which avoids the emission of sulfur in the form of gas in the atmosphere. The desulphurization efficiency is higher when high concentrations of O₂ are used in the oxy-combustion of the coal. The gases generated in the burning recirculation in the system favors the removal of the sulfur formed, because the SO₂ stays longer inside the bed and, thus, the reaction time with the limestone also becomes bigger, which increases the efficiency in the reduction of the emissions. Furthermore, with the use of a specific and fixed value of Ca/S molar ratio (limestone to sulfur) an ideal temperature can be reached for a high efficiency of the sulfur capture process, in the range of 880 to 890 ° C.

Li et al., (2014) conducted a survey of the combustion and emission characteristics of pollutants by testing in a circulating fluidized bed plant. O₂/N₂, O₂/CO₂ and O₂/RFG (gas recycling) were analyzed in three different types of burn modes: O₂/N₂, O₂/CO₂ and O₂/RFG of combustion). The solid fuel used in the combustion was Dalton type coal and for desulphurisation, limestone particles (CaCO₃). Eight tests were performed under different system conditions, such as exhaust emissions (CO₂, CO, SO₂, and NO_x), conversion rates and sulfur capture (desulphurisation) were monitored and presented as a result of the study. The average temperature during the tests was 850 ° C; the fluidization velocity at the bottom of the bed was between 3.85 and 4.47 m/s; the average oxygen concentration in the combustion atmosphere was between 46.4 and 54.6%. From the obtained results, it was highlighted that the sulfur capture efficiency increases with the respective increase Ca/S molar ratio.

Gómez et al. (2014) developed a study analysing SO₂ emissions under different oxy-combustion and conventional combustion conditions in a circulating fluidized bed boiler. In the tests, factors such as the composition of limestone used as sulfur dioxide absorbent (desulphurisation process), the molar ratio between calcium (Ca) and sulfur (S) and bed temperature during fuel burning were considered in the tests. The results obtained were compared with those obtained with conventional combustion in order to analyze the difference obtained in relation to the emissions. It was verified that when the operation is carried out under an oxy-combustion atmosphere, the sulfur capture efficiency is higher in relation to the same conventional combustion process, which is justified by the recycling of the combustion

gases, that cause the SO₂ to remain longer inside the boiler, and intensifies the reactions with the limestone. In conventional combustion, sulfur capture improves at lower temperatures. For a molar ratio (Ca/S) greater than 2.6, there is almost no better capture when compared to the two burning modes. It was also observed that for the anthracite-type coal tests, when the molar ratio is set to a specific value, an ideal temperature for efficient capture of the sulfur, in the range of 880 to 890 ° C, is achieved.

The molar concentration of oxygen in the burning atmosphere is another important factor. When the O₂ concentration in the circulating fluidized bed combustion atmosphere is raised, by changing the existing O₂/CO₂ molar ratio, an increase in the operating temperature is achieved, which consequently increases the combustion efficiency. When the oxygen concentration is increased without adding limestone to perform desulphurisation, a reduction in CO emissions is observed. However, in some cases, high oxygen concentration may harm the power generation process. This is because when the amount of oxygen present in the oxidant that is supplied to the combustion chamber increases, the temperature inside the bed also changes, presenting an expressive increase, being in the range of 1220 to 1870 ° C. This temperature rise can cause problems with the material, in which the circulating fluidized bed is manufactured, not being able to withstand all this heating and to suffer malfunctions. In addition, when this concentration is increased without the addition of calcareous in the bed for desulphurisation, there is an increase in the SO₂ and NO gas emissions.

Duan et al., (2011) tested two types of Chinese coal, a bituminous and another anthracite, performing a survey of operational characteristics such as temperature distribution profiles, combustion efficiency, pollutant emissions and system desulfurization, and discussed the effects atmosphere and the oxygen state during the burning process. Duan et al., (2011) used a circulating fluidized bed plant of 50 KW of power, which has operation in both conventional combustion conditions and O₂/CO₂ atmospheres, enriched with oxygen. The results showed that with the increase of the oxygen concentration in the burning atmosphere an elevation of the temperature level rises in the upward tube of fluidized particles, a factor that generates an improvement in the heat output of the combustion. When limestone was not added to the bed to perform the desulphurisation, it was observed that the oxygen enrichment in the combustion causes an increase in SO₂ and NO emissions, but it reduces CO emission. However, it was found that the desulphurization efficiency is higher with high concentrations of oxygen, when with the same amount of limestone added to the bed. From the effects of the oxygen stage on combustion, there is a greater operational flexibility in relation to the type of fuel to be burned in the circulating fluidized bed, as well as the possibility of reducing NO emissions.

