DUST CONTROL SOLUTIONS IN CEMENT PRODUCTION LINE IN VIETNAM

GIẢI PHÁP KIỂM SOÁT BỤI TRONG CÁC DÂY CHUYỀN SẢN XUẤT XI MĂNG Ở VIỆT NAM

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Abstract: *Controlling dust in industrial production environments is always a pressing issue for businesses, branches, and levels. The document of the 12th National Party Congress 2016 again demonstrated the Party's consistent viewpoint on environmental protection, that is to limit and proceed to overcome the state of destruction and environmental pollution of production establishments and industrial parks, finally to end the situation of environmental pollution, enhance prevention and control of sources of environmental pollution ...*

In our country, there are up to hundreds of cement factories with new and old technology applied. Dust in the production and transportation environment of cement and materials is particularly dangerous to human health and surrounding ecosystems. Knowing so many recommendations, calling from the realities of people's lives, but because of economic pressure, the livelihood of living, sustainable development is exchanged. The contribution of the community from the understanding of the situation, propagating and disseminating knowledge, planning appropriate investment, construction, production, and contributing or providing solutions to solve problems pollution is an important goal of coming up with the root of the problem. This paper presents some studies on technical issues in the design of plant transport chains, new solutions for dust control.

Keywords*: Dust control, cement production, INWASCON, RAZI PUBLISHING.*

Classification number: *2.3*

Tóm tắt: *Kiểm soát bụi trong các môi trường sản xuất công nghiệp luôn là vấn đề bức thiết của các doanh nghiệp, các ngành, các cấp. Văn kiện Đại hội Đảng toàn quốc lần thứ XII 2016 một lần nữa thể hiện quan điểm nhất quán của Đảng đối với công tác bảo vệ môi trường là hạn chế, tiến tới khắc phục căn bản tình trạng huỷ hoại, ô nhiễm môi trường của các cơ sở sản xuất, khu công nghiệp, tiến tới chấm dứt tình trạng gây ô nhiễm môi trường, tăng cường phòng ngừa và kiểm soát các nguồn gây ô nhiễm môi trường...*

Hiện nay, trên cả nước có đến trăm nhà máy sản xuất xi măng với các công nghệ áp dụng cả mới và cũ. Bụi trong môi trường sản xuất, vận chuyển xi măng và các nguyên vật liệu đặc biệt trở nên nguy hiểm tới sức khỏe con người và hệ sinh thái xung quanh. Biết bao khuyến cáo, kêu gọi từ những thực trạng cuộc sống của người dân, nhưng vì áp lực kinh tế, vì cuộc sống mưu sinh mà sự phát triển bền vững bị đánh đổi. Sự đóng góp chung tay của cộng đồng từ việc hiểu rõ thực trạng, tuyên truyền phổ biến kiến thức, hoạch định chính sách đầu tư, xây dựng, sản xuất phù hợp, đến việc đóng góp cung cấp các giải pháp giải quyết vấn đề ô nhiễm là mục tiêu quan trọng của việc tiến tới khắc phục gốc rễ vấn đề. Bài báo này trình bày một số nghiên cứu về vấn đề kỹ thuật trong thiết kế các dây chuyền vận chuyển của nhà máy, các giải pháp mới về kiểm soát bụi.

Từ khóa: *Kiểm soát bụi, sản xuất xi măng, INWASCON, RAZI PUBLISHING.*

Chỉ số phân loại: *2.3*

1. Introduction

Cement consumption in recent years has been constantly growing, and that is an important driving force for the cement industry to develop in some developing countries in Asia. It is forecasted that the demand for cement will increase annually to serve the infrastructure development needs of countries such as China, India, the US, Japan, Korea, Russia, Spain, Italy, Brazil, Iran, Mexico, Turkey, Vietnam, Egypt, France, Germany ... In Vietnam, in the past years, the cement industry has also contributed a significant part to the economic growth rate. The government has identified cement as a strategic development industry to support national economic development. However, the cement industry also causes many bad consequences for the environment, destroys

landscapes, relics, consumes natural resources, causes greenhouse effects.

