EFFICIENT COMBUSTION OF COAL IN BAGASSE/COAL FIRED BOILERS USED FOR COGENERATION IN THE SUGAR INDUSTRY

By

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Abstract

COGENERATION with bagasse/coal fired boilers has become increasingly important in the sugar industry. This has not only led to increased steam temperatures and pressures but also to more reliable and efficient coal firing systems. Reliability and efficiency have become key factors, especially when firing coal. Various ways to optimize these factors, both from an operational as well as a design point of view are discussed in the poster paper. Coal grading varies considerably throughout the industry. In many cases the quality of the available coal has dropped. This has required new studies into how the clean efficient combustion of lower quality coal can be ensured on spreader stoker fired boilers. Some results and some main influences are discussed in the paper.

Introduction

Cogeneration is becoming more and more important in the sugar industry. This has led to the need to supplement the primary fuel, bagasse, with coal. Continuous ash discharge (CAD) stokers provide the means to burn coal effectively. Some features of the CAD stokers that ensure high availability and efficiency are discussed below.

Actual measured performance figures on a retrofitted and a new installation are also included.

Design considerations

The grate rating, i.e. the amount of coal burnt per square metre of grate, is an important factor to ensure efficient combustion. Experience has shown that a rating of 220 kg/hm² of coal produces optimal results.

In contrast to a heat-release based figure, this mass-based parameter has the advantage that it automatically takes into account the quality or heat value of the coal used.

It is important that the whole combustion system which comprises stoker, bagasse and coal feeders, spreaders and air distribution systems are properly matched. The coal bunker as well as the method of introducing the coal into the bunker must be designed to prevent segregation of the coal on the grate.

Availability of the boiler can also be improved by fitting diverter valves on the main ash outlet chutes so that the boiler can still be operated in the event that the submerged ash conveyor is out of service.

Pneumatic spreading

Both coal and bagasse are pneumatically spread into the furnace. Bagasse is metered by a three drum bagasse feeder while the coal is fed via a variable speed screw conveyor. Both fuels are introduced into the furnace through common lower chutes onto which common pneumatic spreaders are fitted at the lower front wall. Considerable development work was necessary in the evolution of this spreader in order to ensure correct spreading of the coal over the full stoker width and depth.

This spreader system is adjustable in such a way that it ensures proper distribution of different qualities and gradings of coal. The spreading air supply is sized so that sufficient momentum is imparted to the larger coal particles so that they can be spread to the rear of the stoker in order to achieve optimal burn-out time.

Coal sizing has a direct bearing on combustion efficiency and particulate emissions. It is important that the coal size distribution is kept within the limits recommended by the boiler manufacturer.
Verbanck, H. and McIntyre, P.

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Fig. 1—Zoned spreader stoker system for bagasse/coal fired boiler.

Zoned stoker

Figure 1 shows a typical spreader-fired combustion system with a zoned stoker. The stoker is divided into a number of compartments, or zones, from front to rear. Each compartment can be regulated to allow appropriate primary air distribution for both bagasse and coal firing.

Zoning is primarily used to compensate for variations in the heating value of the coal, particle sizing, ash content and volatile matter, all of which can have a major effect on the propensity of coal to ignite and burn efficiently.

The amount of air required to efficiently burn the coal and control the formation of various emissions varies along the length of the stoker. The zoning compensates for this.

The zoning of the stoker in effect provides control of the length of the coal fire. The primary air is distributed in such a way that complete burn-out of the coal is achieved before it reaches the discharge hoppers at the front of the stoker.

Stoker construction

The stoker frame consists of generously sized structural steel members. It forms a rigid support system capable of handling the onerous operating conditions.

The spreader stoker runs from the rear to the front of the furnace.

The stoker is driven via the front shaft so that the grate bars are pulled along the grate surface. The rear shaft has no sprockets, allowing the catenary’s geometry to automatically adjust the chain tension.
under the weight of the chain and grate bars. Therefore, no physical adjustments are required to cater for chain wear or expansion. This reduces maintenance requirements.

**Instrumentation**

A comprehensive set of instrumentation is fitted to the combustion system. This allows for monitoring and adjusting the numerous parameters that affect the efficient combustion of the fuels used.

