Business Plan for the Industrial Application of Activated Calcination of Coal Gangue Using an Intelligent Three-Ring Kiln

This business plan outlines an industrial project for the full-component, high-value utilization of coal gangue, employing the large-scale patented HNS series Intelligent Three-Ring Kiln and its associated activation calcination technology, independently developed by Shandong Hening Shun Kiln Industry Co., Ltd. The core concept of this project is to "squeeze every last drop" of value from coal gangue, transforming this low-value, highly polluting industrial solid waste into a diversified product portfolio that includes high-end new materials, fine chemical products, and green building materials. This approach aims to completely solve the solid waste disposal problem and build a high-value-added circular economy industrial chain.

The technical core of the project is the use of the Intelligent Three-Ring Kiln for the "activation roasting" of lump coal gangue. This process efficiently activates its inert silicon-aluminum components, a critical step that unlocks the subsequent full-component separation and utilization. The process yields the following products in sequence:

1. **Core High-Value-Added Products:** Metallurgical-grade alumina (which can be further processed into a series of refined alumina products) and silicon dioxide (which can be further processed into nano-grade silica sol, silica fume, etc.).

2. **High-End Application Products:** Synthetic high-end refractory materials (high-purity mullite products, cordierite, etc.).

3. **Backstop Product:** LC3-50 low-carbon cement.

This project model subverts the traditional cost logic of solid waste disposal through a "triple-revenue" model of "product profit + government subsidies + carbon trading income," ensuring strong profitability and an excellent return on investment. Compared to

traditional processes, this project holds a commanding advantage in energy consumption costs (reduced by over 60%), automation levels, and environmental protection standards.

1. Project Overview and Technical Advantages

1.1 Project Background: From "Industrial Burden" to "Urban Mine"

As an industrial solid waste with enormous reserves in China, the large-scale stockpiling of coal gangue not only occupies land and pollutes the environment but also represents a tremendous waste of valuable silicon and aluminum resources. This project aims to transform coal gangue from an "industrial burden" into a high-value "urban mine" by unlocking its intrinsic value through technological innovation.

1.2 Technical Solution: "Activation Roasting" is Key

The core technological foundation of this project is the use of an Intelligent Three-Ring Kiln to perform "activation roasting" on coal gangue. This kiln is not merely a simple calciner but a highly efficient "chemical reactor and activator."

Core Principle: Through graded temperature control across three zones (preheating, decomposition, activation), the stable kaolinite crystal lattice in the coal gangue is broken down within the activation zone at 900–1100°C, controlled with a precision of ±15°C. This transforms it into highly chemically active, amorphous metakaolin.

Activation Efficiency: This process achieves over 95% utilization of the silicon and aluminum components in the coal gangue. This is the prerequisite and guarantee for the subsequent full-component separation and high-value utilization.

Direct Firing of Lumps: The kiln can directly process large materials from 3 to 30 centimeters, eliminating the need for pre-crushing and simplifying the process, with a raw material utilization rate exceeding 95%.

Energy Efficiency: Thanks to a closed-loop thermal energy circulation system, the comprehensive thermal efficiency is as high as 78%. The cost to calcine one ton of coal gangue is only 60–80 RMB, a reduction of over 60% compared to the 200+ RMB cost of traditional kilns.

Intelligent and Eco-Friendly: The system employs fully sealed robotic operations, replacing 80% of manual labor. Through targeted sulfur fixation, vitrification of heavy metals, and multi-stage dust removal technology, it achieves ultra-low emissions of pollutants like SO_2 and dust, far exceeding national standards.

2. Product Planning: "Squeezing Every Last Drop" for Full-Component Utilization

This project aims for "squeeze every last drop," full-component utilization of resources. It builds a diversified, high-value-added circular economy industrial chain centered around the activated coal gangue clinker.

2.1 Core High-Value-Added Products

Aluminum Product Line: Metallurgical-Grade Aluminum Hydroxide and Fine Alumina

The alumina in the activated clinker is efficiently leached out using a hydrochloric acid graded leaching process to form an aluminum chloride solution, which is ultimately used to produce aluminum hydroxide.