Vietnam currently has nearly 100 cement factories, with many different forms of construction investment: from state-owned or indirectly controlled and owned factories and joint ventures with foreign countries to cement factories invested by localities, industries, and private enterprises. Cement factories in Vietnam still use three types of cement production technologies: vertical kiln technology, wet rotary kiln, and dry rotary kiln. There are now 70 cement plants using rotary kiln technology. These cement factories have been invested to build or convert, upgrade and all use modern production technology from EU and G7 countries. Equipment and technical level of these factories are similar to other factories in Southeast Asian countries. All factories have been invested in electrostatic dust filter system registered by departments, invested in online automatic monitoring systems that their signal of results of monitoring is transmitted to the Department of Natural Resources and Environment, and widely publicized on the electronic board for people.

Besides, the number of cement factories using old technology, outdated equipment is still much. According to the planning of Vietnam's cement industry in the period up to 2020 and orientation to 2030 [1], cement plants must fulfill the goal of converting backward production technology to new technology production lines or converting into grinding stations. But this conversion problem is very difficult. The products of some factories still ensure the quality regulations, so the localities have no sanctions to force transformation. The initial investment capital in machinery and equipment is too large, so the conversion capital source is not available, the research plan to select suitable technology is also not possible. The arrangement of redundancy is really difficult. The delay in solving these factories further aggravates the problem of environmental pollution

2. Cement production process and problems of cement dust generation

The cement production process consists of six main stages: mining, raw material processing, grinding, drying of raw materials, burning clinker, cement grinding, and packaging. The production process starts with the exploitation of raw materials such as limestone, sand, and clay. These materials are usually transported by trucks, conveyors, barges, or ships to primary crushing stations to be crushed into small pieces about 15cm. The finished product after the grinding station is stored in stockpiles before being transferred to the next crushing stations. At the secondary stations, the materials are crushed down to size 2.5cm in preparation for storage and homogenization. These aggregates are mixed with additives such as iron ore, fly ash, slate, pozzolana, coal slag, gypsum... and then homogenize at the grinding station. The ratio of aggregates depends on the nature of cement, the type of cement required. The aggregate mixture is brought to heat treatment to reduce the moisture content to below 1%, then transferred to the roller grinding station to achieve a fine powder and then stored in the silos or transferred to the kiln. With the wet cement production process, the aggregate mixture is poured into the grinding station, with water to be crushed into a slurry. This coarse aggregate is transported by bucket elevator or compressed air to the heat treatment area. This area includes preheating tower and kiln to sinter the mixture of coarse aggregate into clinker. This product is transferred through the cooling area to enhance the silicate reaction in cement. The clinker is then transferred to the silos or storage tanks, preparing for the crushing phase to form a completely fine powder product. This cement product will be transported through air slides to storage silos in preparation for pouring into tank trucks, trains, or moving into bagging stages.

The nature of cement production is the decomposition of limestone and other substances in raw materials at high-temperature.[2] This process causes many adverse environmental impacts such as vibration, noise, water pollution, exhaust gas, dust pollution, and pollution of solid waste. In

the technological process of cement production, dust escapes due to the loading and unloading operations, storage of intermediate materials, finished products and activities of kiln systems, clinker cooling furnaces, or grinding plants. bagging workshops. Dust appears when pouring, dumping raw materials without shield, cover; Dust appears at the transfer points of conveyors, in open conveyors without covers, in conveyors with inefficient cleaning equipment. Open stockpiles also generate more dust due to the impact of weather factors such as tornadoes and blowing wind. Closed storage areas are leaked, do not close the lid, or have spills, or the system of moisturizing the aggregates when stored in poor operation also causes a lot of dust. In the diagram of Figure 1 below, it can be seen that dust escapes at all stages of the production process.

