Note: Citations are based on reference standards. However, formatting rules can vary widely between applications and fields of interest or study. The specific requirements or preferences of your reviewing publisher, classroom teacher, institution or organization should be applied.

Add your comment Cement is a global commodity, manufactured at thousands of plants. The principal and most visible market for cement is the construction industry in a multitude of applications where it is combined with water to make concrete. Most modern civil engineering projects, office buildings, apartments and domestic housing projects use concrete, often in association with steel reinforcement systems. In many developed countries, market growth is very slow, with cement used in bulk primarily for infrastructure construction, based on UNEPTIE. In developing country markets e. China , growth rates are more rapid. Because it is both global and local, the cement industry faces a unique set of issues, which attract attention from both local and international level. Large amounts of electricity are used grinding the raw materials and finished cement. The clinker-making process also emits CO2 as a by-product during the calcination of limestone. These process emissions are unrelated to energy use and account for about 3. Emissions from limestone calcination cannot be reduced through energy-efficiency measures or fuel substitution, but can be diminished through production of blended cement and raw material selection. Cement is a global commodity, manufactured at thousands of plants. Manufacturing industries in general account for one-third of global energy use. Cement production involves the heating, calcining and sintering of blended and ground materials to form clicker. As a result, cement manufacturing is the third largest cause of man-made CO2 emissions due to the production of lime , the key ingredient in cement. Therefore, energy savings during cement production could lead to lower environmental impact. Changes in the chemical formulation of cement have been demonstrated to save energy and reduce CO2 emissions, but their widespread adoption has thus far been hampered by the fact that developing a new industrial standard is complex and requires time. This holds in particular for the cement industry which is a highly capital intensive and competitive sector with long economic lifetimes of existing facilities so that changes in the existing capital stock cannot easily be made. The largest opportunities for improving energy efficiency and reducing CO2 emissions can be achieved by improving the cement manufacturing process. In the cement industry pyroprocessing processing the raw material into cement under a high temperature, e. Grinding and milling account for 5. The following figure presents the cement production process. Cement production process Source: Lootahgroup The potential opportunities for improving energy efficiency and lower CO2 emissions in raw material generation and production of concrete are smaller than in cement manufacturing. For instance, CO2 emissions during transport could be reduced by replacing diesel fuel with biodiesel. Normally, energy efficiency improvements proportionally reduce the emissions of CO2 generated from fossil fuel combustion and electricity generation. However, it should be noted that reducing CO2 emissions from cement manufacturing by a percentage proportional to energy efficiency improvements is not possible. For example, if a near-zero CO2 emitting fuel e. Energy use and CO2 Another way to reduce emissions is to substitute fossil fuels with waste or biomass. Cement kilns are well suited for waste-combustion because of their high process temperature and because the clinker product and limestone feedstock act as gascleaning agents. Used tyres, wood, plastics, chemicals and other types of waste are co-combusted in cement kilns in large quantities. However, very high substitution rates can only be accomplished if a tailored pre-treatment and surveillance system is in place. Municipal solid waste, for example, needs to be pre-treated to obtain homogeneous calorific values and feed characteristics. Another potential source of energy is carpets: Although these alternative materials are widely used, their use is still controversial, as cement kilns are not subject to the same tight emission controls as waste-incineration installations. Worldwide, the sector consumed 2. From a technical perspective, the use of alternative fuels could be raised to 24 Mtoe to 48 Mtoe, although there would be differences among regions due to the varying availability of such fuels. This would yield CO_2 reductions in the range of Mt to Mt a year. Yet another way to reduce energy and process emissions in cement production is to blend cements with increased proportions of alternative non-clinker feedstocks, such as volcanic ash, granulated blast furnace slag from iron production, or fly ash from coal-fired power generation. The use of such blended cements varies widely from country to country. In the United States and in China, other clinker substitutes are added directly at the concrete-making stage. Feasibility of technology and operational necessities top: In the cement pyroprocessing process it is important to keep in mind that waste materials combust and burn at different temperatures under different conditions. Therefore, solid waste fuels need to be introduced into the kiln in such a manner that they do not significantly change the temperature profile and chemical reactions in the overall pyroprocessing. Finally, receiving and handling of alternate or waste fuels can raise technical liability and political concerns. Cement manufacturing companies do not desire to be labeled as handlers of hazardous wastes and surrounding communities may have concerns about hazardous waste transport and handling in a nearby cement plant. Furthermore, blended cements offer a major opportunity for