In the present study, Czakiert et al. (2010) performed the adaptation of a circulating fluidized bed boiler to operate in an oxy-combustion atmosphere in order to analyze the conversion rates of carbon (C), sulfur (S) and nitrogen (N₂) in CO, SO₂ and NO_x, through the burning of coal of the bituminous type. In the tests carried out, it has been observed that for higher fluidization speeds a more even distribution of the fuel particles inside the bed is observed, and that the system pressure drop is reduced at higher operating speeds. In addition, a spike in temperature was recorded when the oxygen concentration varied between 21 and 28%, due to the increase of the charge in the combustion chamber with a high partial pressure, since the rate of excess oxygen remained constant. The nitrogen conversion rate was below 20% in all tests, but a higher conversion of N₂ to NO_x gases occurred, related to the increase in excess oxygen in the boiler. It was verified that the concentration of oxygen in the system is the main factor in the control of the formation of the NO_x gases. In relation to sulfur, the conversion rates were high, which exceeded the value of 85%, where most was by the formation of SO₂ during oxy-combustion. On the other hand, it was verified that with the increase of the temperature of the system, a reduction of the conversion of the sulfur is obtained, in the same way as if the excess of oxygen in the boiler is high, the sulfur undergoes direct conversion to SO₃, which is a much less harmful form of gas (Czakiert et al., 2010).

The operation of the fluidized beds is characterized for occurring at lower and uniform temperatures in relation to the other combustion boilers, concentrating in a range of 800 ° C. The uniformity of the temperature coupled with the system's constant and cyclical operation provides a greater flexibility of fuels that can be burned, which includes even the lower-caliber carbons such as peat (calorific value between 3000 and 5000 kcal/kg) and lignite (4550 kcal/kg, on average). The set of characteristics of the circulating fluidized bed, in general, increases the efficiency of the combustion process of the coal, which implies a greater amount of heat supplied to the system, and thus raises the energy production rates in the thermoelectric plants.

3. BOILING FLUIDIZED BED

Bubbling fluidized beds are characterized for being unstable, with regular bubble formation. The upward movement of these bubbles favors the movement and flow of the particles in the bed in an intense manner. They have as a characteristic the presence of inert material on the entire surface of the burner, which favors the mixing of the particles and ensures a uniform temperature in the furnace. The bubbling beds have high thermal capacity and intense heat transfer, which allows a fast and safe ignition of the most varied types of mineral coal, with high and low reactivity values, characterizing a high flexibility of fuels. This flexibility also applies to coals that have high moisture indices, up to 60%. The average operating temperature is low, between 800 and 900 ° C, lower than ash melting point, a factor that prevents dirt or obstruction of the bed surface problems. Emission levels of pollutants are low in processes in bubbling

beds, retention of noxious gases such as NO_x and SO₂ can reach 95% with the use of caustic soda in bed in correct molar ratios.

When oxy-combustion is used in the bubbling beds, the heat output from the burning of the coal is significantly increased, as well as reducing the emission rates of pollutants and increasing the rate of heat transfer inside the bed, due to the high contents of CO₂ and H₂O found in the oxy-combustion product.

In Fig. 2 below, it is shown an illustrative scheme of a bubbling fluidized bed, according to Almeida, 2016, and the steps of the oxy-combustion process of the coal therein. The indication (arrow) of number 1 represents the addition of the coal to the bed to undergo the firing. In 2, the upward flow of gas for bed fluidization and oxy-combustion performance is represented, this flow of gas in the bubbling beds is in the form of bubbles, which guarantee the continuous circulation of the coal particles. The gas phase reaction is indicated at 3, which represents the chemical burning process of the coal, oxy-combustion, the stage of the process in which the exhaust gases are released. In 4, the ashes are deposited, which are the remains of the coal after burning. The grid, one of the components of the bubbling bed which is shown in Fig. 2, plays an important role in the process. The application of the grid consists in determining the minimum diameter of the particles to be burned, ie, particles with a diameter greater than the apertures of the grid undergo the oxy-combustion until they reach the same diameter of these apertures, reaching this minimum diameter, they leave the and are deposited on the bottom of the bed (4) in the form of ash.

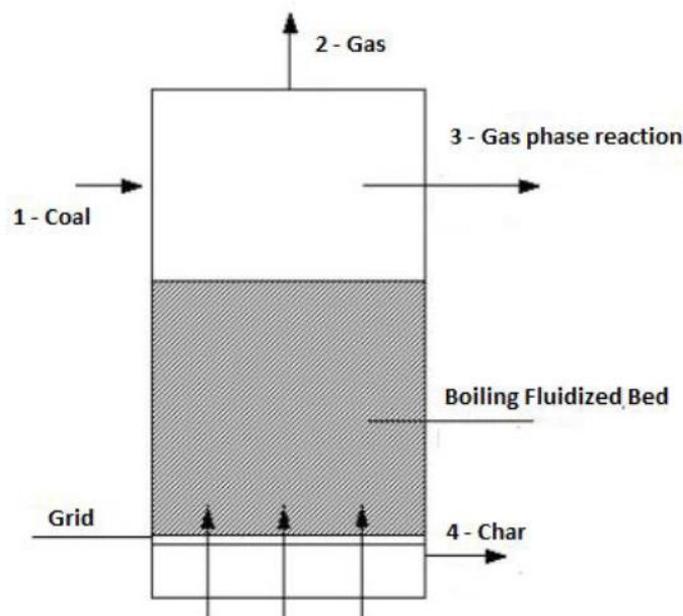


Figure 2 - Representation of the oxy-combustion process in a bubbling fluidized bed plant (modified from Almeida, 2016).