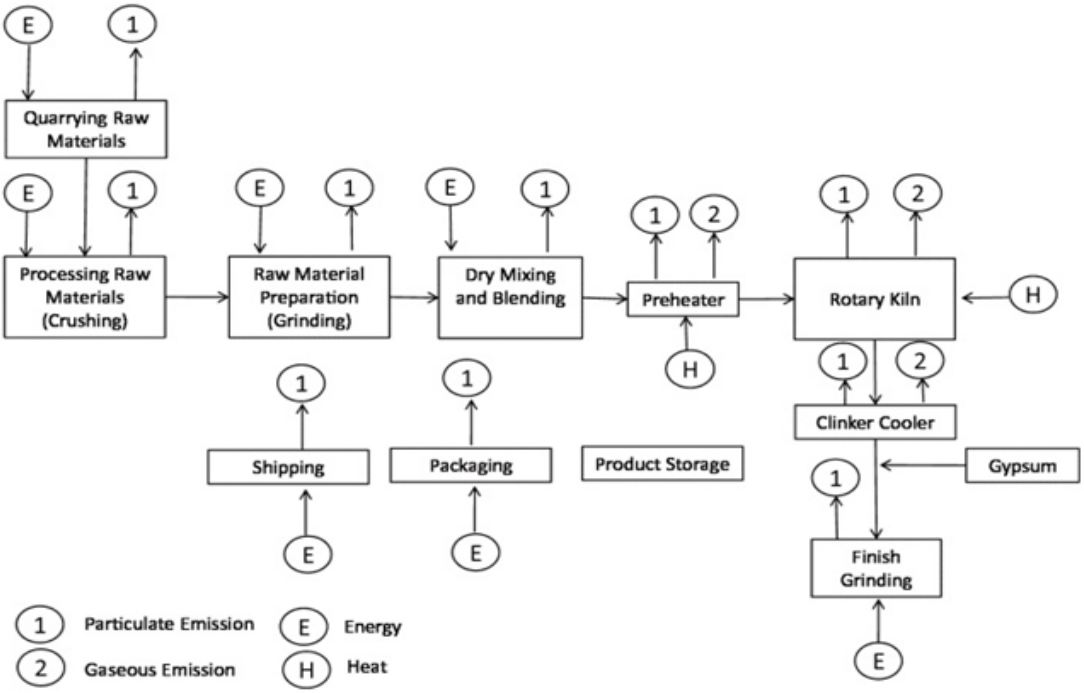

Figure 1. *Dust emission in cement production line [3].*

In each area, production stages, generating dust has different sizes, densities, and characteristics. Mining areas, raw grinding stations, primary crushing stations, or port areas importing raw materials have coarse dust particles or super-coarse size range (approximately 75 micrometers and larger). The dimension of dust particles decreases when entering areas before the grinding area with ball mill, screens, high-efficiency separator. Dust particle size also depends on the type of kiln in the technological line (Table1). Dust in cement kilns is characterized by high temperature, high dust concentration, fine dust which is slightly sticky and corrosive. Cement dust comes from bagging lines, the area for exporting cement bags onto ships, cars, or other means of transport. Cement dust in the transfer of cement from the loading areas and removing cement from silos or exporting cement at ports. The size of cement dust particles generated in the production process is very small (less than 3µm). These particles suspended in the exhaust gas. If they are inhaled, it is very easy to cause respiratory diseases. Especially when having large free SiO2 content more than 2% are capable of causing silicon lung disease, which is considered the most dangerous, most popular occupational disease in the cement manufacturing industry [4]. Besides, cement dust along the wind disperses far away, settling on the water surface, the ground that will cause degradation of cultivated land, water pollution, and great harm to the organism.

Table 1. *Examples of kiln type influence on particle size [3].*

Particle Size, mm	% by Weight		
	Long-wet kiln	Long-dry kiln	Alkali by-pass from preheater/ precalciner
>0.1	5.0	0	2.0
<0.045	85.0	99.2	84.5
<0.003	77.3	98.8	66.0
<0.007	43.0	87.2	14.0
<0.001	12.0	12.0	3.0
<0.0006	7.5	5.6	2.0
Median Size, mm	9.4	3.0	2.2

3. Dust control solutions in the cement production line

Cement production is a process that always has the arising and dispersal of dust. Dust control means controlling and minimizing dust generation. Currently, there are two groups of solutions used to control dust in cement production lines. They are installing dust collection, treatment systems, and technical, technological solutions in designing equipment and machinery in cement production lines to minimize dust generation.

Solution group for installing dust collection, treatment systems: *Dry method* has: gravity-based dust removal such as using gravity setting chambers, fabric filter; centrifugal force-based dust removal with inertial dust filter device, high-efficiency cyclones, and multi-cyclone collectors; electrostatic dust stamping with the electrostatic settling chamber, electrostatic precipitators [1]. These types of dust filter devices are divided into three levels: raw clean filter used for preliminary filtration when dust particles are larger than 100µm, have higher concentration; medium clean filter when dust particles are smaller, lower concentration, filter velocity at about 2.5 to 3m/s; clean filter level when dust particles are smaller than 10µm, have low concentration, low filtration speed reaches 10cm/s. These dust treatment systems are installed according to the industrial ventilation principle to collect airborne dust from the source. Collecting equipment will separate dust according to the intended use while the air is cleaned and returned to the environment. Main technology diagram is Generated dust source -> Suction nozzle -> Piping system -> Filter equipment -> Chimney.