energy conservation and emission reductions, but their use would in many cases require revisions to construction standards, codes and practices. Of the cement production chain steps, grinding and milling operations are rather energy inefficient. Energy improvement of grinding and milling could be increased by using modern mill systems which comprise several units of process equipment with high-pressure, twin-roll presses, tube mills, ball mills, and conventional or high-efficiency separators IEA, Status of the technology and its future market potential top: Pyroprocessing transforms the raw mix into clinkers. The wet process kilns operating in Europe are generally expected to be converted to dry process kiln systems when renewed, as are semi-dry and semi-wet processes kiln systems. The percentage is even lower for developing countries Karstensen, no date. These process improvements will come from better energy management, upgrading existing equipment e. Japan is the leading country when it comes to energy efficiency in the cement sector. The typical energy balances for the major pyroprocessing systems are shown below. These balances show where energy losses occur and which thus represent an opportunity for improving energy efficiency and lowering fuel-based CO_2 emissions. In particular, the table shows that significant improvements can be made by switching from wet to dry cement processes. The individual energy use areas e. Thermal energy balances Source: Perry Through energy audits, including kiln system performance testing and calculation of mass and heat balances, specific opportunities for improving energy efficiency and lowering CO_2 emissions can be identified. A cement manufacturing energy audit should at a minimum address the energy use and recommend potential actions, such as: Wet cement production involves mixing raw materials limestone and clay or loam with water in order to produce slurry. Further in the process, water is evaporated from the homogenized mixture and this step in the production requires significant amounts of energy. The raw meal dried slurry is subjected to high temperatures in a rotary kiln, where the reaction of calcination takes place its final products are lime and CO_2. The lime is further influenced by the temperatures of 1, to 1, oC. This reaction, called sintering, results in clinker. The final stage of cement production is fine crushing of clinker and mixing the substance with mineral components, such as slag, fly ash or gypsum. In the case of dry cement production, the raw materials are mixed without water and therefore the evaporation process can be omitted. Existing technology in the cement industry can be upgraded in several ways. The Table shows that if all US plants would upgrade their pyroprocessing to the level of the best US plant i. Energy use in US kilns In terms of new technologies in the cement sector, several technologies are being tested and demonstrated, such as fluidised-bed kilns. However, in comparison with older, fully capitalised kiln-based plants, the fluidised bed systems are relatively expensive so that they are likely to be considered only for future capacity expansion. Another barrier to adoption of fluidised-bed systems is the reluctance to invest in such large capital expenditures, as the systems have been demonstrated only at small-scale facilities. This could significantly improve the overall energy efficiency of some manufacturing operations. Presently, five cement manufacturing plants produce electricity on-site through co-generation US Department of Energy, Moreover, utilisation of waste heat in preheater heat exchange systems is usually more energy efficient than the co-generation of electricity with its inherently low conversion efficiency of thermal to electrical energy typically about 10, Jouls are required to produce 1 kWh. Although co-generation of steam at a cement plant is possible, cement plants typically require little steam and are located in isolated areas where markets for excess steam generation are often not available. Contribution of the technology to economic development including energy market support top: An important benefit of enhancing energy efficiency in the cement industry would be the reduction in energy costs. However, larger energy cost savings are still possible in other parts of the world. Energy efficiency tends to be lower in regions with low energy prices. In those processes where efficiency is close to the practical maximum, innovations in materials and processes would enable even further gains IEA, Cement manufacturing produces CO2 as it requires very high temperatures to burn raw materials and give the clinker its unique properties. CO2 is generated from three independent sources: There are three central measures by which the cement industry may save direct CO2 emissions in the immediate future: The main approaches to this are to use: Blast-furnace slag that has been cooled with water, rather than air. About half of all blast-furnace slag is already used for cement-making where the slag is water-cooled and where transport distances and costs are acceptable. Fly ash from coal-fired power plants. But the carbon content of fly ash can affect the concrete setting time, which determines the quality of the cement. To be used as clinker substitute, high-carbon fly ash must be upgraded. Technologies for this are just emerging. China and India have the potential to significantly increase the use of fly ash. In China, there are about 30 steel slag cement plants with a combined annual output of 4. However, steel slag quality varies and it is difficult to process, which limits its use. Further analysis is needed to validate the viability of this option. Other materials that could be used to a greater extent as clinker substitutes include volcanic ash, ground limestone and broken glass. In the long term, new cement types may be developed that do not use limestone as a primary resource.

