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Petrochemical - Hydrogenation furnace

Hydrogenation Furnace Insulation: Zoned Refractory & Ceramic Fiber Lining Solutions | CCEWOOL®





Hydrogenation furnaces used in petrochemical hydroprocessing units are typically fired process heaters designed to heat feedstock oil to the temperatures required for hydrogenation, desulfurization, and related reactions. According to CCEWOOL® hydrogenation furnace application data, typical process-side conditions are approximately 100–150 kgf/cm² and 370–430°C. These values refer to the pressure and temperature of the process fluid inside the furnace tubes, rather than the flue gas temperature within the furnace.

These furnaces generally consist of a radiant section and a convection section. The radiant section transfers heat primarily through flame and furnace-wall radiation, while the convection section transfers heat through flowing flue gases. Existing lining designs use approximately 900°C as a reference furnace temperature. The furnace atmosphere cannot be determined solely from the hydrogenation process and must be evaluated according to the actual combustion conditions and flue gas composition.



Selecting Lining Configurations for the Radiant and Convection Sections

The radiant-section walls are directly exposed to high-temperature radiation from flames and hot flue gases, making them primary locations for ceramic fiber linings in hydrogenation furnaces. For furnace

walls suitable for fiber hot-face linings, ceramic fiber blankets can first be installed against the furnace shell as continuous backup insulation, followed by high-alumina or zirconia-alumina ceramic fiber modules as the hot-face lining. The blanket layer provides additional thermal resistance and fills the space behind the modules, while the modules are secured to the furnace shell's steel structure through an anchoring system to form a continuous fiber insulation lining.

Some hydrogenation furnaces incorporate an insulating firebrick transition section along the lower radiant-section walls. In an existing CCEWOOL® application design, this brick section extends approximately 1.8–2.5 m in height. Ceramic fiber blankets are installed behind the CCEFIRE® insulating firebricks, while the remaining upper wall sections use a combination of blanket backup insulation and ceramic fiber module hot-face linings. This arrangement allows the lower brick structure and upper modular lining to accommodate their respective structural and operating conditions.



The 1.8–2.5 m dimension is a reference from a specific lining configuration, not a universal standard for hydrogenation furnaces. The actual brickwork height, brick grade, blanket thickness, and support arrangement must be determined according to burner distribution, furnace-wall height, shell structure, and maintenance requirements. Insulating firebricks provide dimensional stability and form the structural transition, while ceramic fiber blankets serve as the insulation layer behind them and must not be treated as load-bearing components supporting the brickwork.

Burners may be located at the top, bottom, or sidewalls of the radiant section. Areas surrounding burner openings are exposed to flame radiation, localized high temperatures, and high-velocity gas flow. Burner passages and surfaces directly exposed to flames are generally protected by refractory castables, prefabricated burner blocks, or specialized refractory components. The surrounding furnace-wall lining may connect with ceramic fiber modules, but exposed fiber edges must be protected from direct flame impingement and erosion.

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The furnace floor and load-bearing areas must withstand mechanical loads from furnace materials and equipment. These locations generally require suitable refractory bricks or castables. Ceramic fiber blankets and modules must not be used as load-bearing furnace-floor working surfaces or as leveling layers beneath structural supports.

The convection section transfers heat to the process tubes primarily through flowing hot flue gases. Its lining must also account for gas erosion, tube-bank supports, ash accumulation, and maintenance access. CCEWOOL® hydrogenation furnace application designs generally use refractory castables as the primary convection-section lining rather than extending the radiant section's modular fiber lining throughout the entire convection section. Where additional insulation is required behind the castable lining, suitable insulating firebricks, boards, or blankets should be selected according to the castable thickness, hot-side interface temperature, support arrangement, and specified furnace-shell temperature.