Dust settling chambers, inertial dust filter devices are often used for coarse filtration before using other dust filters. Cyclones or multi-cyclone collectors are often located in primary crushers for handling high concentration coarse dust.

The dust baghouses, also known as the sleeve filters, are placed in the position where dry dust collection is required, with the flow, the exhaust temperature is not high (about from -70^0C to + 240^0C, up to + 300^0C using heat resistant type). These baghouses are often found in production lines where cement dust need to be recovered, such as in conveyors transporting raw materials, or bags; in the position of loading into trucks, pouring materials into rotary kilns, at cement grinding stations, vibrating screens, quantitative weighing stations with dust emissions less than 50mg/Nm^3 [6].

The electrostatic precipitators are also used to collect dry dust when the emissions are huge. Electrostatic dust filters can easily remove fine dust particles such as dust and smoke from the air stream. Electrostatic precipitators are now considered as a standard filtration system in cement factories today because of high dust filtering efficiency, long-term use. Electrostatic precipitators have dry and wet types. The wet type is used in environments with moisture, mist, dusty particles. The dry dust filter is the most common type. Dry electrostatic precipitators are usually arranged in cement kilns. Electrostatic precipitators have low operating costs, but the initial installation costs are large, skilled in installation, calibration and there are special notes such as the very high voltage used, the easily human life-threatening. The performance of dust filter devices can be seen in figure 2.

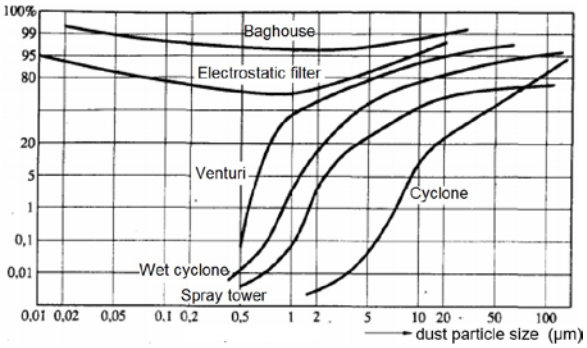

Figure 2. *Dust separation performance in some devices [7].*

With the wet method, liquid (usually water) is used to moisten, wet the material, to prevent dust generation, preventing dust from flying into space. One of the main advantages of the wet method is that it is possible to collect dust particles and collect pollutants in the air to help reduce toxic gases within the range to be able to simultaneously collect particulate matter and gaseous pollutants. However, wet dust filter requires a process of handling waste streams of dust and water. These machines have the following types: spray tower, tower scrubber, foam-filled dust filter with water, packed bed scrubber, wet cyclones, dust-proof water spray system, or spray mist into the dust cloud so that droplets catch dust particles, making them heavier than air and they can fall, not be dispersed as airborne. They are venturi, vertical venturi scrubber. Currently, fog systems are used, which are considered to be the best technology to handle ultra-fine dust particles [8,9]. Fog means making water sprayed into ultra-fine droplets with a size of about 10μ or less. Tiny droplets of water are sprayed out in large amounts like smoke so it is called a fog system. This works well for a large area and has a high evaporation rate, so do not wet the material- only the airborne dust. Dry misting does not consume water as standard wet treatment measures, does not wet the material, causing material properties effect; does not wet the background, creating puddles, causing difficulties for production and travel; The cost of this system is cheaper than usual dust handling measures.

The second group is the dust reduction technical measures (prevention solutions) in the equipment and handling and transporting materials machinery such as conveyors, grinding stations, stockpiles, silos. Although the selection of equipment and machinery at each stage depends on the production requirements, characteristics of each stage process, the use of auxiliary equipment or design improvements of equipment, or some changes in processes also significantly reduces the amount of dust generated. Simple measures are such as supplying shrouds, covers, or enclosures around dust generation sources, limiting transportation routes with multiple transitions, using straight lines; using conveyors instead of trucks, replacing equipment for loading cement powder, cement bags that easily generate dust or tear bag into new types with a new design which limit these problems.[10]