DOWNLOAD PDF TECHNOLOGICAL PROBLEMS IN PYROPROCESSING CEMENT CLINKER

Chapter 2 : Senior Pyroprocessing Engineer (f/m) | HeidelbergCement Group

Home Cement Cement Cement Cement is a global commodity, manufactured at thousands of plants. The principal and most visible market for cement is the construction industry in a multitude of applications where it is combined with water to make concrete. Most modern civil engineering projects, office buildings, apartments and domestic housing projects use concrete, often in association with steel reinforcement systems. In many developed countries, market growth is very slow, with cement used in bulk primarily for infrastructure construction, based on UNEPTIE. In developing country markets e. China , growth rates are more rapid. Because it is both global and local, the cement industry faces a unique set of issues, which attract attention from both local and international level. Large amounts of electricity are used grinding the raw materials and finished cement. The clinker-making process also emits CO_2 as a by-product during the calcination of limestone. These process emissions are unrelated to energy use and account for about 3. Emissions from limestone calcination cannot be reduced through energy-efficiency measures or fuel substitution, but can be diminished through production of blended cement and raw material selection. Introduction Cement is a global commodity, manufactured at thousands of plants. Manufacturing industries in general account for one-third of global energy use. Direct industrial energy and process CO_2 emissions amount to 6. Cement production involves the heating, calcining and sintering of blended and ground materials to form clicker. As a result, cement manufacturing is the third largest cause of man-made CO_2 emissions due to the production of lime, the key ingredient in cement. Therefore, energy savings during cement production could lead to lower environmental impact. Changes in the chemical formulation of cement have been demonstrated to save energy and reduce CO_2 emissions, but their widespread adoption has thus far been hampered by the fact that developing a new industrial standard is complex and requires time. This holds in particular for the cement industry which is a highly capital intensive and competitive sector with long economic lifetimes of existing facilities so that changes in the existing capital stock cannot easily be made. The largest opportunities for improving energy efficiency and reducing CO_2 emissions can be achieved by improving the cement manufacturing process. In the cement industry pyroprocessing processing the raw material into cement under a high temperature, e. Grinding and milling account for 5. The following figure presents the cement production process. The potential opportunities for improving energy efficiency and lower CO_2 emissions in raw material generation and production of concrete are smaller than in cement manufacturing. For instance, CO_2 emissions during transport could be reduced by replacing diesel fuel with biodiesel. Normally, energy efficiency improvements proportionally reduce the emissions of CO_2 generated from fossil fuel combustion and electricity generation. However, it should be noted that reducing CO_2 emissions from cement manufacturing by a percentage proportional to energy efficiency improvements is not possible. For example, if a near-zero CO_2 emitting fuel e. Another way to reduce emissions is to substitute fossil fuels with waste or biomass. Cement kilns are well suited for waste-combustion because of their high process temperature and because the clinker product and limestone feedstock act as gascleaning agents. Used tyres, wood, plastics, chemicals and other types of waste are co-combusted in cement kilns in large quantities. However, very high substitution rates can only be accomplished if a tailored pre-treatment and surveillance system is in place. Municipal solid waste, for example, needs to be pre-treated to obtain homogeneous calorific values and feed characteristics. Another potential source of energy is carpets: Although these alternative materials are widely used, their use is still controversial, as cement kilns are not subject to the same tight emission controls as waste-incineration installations. Worldwide, the sector consumed 2. From a technical perspective, the use of alternative fuels could be raised to 24 Mtoe to 48 Mtoe, although there would be differences among regions due to the varying availability of such fuels. This would yield CO_2 reductions in the range of Mt to Mt a year. Yet another way to reduce energy and process emissions in cement production is to blend cements with increased proportions of alternative non-clinker feedstocks, such as volcanic ash, granulated blast furnace slag from iron production, or fly ash from coal-fired power generation. The use of such blended cements varies widely from country to country. In the United States and in China, other clinker substitutes are added directly at the concrete-making stage. Feasibility of technology and operational necessities In the cement pyroprocessing process it is important to keep in mind that waste materials combust and burn at different temperatures under different conditions. Therefore, solid waste fuels need to be introduced into the kiln in such a manner that they do not significantly change the temperature profile and chemical reactions in the overall pyroprocessing. Sometimes it is necessary to add solid waste through a hatch or valve structure in the kiln shell, which implies a technical challenge and which partly offsets the efficiency gains and CO2 emission reductions. Finally, receiving and handling of alternate or waste fuels can raise technical liability and political concerns. Cement manufacturing companies do not desire to be labeled as handlers of hazardous wastes and surrounding communities may have concerns about hazardous waste transport and handling in a nearby cement plant. Furthermore, blended cements offer a major opportunity for energy conservation and emission