Abstract

Silicon carbide refractories have unique properties for preventing slag and clinker adherence on the lower walls of incinerator furnaces. To fully utilize these properties, these refractories should be installed with arrangements for air cooling the rear surface. The paper discusses the performance characteristics of silicon carbide refractories in incinerator service and the precautions to be observed in their installation.

Silicon Carbide Refractories in Incinerators

In recent years silicon carbide refractories have been installed in the lower and hottest areas of the side walls of the primary combustion chamber. There has been considerable controversy in the industry with regard to the proper application of the silicon carbide shapes, because of the nature of the types of combustible material being burned, and how the chemical reaction of the fuel being burned affects not only the silicon carbide area of the walls, but, also the fire-brick areas, and the relationship between the silicon carbide sections and fire-brick sections to each other.

Physical Properties of Silicon Carbide Shapes

Top quality silicon carbide refractories are free of foreign bond and contain no fire clay, lime, magnesia, or silicate of soda. The shapes are made of 95 to 98 percent pure silicon carbide grain. To best comprehend the properties of silicon carbide, a brief comparison with a high grade, first quality fire brick follows:

<table>
<thead>
<tr>
<th></th>
<th>Silicon Carbide</th>
<th>1st. Quality Fire Brick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity, Btu/sq ft-hr-°F-in.</td>
<td>108.2</td>
<td>9.0</td>
</tr>
<tr>
<td>Average Cross Breaking Modulus of Rupture 70 F, lb</td>
<td>3000</td>
<td>1000</td>
</tr>
<tr>
<td>Compressive Strength in lb/in.²</td>
<td>17,000</td>
<td>2500</td>
</tr>
<tr>
<td>Fusion or Decomposition Temp., °F</td>
<td>4600</td>
<td>3100</td>
</tr>
<tr>
<td>Coefficient of Expansion/°F Mean 70 to 2500 F</td>
<td>.0000026</td>
<td>.0000033</td>
</tr>
</tbody>
</table>

Silicon carbide is a refractory, highly resistant to most acids, gases and alkalies. Silicon carbide has great mechanical strength (7 times greater than first quality fire brick) at room temperature, but it is 10 to 15 times stronger at operating temperature. It has a further advantage of not softening in the slightest at 2460 F as most fire clay does. The softening temperature is of greater importance in changing the refractoriness of materials than the fusing point.

Silicon carbide refractories have a much lower spalling tendency than any other commercial refractory. Standard tests, after heating and cooling 100 times, show no loss from spalling. Silicon carbide is extremely resistant to flame and mechanical abrasion. Because of
the inherent hardness of silicon carbide grain, and the close grained dense structure of the finished refractory, abrasion tests show less than 0.3 per cent loss.

Use in Incinerator Walls

Much has been learned of the application of silicon carbide over the past years, particularly with regard to its adoption to the combustion-exposed walls of all types of furnaces. In the last few years the application of silicon carbide refractories to incinerator walls has proved the possibility to create a trouble-free wall, if installed properly. Basic thinking in proper design indicates the use of silicon carbide refractories in the lower furnace area (particularly the primary combustion chamber) for a limited height above the stoker itself, where it provides a wall area that is free of slag adherence, spalling or break-up of the walls as a result of expansion and contraction.

The real limiting factors are pretty well known, including the known destructive agents that affect silicon carbide refractories. The big element of destruction in incinerator application is oxidation. It is also known that silicon carbide refractories gradually expand. In other words, the silicon carbide refractories will grow, under these oxidizing conditions, if not properly installed, and will not contract but remain in the expanded state. While silicon carbide material has mechanical strength and characteristics that are essential to long life and high performance, but impossible to produce in clay refractories, much of this benefit is lost if silicon carbide is improperly installed in a wall.

With an oxidizing atmosphere, the temperature at which silicon carbide will expand is quite low in comparison to the temperatures at which it will expand under low or non-oxidizing conditions. Over the period of time that silicon carbide refractories have been used in incinerator application much has been learned, and it can be truly stated that this movement can almost be completely eliminated by proper air-cooling of the silicon carbide. The development of an "oxidation resistant mix" for use under these conditions has also proved successful when air cooled.

Because of the high heat transfer nature of silicon carbide refractories, the application of cooling air between the rear surface of the silicon carbide refractory and the fire brick backing-up construction, the movement of silicon carbide can be controlled. The heat thus released through the back face of the silicon carbide is sufficient to lower the temperature of the silicon carbide fire face to maintain it below the temperatures that would otherwise exist in this material. Without such cooling SiC destruction is caused in the majority of cases by oxidation from the fire face.