Díez (2015), in a scientific work by the University of Zaragoza, Spain, carried out an experimental study for the characterization of anthracite-type Spanish mineral coal, which involved the essential burning factors for the generation of energy: combustion efficiency, heat and emission of pollutants. A 90 kW_{th} bubble-bed reactor with oxy-combustion installation was used for the tests. The fuel used in the experiment (Spanish anthracite) has a low amount of volatile compounds, which made it necessary to search for ideal fluidized bed conditions to maximize the burning of coal and to avoid high rates of unburned carbon. For this, variations of the oxygen concentration (O₂) in the bed atmosphere and the fluidization velocity were made. The results were satisfactory. The heat output of the combustion is improved when the oxy-combustion and the rate of heat transfer by radiation increase. For SO₂ emissions, minimum values are found under the richest atmosphere of O₂ and in the temperature range of 880 to 990 °C the highest gas capture rates occur, also the reduction of NO_x emissions is observed.

Another interesting and very advantageous advantage of bubbling fluidized beds is the ability to burn two types of different fuels in the same oxy-combustion process (Lupiañez et al., 2016). It would be the case, for example, of using coal and biomass in the same burning, or else, burning only biomass in one process, and only coal in another. This feature allows the installation of small thermal power plants capable of operating with the most available and economically advantageous type of fuel according to the region and the time of year, in addition to allowing the storage of the generated energy, which represents a great economic gain power generation.

As disadvantages, the bubbling beds operate with limited thermal load, as the thermal load per section of the bed is low, due to the need of several fuel feed points (coal) along the burner. During the oxy-combustion process, the mixture

of the particles with the oxidant is low on the side of the bed, corresponding to about half the level of the mixture vertically.

When it comes to the adaptation of a bubbling fluid bed plant to operate under oxy-combustion conditions, it is difficult to establish positive pressure within the bed. The problem is in the correct design of the suction fan of the gases, without this precise design it is not possible to establish the necessary atmosphere conditions to carry out the oxy-combustion of the coal, because with negative pressure atmospheric air enters the system.

Zen (2011) presented the changes made in a pilot plant of bubbling fluidized bed of conventional combustion of 25MW, to enable the implantation of the oxy-combustion in the process of burning. Through the tests, flow characteristics that required a new system modeling design were identified, with the need to eliminate negative pressure points. The results were not very satisfactory. The suction fan led to the occurrence of false air intake from the system due to the negative pressure that was generated. Even with the establishment of positive pressure, air infiltration continued due to the high requirement of the fan responsible for gas suction. Therefore, it was not possible to achieve an atmosphere of O₂/CO₂ in the fluidized bed feed gases, which did not allow the obtaining of oxy-combustion typical atmospheres. The high levels of CO₂ and H₂O in the exhaust gases (a direct consequence of the oxy-combustion process) resulted in a high emissivity, which led to an increase in the rate of heat transfer through radiation. The volume of the gases generated was reduced by about 80% and a reduction in NO_x gas formation was also observed.

4. COMPARISON BETWEEN ANALYZED FLUIDIZED BED

For a 50 kW circulating fluidized bed boiler in which the desulphurization rates were analyzed, it was shown that the oxygen enrichment in the boiling atmosphere of the boiler rises the temperature in the rising column of solid particles (riser) (Balicki and Bartela, 2014). In the present work, it is possible to observe the results obtained for the supercritical boiler of the circulating fluidized bed when the O₂ concentration in the system is increased (Balicki and Bartela, 2014). In relation to the desulphurisation, with the increase of the volumetric fraction of O₂, an increase in the desulphurisation rate is obtained for the same Ca/S molar ratio, ie, the more oxygen present in the combustion the greater the amount of sulfur gas removed from the gases (Li et al., 2014).

Therefore, in order to reduce the pollution generated by the coal-burning process, Li et al. The concentration of oxygen was an essential variable for the two types of analyzed beds (circulating and bubbling) in terms of increasing the efficiency of the burning process and reducing levels of pollution, mainly sulfur through desulphurisation (Duan et al., 2011, Díez, 2015).

