Monolithic Refractories in Municipal Incinerators

A. W. KALKHOFF
Plibrico Company
Chicago, Illinois

Abstract

Just as a number of factors, working together, dictated the necessity of incineration as a means of waste disposal, so too, a number of developments have been responsible for the progress in incinerator furnace design. This paper covers the contributions made by monolithic refractory construction and the freedom it has given to those who design incinerator plants.

Introduction

Today's large, efficiently operated municipal incinerator became a practical means of waste disposal with the development of the automatic stoking grate especially designed for incinerator use. But the full impact of this development, its far reaching effect on the design and the size of municipal plants was, in a very real sense, dependent upon the capabilities of modern refractories and modern refractory construction. Stokers have made possible higher and wider furnaces it's true. And yet modern refractory construction played a significant part too, overcoming the limitations imposed by the old gravity type walls and the sprung arches.

Monolithic refractories were already available in everyday service, providing suspended, sectionally supported walls and hung flat arches. Various special classes of refractories were either available or were developed to meet the new requirements and conditions as they arose. Up to this time refractories for incinerator service were selected on the basis of "what works in a boiler fire box will work in an incinerator", and as a result spalling, structural failures, high heat loss and exceedingly high maintenance costs were the result.

Little consideration was given to the complete lack of uniformity of the fuel, garbage, and as a result the heat releases in the hand fired incinerators of the 30s and 40s are usually exceedingly low, the charging is haphazard, and the thermal shock on the refractories terrific.

A modern incinerator utilizes refractories not only for containing the heat liberated by burning the refuse, but for heat storage and heat reflection to assist in the complete destruction of the burnable refuse. All operators agree that a well designed and constructed monolithic refractory installation materially assists in destroying exceedingly wet fuel. Proof of this improvement in design is the complete absence of external sources of heat in most incinerators designed and constructed during the past eight to ten years. Granted that the heat content of garbage has risen constantly, it has not increased sufficiently to eliminate the need of external burners in the older type units.

However, when these older units are redesigned, and full advantage is taken of the proper heat release, of furnace volume, of heat storage ability and of a design to reflect the heat back into the material being consumed, external fuel has no longer been necessary.

Monolithic Construction

The flat suspended and sloping arches of the modern incinerator furnace materially assist in accomplishing the above objectives, and here monolithic construction is ideal. Steel
I'll have had another problem, and here again the flexibility of monolithic suspended type construction permits ease of repair. At the same time monolithic construction tends to minimize refractory failures for there are no joints to accumulate dirt and ash when the unit is cool, then block expansion on heat up.

Slagging is a condition that causes a considerable amount of spalling and refractory failure. This condition is present in most installations, in varying degrees of intensity. It is a by-product of the materials being incinerated. True slag is a glassy-like, almost crystalline material, hard and brittle, and is deposited on the surface of the refractory in a liquid or semi liquid state. The material then penetrates the minute voids or joints in the lining, building up until the weight of the material deposited forces separation. However, if the material is allowed to cool, an exceedingly strong bond between the slag and the refractory is effected, and due to different rates of contraction, fractures are developed at the bond points. These fracture lines grow and soon separate, leaving the familiar spall area.

Again, the absence of joints in monolithic construction minimizes the areas of deep penetration, and the dense surface of the monolithic wall, with its minimum of joints, decreases the bonding area offered. As a result spalling is decreased. Even if severe spalling conditions do occur, sectionally supported monolithic construction decreases maintenance cost. The denser the material, the less the spalling, but the denser the material the higher the cost. As a result super grade refractories, due to cost are almost universally employed except in high abrasion areas as previously mentioned.

Bridge walls and drop arches are two areas that are frequently subject to refractory maintenance due to abrasion, the washing action of the flames, mechanical abuse, and structural weakness. Abrasion is caused by particulate matter resulting from the combustion of the refuse impinging on these areas. Surface failure is usually caused either by an erosion action or by the spalling that results from excessive slagging.

In flame washing, impingement of the flames of combustion on the lining results in the liquefaction of minute particles of the refractory. These liquefied particles normally become entrained in the gas stream. When the velocity is not sufficiently high for entrainment, these particles liquify and flow down the surface of the bridge wall or the drop arch. Mechanical failure is usually failure of the arch in the sprung type of drop arch construction. Most modern units employ the suspended type of drop arch, usually of air cooled construction, and as a result failure has been reduced in this area. Here again monolithic suspended type construction is ideal, as all supports, hangers and anchors for supporting the refractory from the steel supports are readily available, and installation is rapid and easy. Arches can be either formed and cast, or can be of
plastic construction in high heat areas. The same construction, namely air cooling, is employed in bridge walls to a great extent.