reductions, but their use would in many cases require revisions to construction standards, codes and practices. Of the cement production chain steps, grinding and milling operations are rather energy inefficient. Energy improvement of grinding and milling could be increased by using modern mill systems which comprise several units of process equipment with high-pressure, twin-roll presses, tube mills, ball mills, and conventional or high-efficiency separators IEA, Pyroprocessing transforms the raw mix into clinkers. The wet process kilns operating in Europe are generally expected to be converted to dry process kiln systems when renewed, as are semi-dry and semi-wet processes kiln systems. The percentage is even lower for developing countries Karstensen, no date. These process improvements will come from better energy management, upgrading existing equipment e. Japan is the leading country when it comes to energy efficiency in the cement sector. The typical energy balances for the major pyroprocessing systems are shown below. These balances show where energy losses occur and which thus represent an opportunity for improving energy efficiency and lowering fuel-based CO2 emissions. In particular, the table shows that significant improvements can be made by switching from wet to dry cement processes. The individual energy use areas e. Through energy audits, including kiln system performance testing and calculation of mass and heat balances, specific opportunities for improving energy efficiency and lowering CO2 emissions can be identified. A cement manufacturing energy audit should at a minimum address the energy use and recommend potential actions, such as: Lower kiln exit gas losses install devices to provide better conductive heat transfer from the gases to the materials, e. Wet cement production involves mixing raw materials limestone and clay or loam with water in order to produce slurry. Further in the process, water is evaporated from the homogenized mixture and this step in the production requires significant amounts of energy. The raw meal dried slurry is subjected to high temperatures in a rotary kiln, where the reaction of calcination takes place its final products are lime and CO2. The lime is further influenced by the temperatures of 1, to 1, oC. This reaction, called sintering, results in clinker. The final stage of cement production is fine crushing of clinker and mixing the substance with mineral components, such as slag, fly ash or gypsum. In the case of dry cement production, the raw materials are mixed without water and therefore the evaporation process can be omitted. Existing technology in the cement industry can be upgraded in several ways. The Table shows that if all US plants would upgrade their pyroprocessing to the level of the best US plant i. In terms of new technologies in the cement sector, several technologies are being tested and demonstrated, such as fluidised-bed kilns. However, in comparison with older, fully capitalised kiln-based plants, the fluidised bed systems are relatively expensive so that they are likely to be considered only for future capacity expansion. Another barrier to adoption of fluidised-bed systems is the reluctance to invest in such large capital expenditures, as the systems have been demonstrated only at small-scale facilities. This could significantly improve the overall energy efficiency of some manufacturing operations. Presently, five cement manufacturing plants produce electricity on-site through co-generation US Department of Energy, Moreover, utilisation of waste heat in preheater heat exchange systems is usually more energy efficient than the co-generation of electricity with its inherently low conversion efficiency of thermal to electrical energy typically about 10, Jouls are required to produce 1 kWh. Although co-generation of steam at a cement plant is possible, cement plants typically require little steam and are located in isolated areas where markets for excess steam generation are often not available. Contribution of the technology to economic development including energy market support An important benefit of enhancing energy efficiency in the cement industry would be the reduction in energy costs. However, larger energy cost savings are still possible in other parts of the world. Energy efficiency tends to be lower in regions with low energy prices. In those processes where efficiency is close to the practical maximum, innovations in materials and processes would enable even further gains IEA, Climate Cement manufacturing produces CO2 as it requires very high temperatures to burn raw materials and give the clinker its unique properties. CO2 is generated from three independent sources: There are three central measures by which the cement industry may save direct CO2 emissions in the immediate future: The main approaches to this are to use: Blast-furnace slag that has been cooled with water, rather than air. About half of all blast-furnace slag is already used for cement-making where the slag is water-cooled and where transport distances and costs are acceptable. Fly ash from coal-fired power plants. But the carbon content of fly ash can affect the concrete setting time, which determines the quality of the cement. To be used as clinker substitute, high-carbon fly ash must be upgraded. Technologies for this are just emerging. China and India have the potential to significantly increase the use of fly ash. In China, there are about 30 steel slag cement plants with a combined annual output of 4. However, steel slag quality varies and it is difficult to process, which limits its use. Further analysis is needed to validate the viability of this option. Other materials that could be used to a greater extent as clinker substitutes include volcanic ash, ground limestone and broken glass. In the long term, new cement types may be developed that do not use limestone as a primary resource. These new types are called synthetic pozzolans. The technological feasibility, economics and energy effects of such alternative cements remain speculative.