Circulating fluidized beds generally have the same operating characteristics and the same parameters that influence the performance of the system. The plants may vary according to the required power and the application in which the circulating fluidized bed is used in the energy industry and may undergo changes in its mechanical structure with the addition of new mechanisms or even interconnection with other systems, such as CO₂ capture and storage unit, for example. They can work in both, conventional combustion and in oxy-combustion mode, which directly implies fuel burning performance levels and pollutant emission rates, both of which are more positive in the oxygen enriched atmosphere mode (Gómez et al., 2014).

The two major fluidized bed models, the circulating, already mentioned, and the bubbling fluidized beds, have similar characteristics to each other, but in some aspects one stands out over the other. The oxy-combustion efficiency is higher in the circulating fluidized beds, because the fuel particles circulate in the system until they are completely burned, that is, until they give all the usable energy they have for oxy-combustion.

Fuel flexibility is a common advantage of both types. In the circulating ones, the uniform temperature and the continuous fluidization allow the maximum withdrawal of energy from the fuel particle, allowing the use of low calorific coals. In the bubbling, the characteristics of high thermal capacity due to the bubble regime and the intense heat transfer ensure the benefit of the energy-poor coals, presenting a very fast ignition in the combustion process. In addition, the bubbling beds still allow the burning of coals with humidity up to 70%, an advantage that is not found in circulating fluidized beds (Santos, 2009).

The operating temperature range in the two models is basically the same, between 800 and 900 ° C, also being characterized for a uniform temperature range during the combustion, which guarantees yield gain and thermal efficiency (Díez, 2015; Gómez et al. al., 2014).

Regarding the pollutant emission rates, the bubbling beds can reduce the pollution generated by coal burning by up to 95%, with the use of caustic soda in the boiler in adequate proportions. In circulating fluidized beds, the process of desulphurisation, which consists in the addition of limestone in the boiler to absorb the sulfur generated by the combustion, helps reducing the pollution levels of the process by about 80%. Both, therefore, present expressive rates of reduction in the emission of the pollutant gases, which can be considered the greatest trunk of the fluidized beds in energy generation by mineral coal, allowing the continuity of the exploration of this mineral resource, that still abundant, in a more sustainable way in industries (Czakiert et al., 2010, Zen, 2011).

Although less widely used and widespread on the market, bubbling fluidized beds have certain advantages over circulating beds, which are already better known and applied. Among these advantages are the possibility of using multi-fuels in the generation of energy, which would be a mixture of two or more different fuels for the same oxy-

combustion, as a mixture of coal and biomass, for example. It is also possible to burn crushed or pulverized particles, obtaining the same heat efficiency larger solid particles (Lupiañez et al., 2016).

5. CONCLUSION

The study of the advantages and disadvantages of the two types of fluidized bed (circulating and bubbling) and the comparison made between them, it was shown that the use of beds in the process of oxy-combustion of coal for the generation of electricity has substantial benefits in terms of oxy-combustion performance and the reduction of the emission of harmful gases into the environment.

In the case of bubbling fluidized beds, the fuel burning energy performance can reach 98% and the emission rate of NO_x and SO₂ gases, which are the most harmful to the environment when released, can be reduced by up to 95%. The operating temperature range of both circulating and bubbling beds is characterized by being uniform and low, not exceeding 900 °C.

Fuel flexibility, or the possibility of using various types of fuel with both high and low heat powers, is also a common factor among fluidized beds. This feature is very relevant in the Brazilian scenario, since the existing coal reserves are mostly composed of low calorific coal, so the fluidized bed technology becomes a viable alternative to generate energy in the country through this mineral resource.

The oxygen concentration in the combustion chamber of the circulating fluidized beds proved to be the determining factor for regulating the amount of NO_x gas that is generated in the burning of the coal, as well as to increase the burning performance and the boiler temperature.

For circulating fluidized beds, the fluidization velocity and the oxygen concentration of the combustion atmosphere are the essential factors for the control of the operation and the bed efficiency, the emissions of pollutants can be reduced by up to 80%, depending on the conditions of operation; the process of desulphurisation is the circulating beds great advantage, since it consists of a simple and efficient mechanism to contain the emission of SO₂ gas.

In the comparison between the two main models of circulating and bubbling beds, many characteristics and advantages were found in a similar way for both. However, although still less known and less used in the industrial market, the bubbling bed had certain advantages over circulating beds, such as the possibility of using a mixture of two different fuels (coal and biomass) in the generation of energy and allowing the burning of crushed or even pulverized particles of coal.

Given the above, it can be stated that the industrial use of fluidized beds for the process of generating electricity in thermoelectric plants by means of oxy-combustion of coal is an entirely viable and advantageous alternative to guarantee the continuity of the participation of this fuel fossil in the world energy matrix, since the great problem that is the polluting gases emission can be significantly softened.

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