In belt conveyors, dust-generating locations are usually at the loading ends, discharging ends, and on the return, belt moving on unload rollers. Realizing that when the materials are loaded into the center of the belt, at a reasonable height, the idlers coated with dampers, and placed close to each other will help reduce the impact of the materials, limiting the vibration of the belt, that should reduce dust generation. Immediately following the loading chute, the skirt boards are arranged, which are high enough, wide enough to hold the material down, as well as with the pressure of the pouring and the air being displaced by the inflowing material and induced air. On the sides of the trough, the rubber strips will be arranged as parts to seal the cavity, to help prevent dust dispersion (Fig 3) ... The belt cleaners should be arranged in both belt branches. In the loaded branch, the belt cleaners should be arranged to clean the remaining material on the return belt when discharging. Occasionally, due to material spills or vibrations during transport, it also drops material into the unloaded surface of the belt, so it is necessary to arrange a V-type cleaning device. If the belt is not cleaned, the remaining material on the belt surfaces will rub with the supporting roller, causing the device to be worn and dust dispersed. When transporting on a belt conveyor, the volume of transport materials is always smaller than the

theoretical volume to 7% to ensure the transport material does not spill out on the belt, reducing dust generation. To ensure the productivity of the belt, it is possible to increase other parameters such as transport velocity, a tilt angle of trough rollers, or belt width. Besides, when using the covers, covering the surface of the belt when transporting also limits the generation of dust into the environment.

In enclosed transport equipment, there are cover boxes such as bucket elevators, screw conveyors, air slides, dust dispersion is less. However, the dust still escapes from the openings in the casing, the loading door, the airtight position is leaked, the position is punctured due to wear after using time ... Therefore, it is necessary to check periodically. The installation of the enclosure, the tight antenna, the transfer chute into the loading and unloading ends to meet the requirements and high tightness ...

With vibratory conveyor, screens: dry screens procedures are often used, so dust is generated a lot. Devices of this type include grizzly screens which sorting material when loading. Satisfactory material elements will pass through the gap of the screen, the larger elements will lie on the incline screens and fall into the container. With vibrating type or cage type, materials are transported by the vibration of the machine, or the rotation of the cage. The amount of dust depends on the particle size of the material, the moisture, the speed and the amplitude of the vibrating screen. Dust disperses when the material is poured into the surface of the trough, filter net, or due to the vibration of the vibrating, shaking, rotating process. When fabricating such devices, a rubber layer should be added to the surface of the sieve to reduce the impact of the material; There should be shields or cover outside. The assembly locations should have sealed joists blocking dust.

Crushers and mills often use compression force or impact force to break raw materials. The crushers generate dust. Crushers use compressive forces such as jaw crushers, gyratory crushers, cone crushers often generate less dust than crushers using impact forces such as hammer mills, roll crushers, impact breakers. Crushers use impact force to create a lot of fine powder and dust. The amount of dust dispersed also increased gradually from primary to secondary grinding stations. The dust dispersed in the crusher is mainly at the loading door and the outlet door. The following ways can be used to minimize generated dust such as using cloths, covers, or boxes; installing sealed feedbox transfer chute to avoid dust, limiting the number of times to open these doors to avoid dust emission, and reducing airflow; avoid to obstruct the crusher.

Transfer chutes are often arranged in segments that transfer between conveyors, or segments from one transport device to another. The hopper must satisfy the flow of materials, characteristics of materials with fine powder and lumps; avoid letting materials fall straight into the belt surface or succeeding equipment; they should have suitable size and structure to both absorb the impact of the supplying materials, reduce noise, reduce traffic congestion, reduce impact, break materials to reduce dust generation, and still ensure device life and auxiliary details. In addition to rockbox, mini-rock boxes, or fines and lumps on a belt, there are many other types of chutes with this purpose such as spiral chute, bin-lowering chute, rock ladder, telescopic. chute.

The cover, the case is used to cover the dust sources. This helps reduce dust dispersion and collect dust effectively for the existing dust collection system. The structure of this part is recommended to be spacious enough so that the flow of dust carrying air is within. These hoppers require hinged door panels for daily inspection and routine maintenance. Open doors should have screens to prevent dust and reduce airflow.

With the tanks, the silo storing material temporarily between production stages, the material is transported by machines such as belt conveyor, bucket elevator, screen. Materials are discharged from silos, containers from bins and hoppers through gravity or vibrating feeders. With these devices, dust often arises in the feeding

position of feed openings, discharge gates, inspection doors. To prevent dust, it is recommended to use sealed containers and funnels, arrange full level sensors to monitor the number of materials. At the discharge line, install telescopic chute hopper or loading spout to reduce the kinetic energy of the material, preventing airflow.

