Iron ore pelletizing

Grate-Kiln™ system

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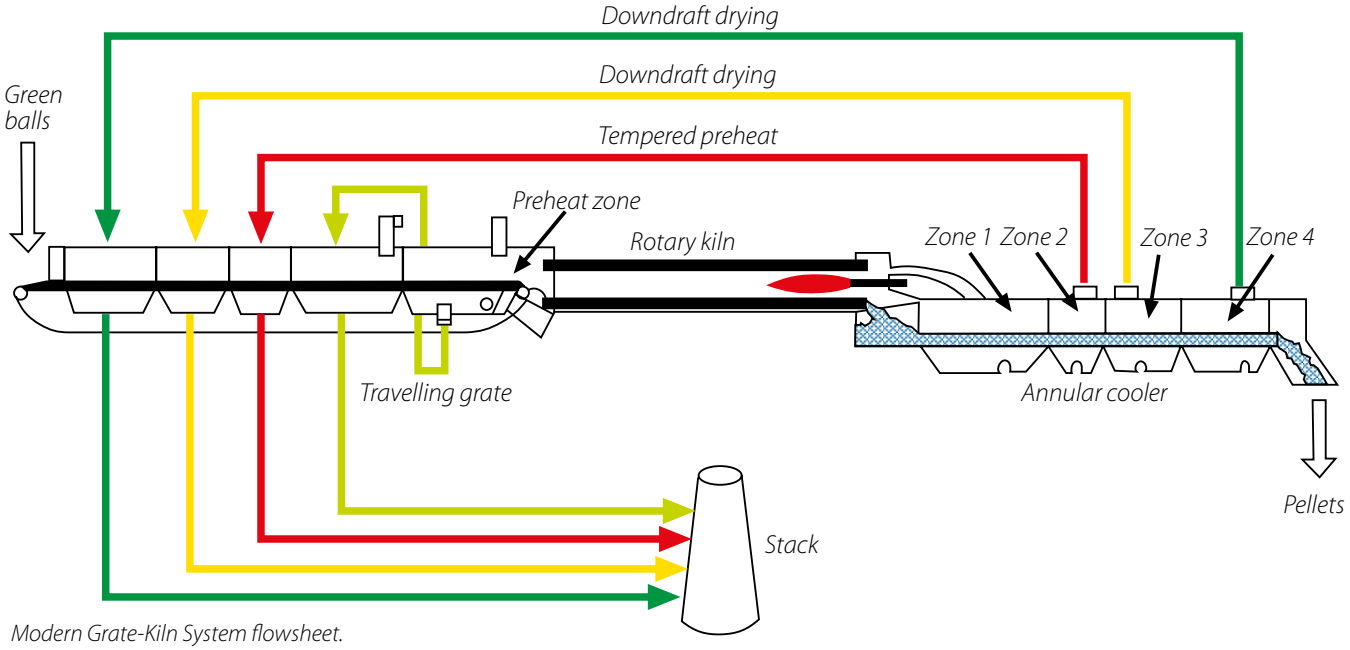
Plant overview

Grate-Kiln™ iron ore pelletizing system

The first Grate-Kiln™ system pellet plant was installed in 1960. The plant took iron ore concentrate and produced superior iron ore pellets (which are spheres of high iron content and uniform quality) for blast furnace and direct reduced iron feed. Since then, Grate-Kiln systems have been used for over 50 plants, on both magnetite and hematite ores, with an installed capacity of over 115 million tpy.



Modern Grate-Kiln System flowsheet.

