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Study on the use of High Temperature Insulation Wool in forging furnaces
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Summary

This study presents measured data and key figures for a furnace in which two different refractory lining concepts were realized in succession. The initially existing lining with “dense refractories” (chamotte) was replaced with a lining of modules made of high-temperature insulation wool (HTIW), in this case alumino-silicate wool (ASW). The casing of the furnace itself, the number and connected power of the burners were not changed.

On the basis of existing measured data, the furnace can be precisely assessed before and after its relining. One limitation for this assessment is the limited volume of data for the furnace lined with chamotte. The data available for the ASW module lining is more extensive and is steadily growing with the ongoing operation of the furnace.

The existing data enable the following principle statements regarding the refractories used.

Furnace structure and investment costs

There is a considerable difference in the total mass of the linings. Here only the mass (of the refractory material) at the furnace walls including the ceiling and door is assessed. For the chamotte lining, a value of 50 t is measured and for the lining with HTIW 3.05 t. For the installation of a new furnace lined with ASW modules, this means that the foundations and the steel structure can be much smaller.

If we look at the costs for the refractories, the costs of a lining with ASW products generally lie slightly above the costs of a chamotte lining (the costs of other types of HTIW can even be much higher).

If the perspective is widened to cover the total investment costs (foundation, steel engineering, refractories, installation, commissioning ...), the costs for a chamotte-lined furnace are higher.

Energy aspects and process management

The energy losses through the walls of the same thickness are lower for a furnace lined with HTIW, the exterior wall temperature is much lower than the furnaces lined with chamotte. To reach the same exterior wall temperature as with a furnace lined with chamotte, with HTIW a lower wall thickness is needed. On account of the much lower thermal conductivity and the lower density of the modules made of high-temperature insulation wool, the thermal storage capacity is very low compared with that of the chamotte lining. This is an advantage during preheating of the kiln, for fast cold to hot cycles and on shutdowns for inspections or repair of the furnace. Downtimes are reduced considerably overall and the operational availability of the plant/furnace is increased. Even after repairs, the furnace can be immediately reheated and used, without drying times and special preheating curves as would be necessary in the case of a chamotte lining. This time aspect has a positive effect on the productivity and energy efficiency of the furnace.

For chamotte lining, the following applies: high density/mass, higher thermal conductivity and higher storage capacity. For the first preheating phase after downtime and fast cold-to-hot cycles, a “heavy lining” with chamotte is a disadvantage. In addition, the furnace needs several days to cool down before it can be inspected. The resulting downtime is much longer than for furnaces lined with HTIW modules. After a repair of the chamotte, the kiln first has to be “dried”. That means that the newly installed chamotte mix is tempered according to a set temperature regime including specific holding times. If the chamotte is not properly tempered, cracks are immediately formed as a result of temperature shock, leading to the destruction of the refractory lining.

An important difference between the two refractory materials is their thermal shock resistance. Here the flexible HTIW module lining boasts a clear advantage. Rapid temperature changes in the chamotte lead to damage, which substantially shortens the lifetime of the lining. HTIW products are very flexible and practically infinitely resistant to temperature changes, which is a crucial advantage for batch furnaces. But for continuously operated furnaces too, a HTIW lining can be an advantage, for example if the furnace capacity is not utilized and furnaces have to be held at low-temperature for later reheating or shut down.

Summarizing overview

The assessment criteria for refractories depend on the specific requirements of a high-temperature process.

In the table the criteria are applied based on the example of the assessed forging furnace

Assessment criteria	**Dense lining/chamotte**	**Lightweight refractory bricks/castables**	**Aluminate silicate wool**
Total mass of the furnace			
Wall losses at same lining thickness			
Storage capacity – utilization of residual heat			
Storage capacity – heating and cooling rate			
Thermal shock resistance			
Process times – operational availability			
Total investment costs (refractory material, steel structure, foundation, installation, commissioning)			
Downtime, repair/maintenance/servicing			
Process flexibility; cold-to-cold cycle			
Energy saving			
CO2 emissions			

In the overall concept of a refractory lining in high-temperature processes, in most cases a combination of different refractory materials is used.

Besides mechanically resistant, dense products, thermally insulating lightweight refractory bricks/castables and products made of high-temperature insulation wools are used.

The goal is the realization of resource and energy efficiency in the high-temperature process and improved productivity and quality.

Key: Comparison of different refractory products

Disadvantage

Neutral

Advantage