CARBON REGENERATION KILN
100 kg/h Diesel Fired Carbon Regeneration Kiln c/w Carbon Holding Hopper

3D Model of the 100 kg/h Diesel Fired Carbon Regeneration Kiln c/w Carbon Holding Hopper
CARBON REGENERATION PROCESS

Activated carbon absorbs neutral species. These species can be of organic and inorganic nature. The presence of these species in the internal surface and in the pores of the activated carbon will reduce the ability of activated carbon to absorb desirable species, in this case gold (in the calcium gold cyanide ion pair). The organic species are removed from the carbon using thermal regeneration, to restore the original porous structure and activity of the carbon causing as little damage as possible to the carbon itself.

The generally accepted conditions for thermal regeneration are in the temperature range of 650 - 750°C for a period of 10 to 30 minutes in a non oxidising atmosphere. Steam is the most economical inert atmosphere to blanket the carbon and prevent the oxidation of the carbon at higher temperatures. This inert atmosphere is created in the first or drying stage of regeneration when the moisture in the carbon is driven out of the porous structure of the carbon as steam. The steam generated atmosphere has a slight positive pressure, preventing oxygen ingressation.

All Kemix kilns are custom designed to meet application requirements with specific regard to mode of firing, voltage, frequency and throughput. Selection of the method of firing is location specific and options include electrical elements, light oil, heavy oil or gas burners.

The kiln components comprise a base frame, heating cabinet, heat source, dewatering feed screw arrangement complete with variable throughput drive, discharge hopper, main and back-up drive units, retort tube, support rollers and a fully integrated control panel.

The retort tube is manufactured from specialised alloys capable of withstanding the high temperatures associated with thermal regeneration. The welding process and method of construction with extremely tight tolerances on both straightness and concentricity on the retort tube ensures longer service life.

The design of the retort tube with consideration to peripheral speed ensures proper carbon bed turnover enhancing the complete thermal regeneration.

All Kemix kilns have an automatic start up and shut down sequence which reduces operator input. Speed variation of the screw feeder facilitates greater flexibility and complete plant integration.
Structure and Casing

The framework is fabricated from a number of rolled mild steel sections which are welded together to form a robust and stable structure. The framework allows for the mounting of the dewatering screw feeder charge section, drive arrangements, roller supports, heating section, cooling section and discharge hopper.

The casing which forms the heating section is made up of mild steel plates welded to the channel section steelwork. The roof of the casing is made from plate work sections, which are removable to allow access to the retort tube.

The kiln is inclined to the required angle on the kiln support structure. As the kiln structure is a one-piece unit, when the kiln is inclined, the screw feeder, feed hopper and discharge hopper are inclined with the kiln.

Dewatering Screw Feeder

Wet carbon is fed by gravity from the feed hopper into the hopper of the screw feeder, where it is fed directly into the kiln retort tube. The dewatering screw feeder is a robust unit and mounts directly onto the kiln structure at the charge end. The feeder casing and screw auger are manufactured from stainless steel.

The feeder is equipped with a variable speed drive unit capable of feeding at the required throughput. Coupled with the slow speed gearbox, inclined screw feeder arrangement and an enlarged screw pitch which assists in reducing the possibility of slugs of water entering the retort tube. The incline of the screw enables the water to run downwards and ensure no water entering the retort. Water entering a retort tube contributes to 90% of premature retort tube failure.

The Kemix screw feeder has a unique dewatering arrangement installed in the feed screw housing which insures that no water could be fed into the retort tube. An over flow has been designed which will drain of access water if the level inside the screw feeder housing reaches critical levels due to blinded screens.

The Kemix screw feeder also makes use of candle filters, for ease of cleaning and replacement. This design does not require any major components to be dismantled to service or clean the candle filters.
The screw feeder flight and casing has been designed to utilize the carbon and acts as a lining medium between the screw and the casing, this design ensure that the outer casing does not wear, the only wearing part in the feed screw is the screw itself.

The screw is supported and the back of the screw by using a custom design bearing support. This enables the screw to penetrate directly into the retort and allows mechanical expansion at different temperatures.

The screw feeder is also equipped with an open drain assembly, this helps the operator to visually identify if the wedge wire screen is blinded or blocked.

