LINING DESIGN CONSIDERATIONS

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I will start out by saying that there are many ways of approaching a lining design and they are all correct as long as the end result fulfills the aim requirements.

Lining design considerations generally encompass many different parameters, only some of which are of a true refractory nature. They can be any one of the following, but generally encompass several competing requirements: product(s) to be made in the unit under repair or construction, maximum acceptable heat losses, maximum and average use temperatures, total refractory cost, speed of installation, available materials, length of time a unit will be in use before a maintenance outage is expected, who will install the refractories and their level of expertise, and so on. Most of these questions need to be addressed before a refractory lining design is considered complete.

OPERATIONAL PARAMETERS

The first issue to be ascertained is the operational parameters of the unit. If the new lining is purely a replacement of an existing one then the refractory requirements and challenges are known. Changes to the design will be small as they are only made to improve the overall operation, the environment, or to incorporate new refractory installation techniques. Unless there is an area which has seen unusual wear, design challenges are minimal.

On the other hand, if the unit represents a new installation, then many questions need to be considered such as, is a comparable unit in existence or is this a first of its kind, either because it is a new and experimental process or it is a pilot unit. Even if a comparable unit exists that will only provide an inkling of possible problem areas as each installation has its own challenges.

Among the operational parameters that require much consideration, as they impact refractory selection and performance, are process temperature and chemical environment. Process temperature encompasses many subcategories. The maximum expected temperature should be used as an overall requirement because if the refractory fails at lower temperatures then it will not be adequate. In addition it has to be ascertained how long the unit will be exposed to maximum temperature and if there will be localized areas which will be even hotter (I realize that this is a contradiction, but it is often encountered). The chemical environment can alter the initial refractory properties by modifying their thermal conductivity or lowering their melting point, changes that can dramatically affect performance.

Engineering parameters: Often the operational parameters and engineering parameters are discussed concurrently. By engineering parameters I mean the physical shape, size and location of unit. Although these issues are discussed early on, refractory knowledgeable personnel are often not involved in this step. Once shell dimensions and shape are committed to or under construction it is often too late for optimum refractory lining design as there may not be sufficient room for proper wall thickness, roof may not be able to support the weight required or unit shape is such that it precludes an easy drying, heating or lining configuration.

Although no unit lasts forever, provisions for its repair are often overlooked. The addition of walkways wide and strong enough for a loaded tow motor to use, openings to remove spent refractories and deliver new ones, and crane assists to properly place the refractories during a repair should all be incorporated into the original design.

REFRACTORY PARAMETERS

The first and most important parameter is, of course, what will take place in this unit. If it is melting or refining then the refractories need to be chemically compatible and inert with respect to the melt and slag, if it is a heating unit then the refractories need to be able to withstand the temperature and atmosphere, and so on. Selection of proper refractories requires deciding on the properties which are most important for success, and then determining what class of refractories embodies them and is most compatible. Often a compromise is required as opposing refractory properties are needed. Once the refractory that best accommodates the differing requirements has been selected then its proper installation method, advisability of using insulation, available method(s) for bringing the unit to use temperature, etc. should be considered. When similar refractory properties can be achieved using a brick, a castable or a plastic then a decision has to be made as to which material form will result in the best lining. One of the deciding criteria should be the level of installation expertise available, the reliability of the quality control of the manufacturer of the different materials, the likelihood of a controlled dry-out/heat up, etc. Cost of installation encompassing materials, forms, labor and dry out also need to be considered. This is also the time when provisions for ease of subsequent repairs should be incorporated into the design.

A unit which is to be used for an experimental process requires considerable imagination to design an optimum refractory lining as many parameters are unknown or poorly understood. In this case combining the best practices observed in units which have some overlapping characteristics with the new one should be taken into consideration, but novel concepts will also have to be developed to address expected challenges. It is imperative to be aware of the inherent risks involved in designing a lining for a completely new concept and one has to be ready to make adjustments quickly as knowledge is being developed.

There will be cases when the properties of the available refractories are not sufficient to properly address the operational requirements. In those cases a combination of engineering together with refractory design will be needed to solve the problem. An example might be temperatures exceeding the refractory's use limit in which case water cooling might need to be added for them to be successful.

I hope to have presented a summary of the most important issues that should be taken into account for a lining design. Obviously, most of these topics could be greatly expanded, but they were selected to provide a framework to use for decision making.

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