Process flexibility

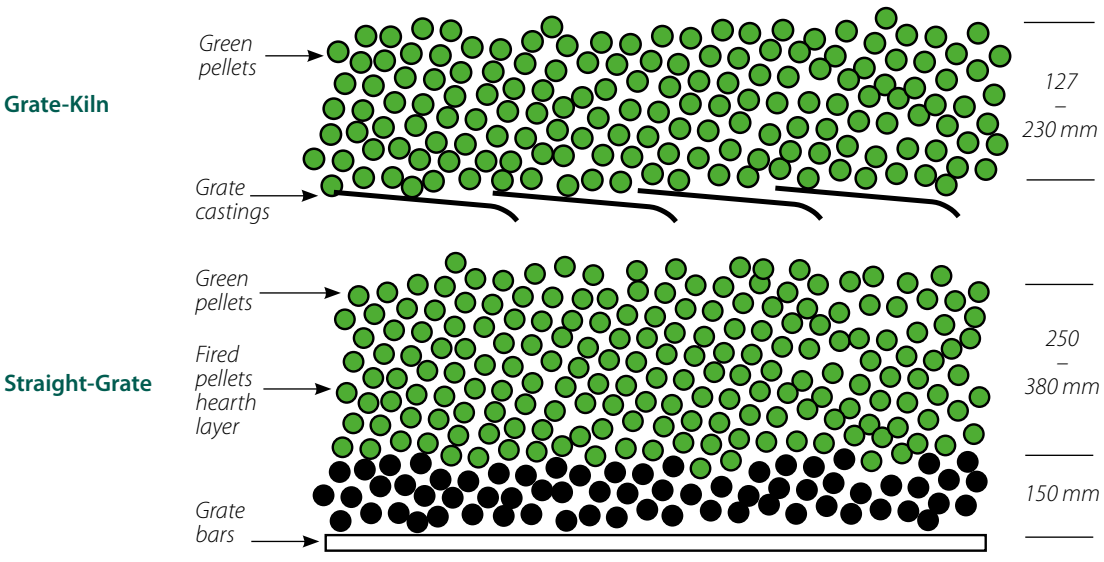
There are two main processes for producing iron ore pellets: The Grate-Kiln system and the straight grate system. In the straight grate system, a continuous parade of grate cars moves at the same speed though the drying, induration and cooling zones. Any change in one section effects the residence time in another.

In the Grate-Kiln system, independent speed control of the grate, kiln and cooler are available to the operator. This provides process flexibility to adjust to changes in concentrate feed.

Pelletization process

Pelletization is comprised of two main stages: (1) agglomeration and (2) induration. During agglomeration, finely ground particulates (usually 80% passing 44 micron) of ore concentrate (with a moisture content of approximately 9%) are mixed with additives and binders and sent to the balling drums or discs where the forces act between the particle grains to create a bonded pellet referred to in the industry as a "green ball."

The green balls formed during the agglomeration process are then strong enough for transport to the Grate-Kiln™ induration machine. There the green pellets are subjected to certain varying process zones of drying, preheating, firing and cooling. Each zone varies by temperature and residence time in order to ensure that all bonds and mineral bridging is formed, strengthening and heat hardening each green ball into an indurated pellet product which is then suitable for feed in the steel making process.



Installation of conveyor chain "Blanket" into travelling grate

Energy efficiency

The Grate-Kiln® induration machine is composed of three separate process pieces of equipment.

The traveling grate is used primarily to dry and preheat green balls for feeding into the rotary kiln, where they are indurated. Once the green balls are made they are spread out evenly across the grate. The traveling grate provides the means for heat transfer with high, medium and low temperature gases.

It utilizes the heat coming from the kiln and cooler to perform this heat recovery. These gases transfer heat by convection so gas to solids contact is required for effective heat transfer. Green balls must be heated at a controlled rate to prevent the development of internal steam (from green ball moisture) which can cause agglomerate rupture if the moisture is evaporated too rapidly. The temperature of the gases used for green ball drying is limited by the characteristics of the specific green balls. It is necessary to promptly remove water vapor from the bed.

The refractory lined rotary kiln performs the induration and creates a mixing of the material bed and complete mineral bridging of the green balls into heat hardened pellets. The kiln also gives a robust firing chamber for combustion of fuel. The rotary kiln is a downwards sloping cylinder from the traveling grate to the annular cooler. The speed of rotation controls the rate of solids flow through the rotary kiln and imparts a mixing action to the pellet burden. The mixing action is important because it creates a homogeneous pellet product. All of the pellets are exposed to the burner flame for an equal amount of time. In the rotary kiln, the preheated balls are heated and maintained at a set temperature to develop pellet quality.