Chapter 3 : Energy Modeling of the Pyroprocessing of Clinker in a Rotary Cement Kiln

Welcome to the Cement Kiln Pyroprocessing course. The course will be published over a 6 week period and will provide 24 lectures on different topics associated with pyroprocessing in cement kilns. There will also be exercises and quizzes to assist with the learning process and exams at the end of weeks 1 to 5.

Add your comment Cement is a global commodity, manufactured at thousands of plants. The principal and most visible market for cement is the construction industry in a multitude of applications where it is combined with water to make concrete. Most modern civil engineering projects, office buildings, apartments and domestic housing projects use concrete, often in association with steel reinforcement systems. In developing country markets e. China , growth rates are more rapid. Because it is both global and local, the cement industry faces a unique set of issues, which attract attention from both local and international level. Large amounts of electricity are used grinding the raw materials and finished cement. One possible way to reduce energy and process emissions in cement production isto blend cements with increased proportions of alternative non-clinker feedstocks,such as volcanic ash, granulated blast furnace slag from iron production, or fly ashfrom coal-fired power generation. Cement is a global commodity, manufactured at thousands of plants. Manufacturing industries in general account for one-third of global energy use. Therefore, energy savings during cement production could lead to lower environmental impact. Grinding and milling account for 5. One possible way to reduce energy and process emissions in cement production isto blend cements with increased proportions of alternative non-clinker feedstocks, such as volcanic ash, granulated blast furnace slag from iron production, or fly ashfrom coal-fired power generation IEA , Gielen et al. Some basic approaches are: Blast-furnace slag that has been cooled with water, rather than air.: Blast furnace slag BFS is a nonmetallic byproduct of the manufacture of pig iron in a blast furnace. BFS consists primarily of silicates, aluminosilicates, and calcium-alumina-silicates. BFS forms when slagging agents e. In the process of reducing iron ore to iron, a molten slag forms as a non-metallic liquid consisting primarily of silicates and aluminosilicates of calcium and other bases that floats on top of the molten iron. The molten slag is then separated from the liquid metal and cooled. The Pantheon in Rome is a testament to the high strength and durability of pozzolan cement. Its hemispherical dome, 43 meters in diameter, is made completely from pozzollan cement and does not contain any reinforcing bars. It has been in use since AD. The addition of pozzolan will modify the characteristics of cement. Depending on the type of pozzolan chosen, the density and compressive strength of the formed concrete may be increased and porosity reduced. Pozzolanic materials can be combined with uncarbonated lime calcium hydroxide to form stable compounds, thus reducing the risk of early leaching or frost damage and increasing the potential durability of the mortar. Concrete research is now calling for increased usage and high-volume usage of pozzolans, especially fly ash. The economic and environmental advantages of adding pozzolan would seem to indicate that their regular and high-volume use will become standard practice in the concrete industry. This is beneficial in two ways: Of the 68 million tonnes of coal fly ash produced in , However, it should be noted that fly ash can contain elements e. Nonetheless, fly ash and slags react with any free lime left after the hydration to form calcium silicate hydrate, which is similar to the tricalcium and dicalcium silicates formed in cement curing. This process increases strength, improves sulfate resistance, decreases permeability, reduces the water ratio required, and improves the pumpability and workability of the concrete. EU and US-based coal-fired power plants produce better fly ash for concrete than other plants in the world, because of the lower sulfur and lower carbon content in the ash. Fly ash from waste incinerators cannot be used. Other materials that could be used to a greater extent as clinker substitutes include volcanic ash, ground limestone and broken glass. The possible contribution of Best Available Technologies for the cement sector are displayed in the Figure below. Energy savings for cement Source: IEA, Feasibility of technology and operational necessities top: About half of all blast-furnace slag is already used for cement-making where the slag is water-cooled and where transport distances and costs are acceptable. The carbon content of fly ash can affect the concrete setting time, which determines the quality of the cement. Technologies for this are just emerging. China and India have the potential to significantly increase the use of fly ash. In China, there are about 30 steel slag cement plants with a combined annual output of 4. However, steel slag quality varies and it is difficult to process, which limits its use. The use of steel slag as a cementing component should be given a priority for technical, economic, and environmental reasons. The use of such blended cements varies widely from country to country. Inthe United States and in China, other clinker substitutes are added directly at the concrete-making stage. Blended cements offer a major opportunity for energy conservation and emission reductions, but their use would in many cases require revisions