Electrical interlocks are incorporated in the control design, to prevent the screw feeder transferring carbon into the retort tube until a pre-set temperature or should rotation of the tube stop.

**Advantages by using the Kemix screw feeder arrangement:**

- No Pre Drying of Carbon Required.
- No Additional Steam required.
- **No Water entering the retort via screw feeder and cause premature retort failures.**
- Less down time to replace the screw flight, wedge wire panel and other sub assembly parts.
- Minimum maintenance required on wedge wire panels.
- Screw Feeder is fully fabricated from Stainless Steel.
- Use of mechanical reduction to optimize power efficiency and low rpm on screw flight, Low Operating Cost.

**Retort Tube**

The retort tube of the kiln is manufactured from 321 stainless steel. The length of the tube is sufficient to accommodate the heating zone, cooling zone, charge section, drive arrangement, support rollers and discharge hopper.

Fitted inside the retort tube at the feed end is a stainless steel end plate which allows the feeding portion of the screw feeder to project into the tube and prevents carbon feedback into the charge section.
The retort tube is a one-piece unit and is supported by two forged steel riding rings, located at the feed and discharge ends of the kiln, i.e. either side of the heating zone.

The solid support rings are bolted to stainless steel spokes which are welded to the outer wall of the wrapper plates. The "Z" shaped flexible spokes allow for expansion of the retort tube.

EN9 steel rollers, supported by roller bearings in plummer blocks, carry the retort tube via the riding rings. The tube is positively fixed at the feed end between two thrust rollers, mounted either side of the front riding ring on the kiln support structure.

The support rollers at the discharge end have a face width greater than the calculated expansion which allows free movement of the tube along its length.

The riding rings, plate wheels, chains and steel rollers are enclosed within expanded metal guards.

A removable inspection cover is provided in the rear wall of the discharge hopper which allows for inspection and deposit removal inside the retort (silica for example).

Fitted to the sides of the kiln at the discharge and feed ends are automatic drip feed lubricators filled with oil, which is allowed to drip lubricate the chains, support rollers and riding rings. The bearings and thrust rollers are provided with greasing points mounted outside the guards. The main kiln drive, emergency DC drive and chain tensioners are mounted inboard of the kiln structure.

Discharge Hopper

Located at the discharge end of the kiln is a stainless steel hopper mounted on the main frame. Because the retort tube is "fixed" at the charge end between the two thrust rollers, the expansion which takes place along the length of the tube is accommodated in this hopper. Mounted on top of the hopper is a discharge duct, for the release of steam/volatile gases, etc., from the interior of the retort tube. An exhaust stack would be connected to the discharge duct during installation.

A large access door is mounted in the rear wall of the discharge hopper which allows access to the retort tube for maintenance and cleaning of the inside of the tube.

A small inspection cover plate is fitted to the access door which permits the operator to visually monitor the progress of carbon along the tube.

A stainless steel discharge pipe is fitted to the bottom of the hopper, allowing carbon to be discharged directly into the quench tank below.

Seals

Sealing of the retort tube at the face of the charge section, discharge hopper and furnace casing is affected with 50 mm square ceramic fiber seals. This eliminates unnecessary heat loss and provides a positive pressure within the tube. The seal housings are adjustable to compensate for wear on the seals.

Thrust Rollers

The thrust rollers are mounted on the main frame and are located on either side of the feed-end riding ring on the centerline of the tube at a height which allows them full contact surface with the sides of the riding. The distance between the inner surfaces of the thrust rollers is approximately 5mm greater than the width of the feed-end tyre.

Support Rollers

The mass of the rotating kiln tube together with the material content in operation, is carried at the feed and discharge ends through riding rings. These are mounted concentrically to the kiln tube and on rollers mounted directly to the main frame. The expansion in tube length at operating temperature is accommodated by the longer discharge end rollers as the feed end remains located between the thrust rollers. Both the feed end and the discharge end rollers are mounted parallel and equidistant to the center-line of the tube. The accuracy of this alignment is important, both from the point of view of tyre / roller wear and steering.