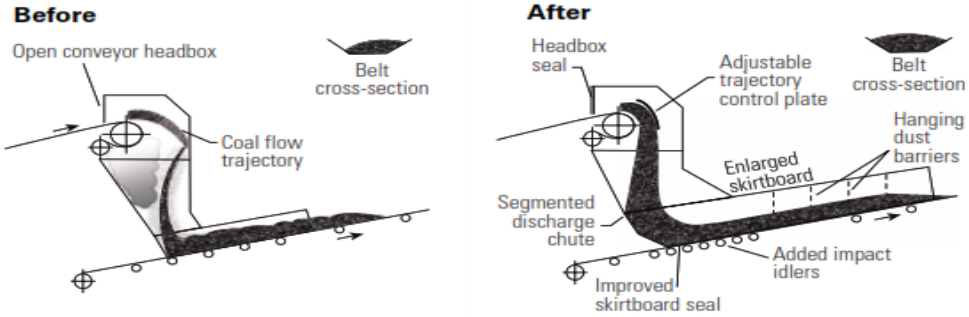

Figure 3. *A properly designed transfer chute loads material onto the center of the receiving belt [10],[11].*

4. The current problem of dust treatment in cement plants

The problem of dust pollution does not stop happening in both old technology cement factories, technology conversion factories, and new construction cement plants. Dust fumes mainly arise in the chimneys of cement kilns. Households in near areas are still under facing the dust and noise of the factories. They often discharge dust and smoke at night, discharge without electrostatic precipitator system causing environmental pollution, a great impact on the daily life of people. When it rains, the mudflows from them down to the residential areas, pouring into people's houses. The reason of discharging of dust at night, especially in rainy nights, without discharge through electrostatic dust filter system is that the dust filter system has problems or needs to be interrupted during maintenance, periodic repair when there is an electrical fault, mechanical problems, or when restarting the kiln, it is necessary to shut down the dust filter system to ensure stable voltage. The reason is that because of complicated administrative procedures, new equipment and technologies that are difficult to import to Vietnam or have not been registered should be imported but cannot be used ... In addition to dust pollution, due to the exploitation and transportation of materials from mines, ports of input to the plant's grinding station, because open-air storage facilities contain unmanaged materials, shielding, and good dust handling. Pollution occurs in the production environment of the factory due to equipment, machinery and production lines, dust filtration systems are not periodically checked, evaluated, and overcome the disadvantages arising dust ...

Besides, there are still some cement factories to periodically review and assess the current status of sources of wastewater, exhaust gas, dust, hazardous waste ... At the same time, they invite independent units with sufficient capacity to force for environmental monitoring 2 times per year, emission monitoring 4 times per year. From the monitoring results, the plant implements measures according to environmental regulations to thoroughly handle the risks of pollution generation. At locations of limestone processing, cement grinding, bagging, dumping, conveyor navigation points, etc., dust handling system is installed. In areas of crushing raw materials, clinker, compressor stations, all rooms are designed for soundproof, ventilation, and noise protection. The factory also uses new technology in stone exploitation to ensure safety, reduce noise, vibration, and dust pollution. Electrostatic precipitator systems are periodically maintained and will be gradually replaced by baghouses due to the disadvantages of electrostatic filtering equipment on the use of voltage, cost, and complexity in equipment imports. These plants are being installed, putting the online environmental monitoring system into operation. Automatic dust measuring system and surveillance camera to monitor and warn regional environmental quality when there is

a high risk of pollution. The plant also researches and installs an automatic car wash system at the entrance gate, maintains spraying water for washing roads, planting more trees and lawns to create a green - clean - beautiful environment**.**

Figure 4. *Dust pollution in some cement plants.*

5. Conclusion

The cement industry is an important economic sector in the development of the country, requiring the coordination of many other sectors such as transportation, electricity, energy, mechanics, equipment ... This industry requires a big amount of input for production such as construction area, raw materials, fuel, and materials for production, transportation needs. However, the cement manufacturing industry produces and entails many other production and service industries to develop, creating many jobs, creating economic development for urban and local. Therefore, the cement industry requires a long-term vision of finance and profit. Along with changing strategy towards "greener" cement production, it is important to implement dust control solutions or to resolutely stop production in unwarranted factories with no strategies to overcome pollution and sustainable development, the cement industry will be a key economic sector of the country❑

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