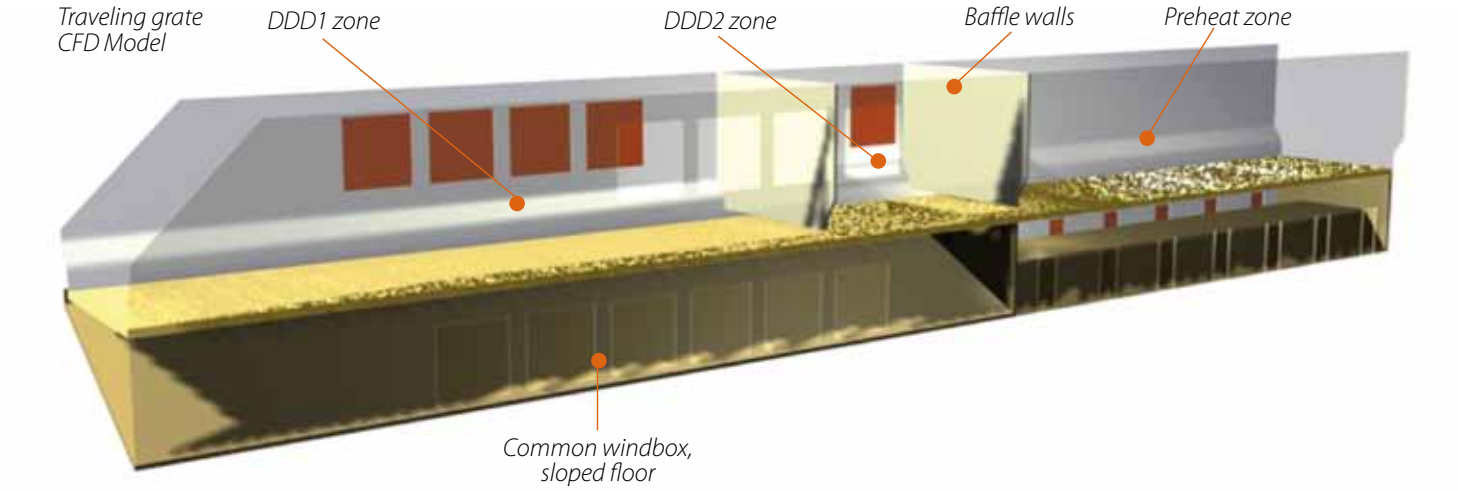
The rotary kiln in the GK System is designed for a retention time based upon the pellet feed and product requirement. This residence time is sufficient to uniformly indurate all pellets, thereby minimizing the ball-to-ball quality differences inherent in pellets discharging from the static bed processing. Depending upon the pellet, the designed residence time will vary from 13 to 30 minutes. The rotary kiln has a variable speed drive system for control and optimization.

The forced air annular cooler is used to cool the fully indurated pellets. This recoups the heat and allows for handling of the pellets to storage and shipping. The annular cooler is functionally the same as the traveling grate except for its annular configuration. Hot pellets discharging from the rotary kiln are discharged directly to the annular cooler. Ambient air is forced upwards through the conveying elements (pallets) and the bed. Thus machine parts are not exposed to high temperatures.

The pellets are leveled in the annular cooler to a uniform bed depth and conveyed over the primary and final cooling zones. In each cooling zone, sufficient cooling air is provided to produce the mass of air at temperature required by the rotary kiln and traveling grate. Sufficient total air is supplied to cool the pellets to the temperature that the product handling system will tolerate. The annular cooler is divided into three windbox zones under the pellet bed with cooling air supplied to each zone by an independent fan. The area above the bed of pellets is also divided into four zones.

In a straight grate, the grate cars have to go through the drying and induration zones. So, a deep bed of pellets with a hearth layer is required.

Another part of the Grate kiln system process flexibility is because there is only one burner. The kiln burner can use liquid gas, or solid (coal or biomass) fuels separately or in combination. One burner reduces maintenance costs and improves fuel efficiency. In the Grate Kiln System, 95% of the air used for combustion is +1,000 C air from the cooler.



Feautures and benefits

Pellet quality

Because the induration of the pellets occur in the rotary kiln, the pellets produced in a Grate-Kiln system are consistently of higher quality than those produced in a straight grate. The rotary kiln provides constant mixing of the pellets, bringing all the pellets to the same temperature. In a straight grate, the pellets at the top of the bed are "over cooked" and those at the bottom are "under cooked". Higher quality means fewer fines, better reducibility and less variation in compression strength.