Many applications of silicon carbide refractories have been made on the basis of solid-wall construction in which a 4½-in. layer of silicon carbide brick would be installed on the fire side of the furnace wall, with this silicon carbide brick bonded into the backing up fire-brick wall. Because of the oxidizing atmosphere on the fire side, the silicon carbide refractories would begin to move as a result of expansion, and many times shear off the header tics, thus allowing the silicon carbide front face to separate from the fire brick rear face. In many instances the silicon carbide fire face would separate enough to allow sections to fall in, necessitating repair. The silicon carbide face, when laid up as a solid wall backed up with fire-brick, is more susceptible to destructive elements, because instead of the heat being released from the silicon carbide it is bottled up within the silicon carbide pieces (as a soaking pit). The fireclay backing has only about 1/12 the heat transfer rate of the silicon carbide. As a result of this condition the fire brick backing up the silicon carbide creates an insulating condition, as a result of which any destructive elements present in the combustion chamber have a "field day" with the silicon carbide.

This entire condition can be overcome through the use of air under pressure between the back surface of the silicon carbide shapes and the surface of the fire brick wall immediately behind the silicon carbide construction.

Proper design of present day incinerators calls for a certain amount of overfire air in the primary combustion chamber, to create turbulence and for control of furnace temperature. Admitted in proper quantities, this turbulent air creates one of the best conditions to more completely consume combustibles and smoke, thereby becoming a prime element of eliminating smoke at its final exit from the stack.

Because of the high heat transfer through the silicon carbide fire face into this air stream, the temperature of the air discharged into the furnace is increased; this in turn is responsible for increased efficiency in operation. It is definitely known that cooler outside walls result from the use of this cooling air, because instead of a saturating heat being transferred to the fire brick wall, behind the silicon carbide, the back-up fire brick is subject to lower temperatures. The final answer is cooler outside walls.

A silicon carbide refractory air-cooled wall, installed properly, eliminates any possibility of heat build-up in the back-up wall, as well as eliminating any possibility of heat build-up of a destructive nature in the silicon carbide wall.

Because of the nature of fire brick and because it expands under heating and contracts under cold, proper provisions must be made to provide for sufficient movement through expansion joints. The expansion joint should be packed with compressible material which remains compressible both during operation and when the furnace is cold. Provision should therefore be made between the gravity section of the wall and the upper fire
brick sections, which in most instances are supported walls. To eliminate the necessity for large expansion joints in the actual silicon carbide area, provision must be made to eliminate possible crushing in the areas where the two types of walls meet each other.

Slag Formation on Side Walls

When refuse burns, ash is released mainly as fine particles. Some of the ash particles are heated into the softening and fusion temperature range. Those that are thus softened and tacky can adhere to a refractory surface of the same or higher temperature. A cooler refractory surface acts as a chill to the oncoming particle and prevents adhesion.

An air-cooled silicon carbide refractory wall eliminates build-up of slag on the silicon carbide area. Because of the nature of the fire brick construction and its known porosity, which will allow hot slag to fuse to it, it is very easy to understand why in some instances it would appear that slag was building up in the upper areas of the silicon carbide wall. Careful examination will disclose that what appears to be build-up in the upper silicon carbide area has been caused by the slag from the fire brick area above the silicon carbide, where the slag has fused to the fire brick and flowed down over the face of the silicon carbide.

Careful examination immediately after the shut-down and cooling of an incinerator shows that this slag has not adhered to the silicon carbide at all and can be snapped off clean from the face of the silicon carbide while remaining frozen to the fire brick areas directly above it. This statement is primarily true when the silicon carbide wall is properly cooled.

Summary

Silicon carbide refractories, properly manufactured and installed, offer the best known solution to the building of walls and provide trouble-free, effective overall operation. The only thing that has been wrong with silicon carbide in incinerators has been improper application. This condition can be corrected by proper design that can be developed in cooperation with the consulting engineers who have obtained the advice of specialists in silicon carbide applications.

By providing a cooler, heat-conducting surface to the fire and hot ash particles, clinker and slag adhesion is prevented in the zone where such agglomerations would interfere with stoker operation and good fire behavior.

These walls will last longer periods of time without maintenance and will provide a maximum of additional benefits in the overall operation of the incinerator by providing high temperature overfire air in the primary combustion chamber to improve the overall efficiency of the incinerator itself.

As a result of the lower area in the walls of the primary combustion chamber being built with air-cooled silicon carbide (properly installed), the potential life of the surrounding fire brick areas is increased.