A Sustainable and Substitute Energy Resource Model with LPG Utilization in the Alumina Production Process

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Abstract

The final stage of the alumina production is so-called calcination process which have been witnessed to utilization of different kind of fuel sources for decades in the refineries. Type of fuel which is the most important key element of the alumina calcination process has significant impact either on greenhouse gas emissions or specific energy consumption. Beside this, accessibility to the reliable fuel resources has become an important prerequisite to achieve sustainable smooth process conditions and prevention of undesired production curtails. Two different fuel types have been used so far in the calciners of Seydisehir ETİ Aluminium Plant (SEAP) where the new energy resource conversion takes place. When SEAP was privatized by Cengiz Holding in 2005, a huge modernization effort was completed on fuel resource conversion from fuel oil to natural gas (NG) which is easier to use and extremely clean. Nowadays, a requirement to find an alternative fuel resource to NG has become highly outstanding situation at SEAP due to unexpected and overwhelming fluctuations in the energy prices all over the world. As a result of researches and feasibility studies among various fuel resources, it was determined that Liquid Petroleum Gas (LPG) would be the most economical and reliable option to consume in calcination systems. As it was known, the direct use of LPG in the firing systems is not as suitable as NG, it requires further processing steps in terms of vaporizing and calorific value adjustment. At SEAP, once the liquid has been vaporised, it needs to be blended in adequate ratio with compressed air to duplicate the calorific value of NG at a rate equal to the appliance rate of consumption, and at a quality such that calciner operates equally well under either gas. The resulting product, Synthetic Natural Gas (SNG), is ready to feed to calciners. The most critical parameter to follow in this process is Wobbe Index which indicated the appropriate calorific value for the LPG-Air blender system. The mentioned system has been commissioned and fired at one of the calciners in SEAP. The outcome of this trial has been monitored via collecting relevant process data and it will be evaluated with the comparison of specific energy consumption as well as stable operating conditions in the details of this paper.

Keywords: Alumina calcination, Alumina production, LPG usage, SNG, Wobbe index

1. Introduction

The alumina production process is a labour-intensive process that must be continuously kept under control. This process is well-known all over the world as the Bayer Process which is mostly preferable in alumina production with respect to achievable low production costs thanks to its high efficiency and low energy consumption performance. Until the final product, alumina, is obtained from bauxite ore, stages such as bauxite crushing and milling, bauxite digestion, liquor clarification, gibbsite precipitation and evaporation are completed by keeping the required parameters at appropriate values [1]. The next and final stage is calcination. After completion of the decomposition and filtration sections (parts of gibbsite precipitation), Aluminium tri-hydroxide $Al(OH)_3$ or in other words $Al_2O_3 \cdot 3H_2O$ product is obtained and fed to the calciners in order to perform the related phase transformation by removing physical and chemical water it contains. After all these processes, Alumina (Al_2O_3) is finally obtained, which will be transferred either to the smelter cells for primary aluminium production process or to the commercial storage silos for domestic and foreign sales.

In energy-hungry industrial applications such as the alumina calcination process, the importance of the type of fuel used becomes more evident. All possible units in SEAP facilities had been converted to NG. For alumina calcination, which is the main subject of this paper, combustion with NG takes place in both stationary fluidized bed furnace and rotary kilns. Although the system is operated regularly with NG gas, necessity of a new alternative fuel resource has been occurred. The reason for the emergence of this need is fluctuations in energy prices and energy supply problems all around the world. That is why, necessary studies were also carried out in SEAP and LPG was determined as the most suitable fuel type to be utilized. Normally, LPG is a mixture that consists of mostly propane and butane compounds, but considering the industrial controllable conditions and its higher heating value to replace NG, SEAP preferred to set up its LPG system with 100 % propane content in its alumina calcination process. SEAP decided to use this fuel resource since LPG prices depend on the petroleum market prices and natural gas has its own pricing, they have to be considered separately. It is important to follow the prices regularly so that an estimation can be done and decision can be made on which fuel is going to be used in the following production period. LPG storage tanks, LPG vaporizer and LPG/Air blender were selected appropriate to utilization of propane.

LPG can directly be used in gas phase in the burner systems as a fuel resource but this does not encounter the purpose of mentioned changes because it would require changes in the burners and flow trains since those two gases belong to different gas families, the interchangeability between NG and LPG is not straightforward. To give an example from a related industry, the Alcoa Company implemented an LPG-Air mixture system due to energy savings and environmental impact, LPG-Air mixture had to replace diesel oil, the fuel used in the anodes baking furnaces in Alumar's facility, the largest refinery of alumina in Brazil [2]. The mixture capacity range is 0–3200 Nm^3/h each unit, mixture outlet pressure is 4.0 bar, mixture average composition is 57 % LPG + 43 % Air, mixture Wobbe Index is 11800 $kcal/Nm^3$ while mixture HHV is 13 300 $kcal/Nm^3$.

NG mostly consists of methane and it has a lower calorific value than propane. While the higher heating value of NG is around 9 200 $kcal/Sm^3$, the gross calorific value of propane is around 12 000 kcal/kg since it has a higher carbon content. Since the aim of this study is to acquire an alternative with same properties to NG, propane is not directly fed to the burners. SNG is defined as Synthetic Natural Gas or Substitute Natural Gas. SNG, also known as LPG-Air or Propane-Air mixture, is a gas produced with the use of LPG that has almost exactly the same properties as NG, making it a perfect substitute for NG. The necessary amount of LPG is combined with a fixed proportion of air to obtain targeted properties. With the aid of a vaporizer, liquid LPG must first be transformed into a gaseous phase [2]. Layout and arrangement of the above-mentioned system can be seen on Figure 1.

As it was clearly indicated in this paper, the resulting production data revealed that the SNG produced with LPG can be used successfully. If the increase in NG prices exceeds LPG, SNG may even be SEAP's main fuel choice since the difference is really low. Finally, this paper demonstrates us, LPG can be used not only in alumina calcination but for various purposes such as standby or backup, base load, peak shaving and commingling systems.

5. References

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