The product can meet metallurgical-grade standards (Al_2O_3 ≥65%) and can be further extended to fine alumina products such as nano α-alumina.

Silicon Product Line: Nano-Grade Silica Sol and Silica Fume

The insoluble silica residue from the acid leaching undergoes steps like alkali dissolution for silicon extraction and nano-colloid stabilization to produce a high-purity, high-specific-surface-area silica sol powder product.

It boasts excellent technical specifications (particle size 30±5nm, specific surface area >500m²/g) and can be widely used in strategic industries such as semiconductors and new energy.

2.2 High-End Application Products: Synthetic Refractory Materials

The high-purity alumina and high-activity silica sol produced are ideal raw materials for synthesizing advanced refractory materials like mullite and cordierite. The activated clinker itself can also be used as a raw material for high-end refractories (e.g., as a substitute for flint clay). This approach opens a new path for producing metallurgical-grade alumina and high-end refractories without relying on high-grade natural minerals like bauxite, which helps ensure the security of China's basic industrial supply chain.

2.3 Backstop Product: LC3 Low-Carbon Cement

After the high-value aluminum and silicon components have been extracted, the final residue is used to prepare low-carbon cement (LC3-50) clinker. This step is key to achieving "zero solid waste discharge," transforming an environmental burden into a valuable green building material. The produced LC3-50 cement can reduce the carbon emissions of the cement industry by 40%.

3. Market Analysis and Business Model

3.1 Market Positioning and Outlook

This project is positioned to become a leader in the two major fields of "high-value utilization of industrial solid waste" and "inorganic non-metallic new materials."

Market Opportunity: Under the "Dual Carbon" goals, the resource utilization of solid waste is a market with enormous potential. At the same time, using low-cost solid waste to produce high-end materials as a substitute for expensive natural minerals provides unparalleled market competitiveness.

Target Customers: Downstream customers include multiple high-growth industries such as alumina, fine chemicals, high-end refractory materials, semiconductors, new energy, and green construction.

3.2 Business Model: The "Triple-Revenue" Model

This project breaks the traditional industrial model of relying on single-product profit by constructing a robust and diversified "triple-revenue" economic model.

Core Product Profit: The primary income is generated from the sale of the aforementioned high-value-added product portfolio.

Government Financial Subsidies: As a key project encouraged by the state for the comprehensive utilization of bulk solid waste, it is eligible for corresponding financial subsidies and policy support.

Carbon Trading Market Revenue: The project's significant energy-saving effects and CO_2 emission reductions can generate considerable additional income in the carbon trading market.

4. Financial Forecast and Socio-Environmental Benefits

4.1 Financial Forecast

Cost Structure: Raw material costs are extremely low, and there are government subsidies for solid waste disposal. Energy costs are reduced by over 60% compared to traditional processes. The high level of automation saves 80% on labor costs.

Revenue Structure: The diversified product portfolio mitigates market risks, while high-value-added products ensure high-profit margins.

Return on Investment: Thanks to extremely low operating costs and diversified revenue sources, the project demonstrates strong profitability and an excellent outlook for return on investment.

4.2 Social and Environmental Benefits

Environmental Benefits: The project achieves the harmless disposal and resource utilization of coal gangue, with the scale of disposal determined by the project investment, effectively solving the problem of solid waste stockpiling. By producing low-carbon products, it also helps downstream industries achieve synergistic carbon reduction.

Social Benefits: It promotes the transformation of the regional economy from resource-dependent to technology-driven, helping to build an industrial cluster worth a hundred billion. It secures the supply chain for key raw materials and serves as a model for practicing the concept of "new quality productive forces" and advancing green, high-quality industrial development.

5. Conclusion

The project for the industrial application of activated calcination of coal gangue using an Intelligent Three-Ring Kiln offers a "Chinese solution" to the global problem of coal gangue that is simultaneously economical, environmentally friendly, and strategic. It achieves this through its disruptive "activation roasting" technology and its "squeeze every last drop" full-component utilization model. This is not just a solid waste treatment project, but a new industrial paradigm driven by smart manufacturing, guided by a circular economy, and aimed at the output of new materials. With high technical barriers, broad market prospects, and a clear profit model, this project possesses extremely high investment value and vast potential for widespread implementation.