Steering

In order to achieve a continuous positive flow of material through the inside of the tube, the entire furnace is set at an inclination to the horizontal, the feed-end being higher than the discharge-end. As the rollers are attached to the main frame, they too will be inclined to the horizontal at the same angle and in full contact with the riding rings attached at right angles to the tube.
This inclination to the horizontal, whilst relatively small, creates a horizontal component of the vertical loads and must be counteracted.

The ideal running condition is achieved when the feed end riding ring runs continuously between the upper and lower thrust rollers without making contact. However, due to variations in load, and/or lubrication conditions, this is not always achievable on a continuous basis. The thrust rollers will handle periodic contact.

In order to preserve the life of both the riding rings and the rollers, the contact surfaces between them should be continuously and adequately lubricated.

Chains and Riding Rings Lubrication System

Lubrication of the chains and riding rings is automatic. Solenoids mounted on the base of cylindrical oil tanks are operated via the shutdown temperature controller to automatically start and stop the oil feed during operation, this prevents unwanted oil flow onto the chains and riding rings during shut down periods.

Oil drip rates are adjusted via valves mounted on the underside of the oil tanks.

Sight glasses monitor oil level in the cylindrical tanks. Periodic topping up is all that is required, as and when necessary.

Bearings

The support and thrust bearings are manually serviced via grease nipples mounted on easily accessible greasing stations on the side of the kiln.

This needs to be done on a weekly basis, as high temperature grease needs to be purged regularly to prevent drying and caking in the bearing housing.

Kiln Main Drive

When operating under normal conditions, the retort tube is driven by an AC motor, close coupled to a reduction gearbox with a keyed shaft arrangement.

Mounted on the output shaft of the gearbox is a free-wheel clutch fitted with chain sprocket. The driving of the tube is effected with a simplex chain from the driving sprocket to a plate wheel mounted on the tube.
A frequency inverter is installed in the electrical control panel to provide the required rotational speed of the retort tube.

**Emergency Drive**

An emergency DC drive system is incorporated to protect the heated retort tube from distortion when the main power supply is interrupted. Changeover from mains supply to emergency supply and vice versa is automatic and instantaneous. The speed is fixed.

The battery supply will drive the tube for a minimum period of four hours to allow the tube to cool to a safe temperature. As the emergency drive system is dependent on power from the batteries for its function, it is important to remember that for the emergency backup system to function properly, the batteries need to be kept charged.

If a rotation fail or mains fail situation occurs, the kiln will automatically trip to emergency drive. This condition will remain to run until one of the following occurs.

i. The alarm is reset and the fault is cleared.
ii. The kiln temperature has dropped below the level set on the DC shutdown controller.
iii. Low battery voltage is detected.
iv. The mains are restored in case of a power failure.

**Rotation Check**

Continuous checking of the tube rotation is achieved with a proximity detector, which supplies a reset pulse to the pulse relay card mounted in the control panel. If no pulse is received the timer relay energises after a preset period and initiates the alarm system.

i. Sounds an audible “Rotation Fail” alarm.
ii. Switches off the power to the main drive motor.
iii. Switches off the power to the heating system.
iv. Switches off the screw conveyor motor.
v. Switches on the auxiliary drive motor.

The rotation check will operate exactly the same way, no matter if the failure is electrical or mechanical.
The following rotation check devices are available:

i. Inductive Proximity Sensor
ii. Laser Proximity Sensor

**Alarm system back-up**

The 24V DC alarm system is designed to control the changeover from main to emergency drive and shut down the kiln in an orderly fashion to keep the retort tube rotating until sufficiently cool to stop.

**Insulation**

The roof, side and end walls are lined with various grades of ceramic fibre blanket, limiting heat losses to a minimum and significantly reducing the overall weight of the kiln. The blanket is attached to the casing with heat-resistant, high chromium steel studs, stud-welded to the inner wall and held in place with Twist-lock washers.

**Electric Kiln Heating Medium**

The layout out and positioning of elements in a Kiln is the most critical criteria to be reviewed during design and construction phase, this part of the Kiln will determine the operating cost as well as the down time required to replace or maintain these elements.

The following points need to be taken in consideration with position and selection of elements:

- Access to elements to replace and maintain.
- Dust accumulation on elements.
- Mechanical parts to be removed to gain access to elements (Retort).
- Electrical connection points.
- The accumulated heat from the element into the electrical connection point.
- Heat Transfer coefficient to the Carbon bed.
- Watts loading per element.
- And the philosophy of electrical current control.