Secondary combustion and dry settling chambers have the same inherent refractory conditions as those present in the primary or furnace section. Usually the refractories selected for the furnace section are also selected for this area. Some designers have employed monolithic castable linings in these sections with marked success.

In the spray or wet chamber section of the modern incinerator, the refractories must withstand temperatures ranging from 1600 to 1800 °F down to low operating temperatures of 400 to 600 °F. They must have high abrasion resistance, withstand water vapors resulting from the water contacting the hot flue gases, and they must have good acid resistance. Several excellent refractories are available to meet these conditions, both prefired and monolithic, but care must be exercised with any refractory in this area to prevent direct water impingement.

Selection of Refractories

By far the simplest and best method of selecting the proper refractories is to contact the technical representative of a refractory manufacturer. Discuss the conditions to be met and have him recommend the materials best suited for service in the various areas of the unit. Specifications are then usually written giving cones, ASTM numbers and other data to prevent so called “exclusion” specifications. Or one product can be named and/or equal specified.

The best material for a particular area may not always be the most expensive. The refractory that gives excellent results in, say a boiler, will not always give the same excellent results in an incinerator. This is particularly true in large industrial type incinerators, where certain chemicals, by products or other materials are present that may attack refractories.

Classes of Refractories

In general the refractories used for most incinerators fall into the following broad general categories.

High Abrasion Areas. In areas of high abrasion the corundum, mullite and sillimanite class of refractories are employed. This class of refractory has a pure aluminum base, and the resulting refractory is dense, extremely hard, and has one of the highest heat transfer ratios of commercial refractories. This material can be obtained for monolithic installation in both plastic and castable types, and also in prefired shapes. The plastic material is either rammed or pounded in place, while the castable is installed in the conventional manner.

This class of refractory features high abrasion resistance, low penetration with resulting decrease in slag adhesion, and it is extremely hard in its final state. Its alumina content is in excess of 80 per cent, and its silicate content is less than 14 per cent. The temperature range is from 2000 to 3400 °F, and abrasion and penetration resistance are excellent.

Furnace Section. In this area refractories of super duty commercial grade are usually employed. These refractories are of the Alumina-Silica group, being composed of from 36% to 43% per cent alumina and 56% to 50 per cent silica. This grade of refractory, both in the castable and plastic types is the work horse of the refractory industry. It resists normal gases produced by incineration, it is nominal in cost, and it can be obtained readily. As another description of this material, it can be classed as a dense, smooth flint type of refractory. Slag resistance is good due to the relatively smooth surface. Resistance to spalling is good. Thermal conductivity is fair. And as previously mentioned, cost is moderate. This class of materials is widely used in boiler fire boxes, industrial furnaces, and is normally referred to as either No. 1 or Super Duty fire brick in its prefired state.

Settling Chamber. Dry settling chambers are normally constructed of either castable or prefired refractories having the general specifications of a dense, smooth type flint refractory with about 42 per cent alumina and 39 per cent silica content. Again, suspended walls should be employed for ease of replacement and long life.

Spray Settling Chambers. The refractory in this area should be acid resistant, abrasive resistant, with high strength over the entire temperature range from 400 to 1800 °F.

Conclusion

Municipal incinerator designs vary widely. No one design has been developed that can be considered the ultimate, the untouchable. In developing new incinerator designs, engineers can give full expression to their ingenuity, knowing that the adaptability of monolithic refractory construction frees them from restrictive limitations. Monolithic refractories conform readily to any contour designed. And their methods of anchorage and support permit durable construction in any design.

Modern monolithic construction doesn’t merely safely contain heat, but it substantially assists in promoting efficient combustion, with enclosures that combine a variety of refractory types to meet the specific service requirements of every area. Designers can preplan combustion efficiency, enclosure service life, and place a positive restraint on maintenance costs by utilizing the technical and practical knowledge of a refractory company specialist. With the rapid developments in both products and installation techniques, it’s wise to take advantage of his specialized knowledge. It’s yours for the asking.