Ported kiln operation

By injecting air under the bed of pellets in the rotary kiln, complete oxidation can occur in magnetite pellets prior to the annualar cooler. This patented development by Metso, in addition to lowering fuel consumption, significantly improves pellet quality. Full oxidation at induration temperatures produces stronger pellets, while maintaining reducibility. This capability is unique to the Grate-Kiln system.

Predictive control systems

The use of control systems employing expert system designs increases the opportunity to optimize plant performance on a continual basis. By being able to correlate changes continually, the plant can anticipate operational changes and make corrections. Metso's implementation of this type of control technology for Grate-Kiln® pellet plant will make it possible for operators to increase capacity, reduce fuel and power consumption, and reduce maintenance costs.

Kiln drive components

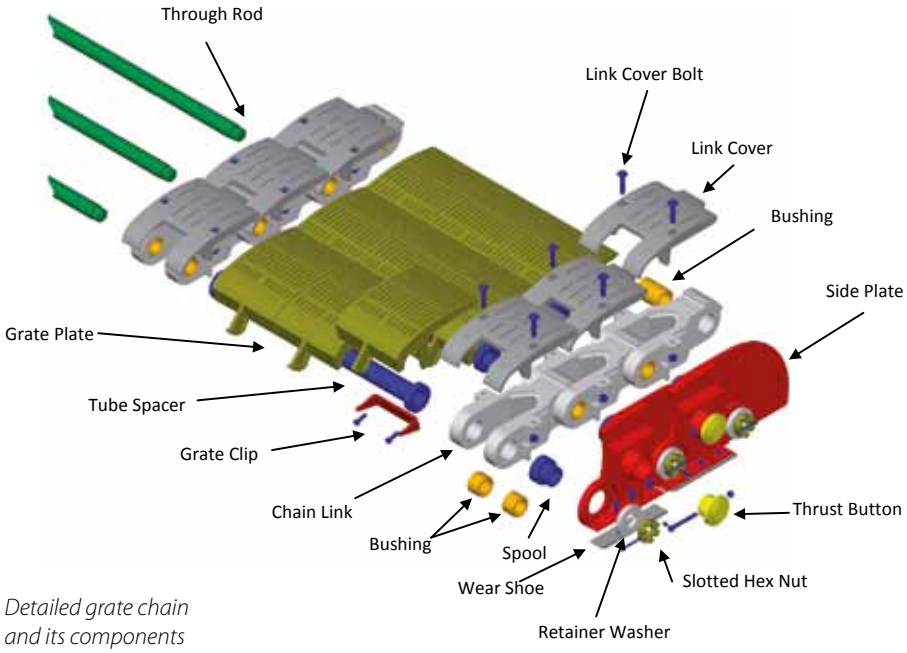
Equipment description

Grate

The traveling grate is a conveyor that transports balled iron ore concentrate through cross-flow processing zones. The conveying element is a continuous loop assembly of slotted ferrous stainless steel grate plates, chain castings, and side plates to carry a bed of agglomerates. The upper, active, carrying portion of the conveying element is supported level and flat over a head shaft, intermediate upper supporting shaft/roller assemblies and a tail shaft.

The grate is driven by a bull gear drive assembly and a variable frequency drive and motor or hydraulic drive at the head shaft, and sufficient speed variation is provided to maintain the required bed depth over a reasonable wide variation in feed rate.

The processing zones consist of furnace over the active run, and windboxes underneath. These are enclosures to contain and direct process gases as they flow through the grate. The elements of the conveyor and the upper and lower enclosures are supported on a frame of steel structural members. The frame, being a machine element, is meticulously set, rigidly braced, and force-air cooled in the preheat zone to assure the true alignment of the conveying element during operation, heat-up, and cool-down.