Kemix has developed the use of the SIC Element which is controlled by using Phase Angle Controllers which enables to deliver the required heat at a given time without any delays.

The SIC Elements offers the following advantages against other types of Elements:

**Advantages of Kemix SIC elements above any other Element Type:**

- Less elements required to produce the same KW of heat.
- The elements offers a cold connection point on both sides of the elements, which led to no heat losses outside the insulation area and has no hot electrical connections.
- Specified heat radiation surface which enable direct heating onto the carbon bed positioned on the lower side of the retort tube.
- Elements extend through the sidewall which enables replacement from the side of the kiln, instead from the top or even from the inside of the cabinet.
- Elements are position below the retort tube in close proximity to the carbon bed which reduce heat losses due to the direct heat radiation in to the carbon bed.
- Elements are raised from the floor which allows accumulation of dust and spillage on the bottom of the floor without effecting the elements.
- Elements does not deform and cause to short out and burn off.
- Estimated Life Cycle on Element set is 5-7 Years.
- Maintenance is greatly simplified as elements can be replaced while the furnace is hot reducing downtime due to replacement while furnace is hot, Element replacement takes 5-10 min and only requires one person to perform the task.
- In some applications the use of metallic elements (including candle elements) creates a risk of short circuit / tracking due to conductive dust (including carbon regen & vanadium furnaces). SIC perform better in this environment.
- Maximum element temperature capability exceeds those of metallic heating elements.
- Element support is simplified (only uses one or two ceramic supports compared to many hangers needed for metallic strip elements)
- Higher power density is possible with SIC compared to metallic heating elements
- High efficiency due to increased emissivity
- Can be installed across long distances (in excess of 3m in special cases) due to high mechanical strength

KEMIX SIC Elements

Clamping Arrangement on SIC Elements (No Bus Bar Connection Required)

Kemix SIC Elements Installed on Bottom of the Retort, Operation at Temperature

Cold Connections on Bus Bars when the Kiln is in Operation

Installation of SIC Element from Outside of Kiln with no Mechanical Access Required, Only Electrical Isolation Required.
Strip and Candle Element Disadvantages:

Strip Elements

- Strip elements have a design Watt loading of 2 - 3 W/cm² which results in many elements to provide the KW Heat required. (Photo 1)
- Elements will be positioned on the bottom of the retort and on the side which requires the retort to be removed to gain access to replace the units. (Photo 1&3)
- Temperature on the connection points of the elements is approximately 170Deg C, which results in cable and bus bar fatigue. (Photos 6-8)
- Dust settling within an on top of elements which insulate the strip and cause elements to burn off.
- High Operating cost on replacing elements. (Life expectancy on elements is between 1-2 years on a set)

Candle Elements

- The watt Loading per element is similar than the strip elements due to the same material of construction which results in much more elements to be installed to provide the KW heat required.
- The roof will be fully fitted with elements supported from the top hanging down on both sides of the retort. Due to the Elements being positioned on the side of the retort which has no direct heating into the carbon bed (Heat Transfer Efficiency into Carbon is less than SIC Elements)
- The elements will start to stretch under its own weight at operating temperatures, and cause premature failures.
- Temperature on the connection points of the elements is approximately 170Deg C, which results in cable and bus bar fatigue.
- Dust settling within the ceramic discs causes elements to burn off.
- High operating cost on replacing elements (Life expectancy on elements is between 1-2 years on a set)
- Removal or replacement of elements after being in operation becomes difficult due to the bending and distortion of the elements.
New Replaced Strip Elements – Actual Down Time to Complete Repairs 52 Hours

Electrical Connection onto Bus Bars – The Discoloring of the Bus Bar Must be Noticed

Bus Bar Fatigue as a Result of Excessive Heat From the Element Connection

Cable Insulation Started Melting as a Result of Excessive Heat from Element Lead Out From the Cabinet

Strip Element Burned Off – Mayor Safety Risk That Could Cause Electrical Short Circuit

Candle Element Burn Off and Distort After Being in Operation
Electric Fired Carbon Regeneration Kiln c/w Kemix SIC Elements

1700 kg/h Diesel Fired Carbon Regeneration Kiln