to construction standards, codes and practices IEA A key parameter determining the suitability of a material as a clinker substitute is the compressive strength, in addition to tensile strength and water absorption Gielen et al. Changing the composition of the cement output through the new materials could have an impact on the quality of the product. Changes in cement product formulations require significant time before they are incorporated into international standards and accepted in the market. Status of the technology and its future market potential top: While slag cement use is miniscule in contrast with portland cement use, it has been around for a while. In fact, it was used in the building of both the Paris underground system and the Empire State Building. In developed countries, such as the U. This is especially true for the long-term availability of air-cooled slag, given the continuing decline in the number of operating blast furnaces In the long term, new cement types may be developed that do not use limestone as a primary resource. These new types are called synthetic pozzolans. The technological feasibility, economics and energy effects of such alternative cementsremain speculative IEA A wide range ofnatural pozzolanic materials, sand, limestone, granulated blastfurnace slag, fly ash, and broken glass can be used as mineral additives in these cements Gielen et al. How the technology could contribute to socio-economic development and environmental protection top: An important benefit of enhancing energy efficiency in the cement industry would be the reduction in energy costs. Energy efficiency tends to be lower in regions with low energy prices. In those processes where efficiency is close to the practical maximum, innovations in materials and processes would enable even further gains IEA, It affects all new residential and non-residential buildings, including renovation of large existing buildings. It is intended to lead to substantial increases in investment in energy efficiency measures within these buildings. According to the EU Directive, this will be mainly achieved by imposing energy performance standards, promote renewable energy sources and establish a system of regular inspections. The cement industry does not have a so critical role throughout the process. However, the modernisation of existing procedures of cement production can lead to considerable improvements, in the sense that it will reduce heating and lighting losses. Energy intensity in the cement production Contribution of the technology to economic development including energy market support top: The availability of clinker substitutes is sufficient to allow the cement-to-clinker ratio to be reduced to 0. Taking into account all these potentials, the global intensity of cement production could be reduced by 0. Contribution of the technology to protection of the environment top: By using several products for clinker substitution, such as for instance coal ash power, reduced coal ash powder waste and reduced land are needed to dispose of coal ash powder. This methodology helps to determine a baseline for GHG emissions in the absence of the project i. Financial requirements and costs top: Global demand for cement is forecast to grow by 4. China, which is already by far the largest market for cement in the world, will show the largest increase in total amount of cement sold. Vietnam, Thailand, Ukraine, Turkey and Indonesia are also expected to record strong increases in percentage terms. Market advances will be less robust in the developed areas of the USA, Japan and Western Europe, with maintenance and repair construction accounting for most of the growth in cement demand through However, a pickup a construction spending in Germany and Japan following an extended period of decline will help bolster overall developed world market growth. Cement industry has devoted substantial effort to introducing innovative procedures in cement production. Considerable resources have been spent in recent years to investigate emerging and hopefully non-controversial and non-polluting technologies. Unfortunately, many such technologies have low capacities some are still under development , are technically sophisticated, and currently not affordable by many developing countries. When comparing the state of the art technologies in terms of sustainability, suitability, performance, robustness, cost-efficiency, patent restrictions availability , and competence requirements it can be concluding that at least in the short term cement industries are going to be based on pyroprocessing and grinding mills. Anecdotal prices in the U. Much of the additional investment will be needed in developing countries where CO2 policies are now emerging IEA Clean Development Mechanism market status top: For optimizing the use of clinker: There are only 33 cement projects in the CDM pipeline. Overview of clinker substitute projects in the CDM Source: USD 4,, References top: Coal Combustion Product Survey. Energy and Emission reduction opportunities for the cement industry. US Department of Energy. Reducing industrial energy use and CO2 emissions: The role of materials science. MRS Bulletin 33, pp. Energy Technology Perspectives - Scenarios and Strategies to

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Chapter 4 : Energy Efficiency and Saving in the Cement Industry | ClimateTechWiki

Producing white clinker and cement requires the right raw materials and mix, the right fuel and optimal plant process conditions. JK Cement Works Fujairah explains what action it takes to keep its white clinker and c.