Detailed grate chain and its components

Kiln

The kiln is a refractory lined cylinder rotating about its axis. The kiln slopes slightly downward from feed to discharge end. The slope and rotation of the kiln move the material through it. Kiln speed is variable to vary pellet retention time. The kiln is a single chamber with an open feed end connected by housing to the grates preheat furnace

Through this connection is the inflow of material to the kiln and outflow of kiln gas to the preheat furnace. The kiln's discharge end is open and connected to the cooler by a firing hood. Through the firing hood, pellets flow from the kiln to the cooler and primary cooler off-gas flows into the kiln.

The rotary kiln has two (2) main drive motors for speed control between 0.5 to 1.5 rpm kiln speed. Two auxiliary drives, one electric and one diesel, are provided and they drive the kiln at 0.1 rpm.

Dual drive iron ore kiln

Cooler

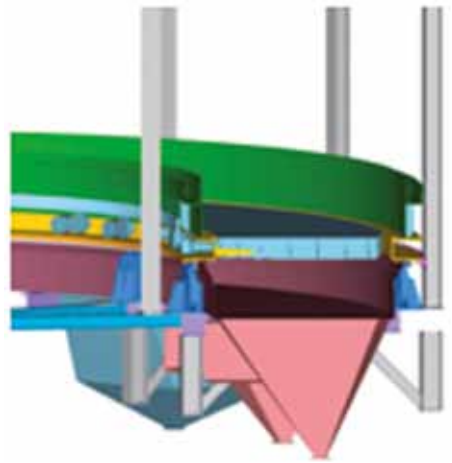
The cooler is essentially a grate formed into a rotating annular channel. Pellets discharging from the kiln are leveled to a uniform bed depth by the screed wall. As the annulus rotates, the bed of pellets is conveyed through the cooling zones. The bed is carried on slotted, heat resistant pallets from the upward vertical passage of outside air. The sides of the bed are supported by refractory walls. After cooling, the pallets are tipped to discharge the pellets. Cooler speed is variable to control indexing of cooler. The active run of the cooler is enclosed above and below superimposed chambers that form the cooling zones.

Continuous improvements

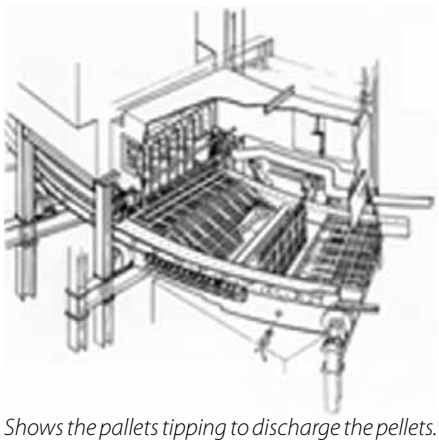
There are on-going developments in the Grate-Kiln system that have significantly improved the reliability and ease of maintenance of the equipment. The use of higher grade alloys in the traveling grate have proven effective for longer life. Foating seals in the traveling grate reduces air leakage. Annular coolers are now made with water seals and fabricated steel pallets. The rotary kiln and dump stacks uses the patented Metso Superdeal[tm] kiln seals to reduce air leakage.

Metso has on-going development programs using advanced modeling systems to improve the system. Finite element analysis is used on the grate components to improve life. CFD analysis is used to continue reducing the fuel and power requirements. heat and mass balance model studies are done to optimize a system for a particular iron ore concentrate or fuel.

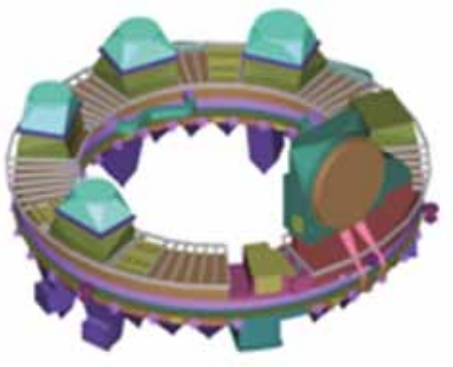
These changes have also made it possible to increase the capacity of the Grate-Kiln system. The original plant had a capacity of 300,000 tpy. Plants today are operating at close to 6.0 million tpy, and Metso has designs for a Grate-Kiln system with a capacity of up to 7 million tpy.



Side view of the pallets that carry the indurated pellets



Shows the pallets tipping to discharge the pellets.



Show the overall cooler and how the cooler is laid out.



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