Matching Module and Backup Insulation Grades to Actual Temperatures and Atmospheres



For areas requiring higher hot-face temperature resistance, CCEWOOL® 1430HZ zirconia-alumina ceramic fiber modules may be considered. This product has a classification temperature of 1430°C, a specified operating temperature of 1350°C, and a ZrO_2 content of at least 15%. Selection must consider the actual module hot-face temperature, furnace atmosphere, localized flame impingement, and long-term shrinkage characteristics. A reference furnace temperature of 900°C does not automatically require this higher-temperature grade. Conventional high-alumina modules may also be suitable, depending on the actual interface temperature and hot-face exposure conditions.

The temperature grade of the backup blanket does not necessarily need to match that of the hot-face module. The blanket layer is generally exposed to a substantially lower interface temperature than the hot face, so its temperature grade can be selected according to the temperature behind the modules and the

allowable furnace-shell temperature. Specifying an unnecessarily high temperature grade does not inherently improve thermal insulation and may increase material costs, while selecting a grade below the actual service requirements may lead to premature fiber deterioration and shrinkage.

Maintaining Lining Continuity Through Anchoring, Joints, and Interface Sealing



The furnace roof particularly illustrates the importance of coordinating module anchoring and arrangement. Continuously exposed to hot flue gases and radiant heat, the roof lining must account for its own weight, anchoring reliability, thermal expansion direction, and central opening configuration. For furnace roofs suitable for ceramic fiber modules, two layers of ceramic fiber blankets can be installed against the steel shell as backup insulation, followed by high-alumina or zirconia-alumina ceramic fiber modules as the hot-face lining. Modules may be installed using single-hole suspension anchoring systems or other arrangements suited to the roof structure, while edge-folded modules must be coordinated with the anchoring positions along the furnace walls.

For cylindrical furnace roofs, a parquet-pattern module arrangement may extend from the centerline toward the furnace wall. Edge-folded modules are secured using anchors welded to the furnace shell, while the precompressed modules recover in the designed compression direction to help close installation joints. Box-type furnace roofs may also use parquet-pattern arrangements based on the central suspension structure. Module layout must consider more than individual dimensions: central openings, perimeter closures, fiber-fold orientation, and anchor positions must all be checked to avoid continuous through-joints.

Tube penetrations, thermocouple openings, observation ports, inspection-door edges, and roof-to-wall connections are susceptible to gap formation caused by temperature changes and structural movement. For narrow joints and contact surfaces not directly exposed to flame erosion, ceramic fiber paper or rope

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may be selected according to the joint dimensions, while wider or irregular cavities may be filled with suitable ceramic fiber blankets or bulk fibers. Sealing materials must be selected with consideration of operating temperature, compression requirements, and maintenance access. Where an interface is directly exposed to high-velocity flue gases or flames, refractory components should first protect the hot face, with flexible fiber sealing applied behind the protective structure.

The integrity of a modular fiber lining depends not only on its initial precompression but also on fiber-fold orientation, anchoring configuration, and treatment of joints between module rows. Radiant-section walls may use herringbone or angle-iron anchoring arrangements, depending on furnace geometry, with adjacent modules installed according to the specified fiber-fold orientation. Between module rows, ceramic fiber blankets of the same material grade may be folded into a U-shaped configuration to provide shrinkage compensation and help maintain insulation continuity. Three different mechanisms must be distinguished: the recovery of precompressed modules during installation, permanent shrinkage during service, and thermal expansion of steel structures and brick linings. Their compensation allowances are not interchangeable.

Anchor materials, weld locations, module compression allowances, blanket thicknesses, and maintenance clearance must all be specified in the installation drawings. Taken together, these three considerations form a complete lining selection approach: furnace zoning determines the lining configuration; actual interface temperatures and atmospheres determine material grades; and anchoring and sealing details integrate these selections into a coordinated furnace lining system. CCEWOOL® can match ceramic fiber modules, RCF blanket backup insulation, insulating firebricks, and suitable sealing products to the furnace drawings, individual operating zones, actual temperatures, and atmosphere conditions. For additional details on zoned lining configurations, refer to the CCEWOOL® Hydrogenation Furnace Lining Solution.