Ample thermocouples are fitted along the skid bars that support the grate bars. By monitoring the temperatures across the grate, it is possible to detect blockages of coal feeders, identify coal segregation, and optimize the set up of the spreaders and zoning dampers. Being able to trend parameters makes it easy to determine the effect of varying one or more of these parameters.

![Grate rail temperature profiles](image)

**Fig. 2**—Typical stoker rail temperature profile.

Figure 2 shows a typical grate rail temperature profile across the length of the grate for both bagasse and coal firing.

Monitoring equipment for CO, O₂, NOₓ and SOₓ can be used to adjust primary and secondary air, fuel-to-air ratios and other parameters in order to optimize combustion conditions. Oxygen trim control ensures maximum efficiency at all times.

Annubar signals measuring the air flow to the right and left hand sections of the stoker are temperature compensated so that the controls assure a uniform flow distribution of the primary air across the grate.

**Grit refiring**

A small increase in efficiency can be obtained by fitting a grit refiring system. When burning coal, unburnt grits are collected in the area of the convection bank. They are then pneumatically re-injected into the furnace as part of the secondary air system. Figure 1 illustrates such a system.

When firing bagasse this grit re-firing system is bypassed to avoid erosion caused by re-introducing sand particles.
Table 1—Performance figures.

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Retrofit Before</th>
<th>Retrofit After</th>
<th>Boiler Before</th>
<th>Boiler After</th>
<th>New JTA</th>
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<tbody>
<tr>
<td>Steam Flow</td>
<td>TPH</td>
<td>86</td>
<td>86</td>
<td>117</td>
<td>117</td>
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<tr>
<td>Fuel Burnt</td>
<td>kg/h</td>
<td>11006</td>
<td>9282</td>
<td>14695</td>
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<tr>
<td>GCV 'As Fired'</td>
<td>kJ/kg</td>
<td>27810</td>
<td>28060</td>
<td>28240</td>
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<tr>
<td>Final Gas Temp</td>
<td>Deg C</td>
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<td>166</td>
<td>196</td>
<td></td>
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<tr>
<td>Boiler Efficiency on GCV</td>
<td>%</td>
<td>76.8</td>
<td>86.8</td>
<td>85.2</td>
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<tr>
<td>CO₂</td>
<td>% dry</td>
<td>11.5</td>
<td>12.9</td>
<td>12.7</td>
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<tr>
<td>O₂</td>
<td>% dry</td>
<td>8.4</td>
<td>6.5</td>
<td>7.1</td>
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<tr>
<td>Undergrate Air Temp</td>
<td>Deg C</td>
<td>153</td>
<td>147</td>
<td>150</td>
<td></td>
<td></td>
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<tr>
<td>Carbon in Coarse Ash</td>
<td>%</td>
<td>37</td>
<td>13.9</td>
<td>13.2</td>
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</tr>
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</table>

Table 1 illustrates the actually measured performance data of both a retrofitted zoned CAD stoker as well as a CAD stoker in a new boiler.

Acknowledgments

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COMBUSTION EFICIENTE DEL CARBÓN EN CALDERAS ALIMENTADAS POR BAGAZO/ARBOLADO USADAS PARA LA COGENERACIÓN EN LA INDUSTRIA AZUCARERA

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PALABRAS CLAVE: Carbón, Combustión, Caldera, Cribrado.

Resumen

La cogeneración mediante calderas alimentadas por bagazo/arbolado es cada vez más importante en la industria azucarera. Lo anterior ha llevado no sólo a crecientes temperaturas y presiones de vapor, sino además a sistemas de combustión de carbón más confiables y eficientes. La confiabilidad y la eficiencia se transforman en factores clave, especialmente cuando se quema carbón. En este documento se estudian diversas formas de optimización de dichos factores, tanto desde un punto de vista operativo como de diseño. La graduación del carbón varía considerablemente a través de la industria. En muchos casos ha caído la calidad del carbón disponible. Ello ha obligado a la realización de nuevos estudios en cuanto a cómo asegurar la combustión limpia y eficiente de un carbón de calidad inferior en calderas operadas por un cargador distribuidor. En este documento se tratan algunos de los resultados e influencias principales.