Ment Clinker Processing Technology Energy optimization in cement manufacturing -. Chat With Sales process of ball mill in ce ment production -. China High Capacity CE. ZKG 49 the chemical composition of the raw material de-posit, further components such as iron ore or sand must be added. Following excavation by means of drilling and blasting or heavy equipment, the ma-terial is conveyed to the crushing plant where the ROM material is subjected to pre-crushing. Apr 7, pages. Features This unique handbook contains the most essential engineering formulas used in the cement manufacturing process. All formulas are presented in both English and metric systems of units. Examples are given to familiarize the reader with the usefulness of. Modern processing technology solutions depend on innovative thinking and con-tinuous further development. So it is possible to minimise therefore necessary plant downtimes. Since Portland ce-ment clinker essentially controls the performance of cements, the continu-ous and detailed monitoring of clinker properties is state-of-the-art in mod- ern cement production. Sustainability and environmental concerns have been key considerations for the cement industry in recent years. In response, changes to cement manufacturing have. An Energetic Comparison During cement production, C02 emissions come from two main sources: A significant amount of C02 is emitted due. Concrete is formed when portland cement creates a paste with water that binds with sand and rock to harden. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Main features Introduction 2 P l a n t S e r v i c e s The increased strength poten- content such as some types tial of mineralised cement can of petcoke and fuel oil can be used directly for high- greatly reduce fuel costs. The advantage and some related issues of co-processing SS in cement kiln have been discussed. The technical model and projects of Huaxin cement for co-processing SS in cement kiln also have been introduced. Combined hydrometallurgy-flotation scheme for Waelz. The total energy costs. A pozzolan is a siliceous material that develops hydraulic cementitious properties when interacted with free lime CaO and water. Straight portland cement is made by grinding together portland cement clinker the interme-diate product of cement manufacture with a small. Actual technological scheme for Waelz clinker processing. Thus the problem for development of clinker pro cessing technology is a question of present interest. The aim of this research work is to test the feasibil ity of obtaining of high quality copper concentrate with a high content. Chat With Sales No. Commissioning of the new grinding plant is scheduled for the first quarter A few days before. Chat With Sales Addition of large amount of municipal sewage. The course will be published over a 6 week period and will provide 24 lectures on different topics associated with pyroprocessing in cement kilns. There will also be exercises and quizzes to assist with the learning process and exams at the end of weeks 1 to 5. Chat With Sales Process technology for efficient and sustainable cement. China since then has become market leader in terms of.

Chapter 5 : Cement kiln - Wikipedia

Abstract: Optimization of energy use in the pyro-processing of clinker is the most important step in the modern cement industry. Since the process of clinkerization consumes the largest share of the purchased energy, engineers and managers at the cement plants are constantly trying to monitor the.

We use cookies to improve your website experience. Learn about our cookie policy. Accept Back to Cement 1. QUARRY Limestone, clay and marl is blasted or scraped up in the quarry and fed into the cement process via dump trucks which dump the material into the primary crusher. The crushed material falls onto a belt, or series of belts, which takes it to the limestone stockpile. ISSUES Limestone is still relatively large with sharp corners and causes belt damage under the crusher and at transfers. Sharp pieces of limestone moving through the tail pulley can damage the pulley, lagging, splices and belt. The Flexco V-Plow discharges materials from the return side of the belt, protecting the tail pulley and the belt. The robust designs of these cleaners can handle the high tonnage and abrasion caused by larger materials found earlier in the process. Often belts to the limestone stockpile are long and the quarry is in a remote location relative to the plant, making cleanup and maintenance more time consuming. Even after crushing, the limestone is still relatively large with sharp corners, causing belt damage. Mistracking belts are causing damage to belt edges, and these longer belts are costly to repair or replace. Slider Beds or Impact Beds at transfers can be used to protect belts from conveying quarried material to the stockpile. The slider bed with impact rollers is a great choice for containment in the lower impact load zones. There may be limited space to access the impact zone under the secondary crusher. Sticky carryback material piles up on the ground and builds up on conveyors and other equipment. Slider Beds or Impact Beds can be used to protect belts. The slide-out service of the DRX impact beds also make maintenance fast and easy in confined spaces. For mechanically fastened belts, the robust design and long-lasting urethane formulation of the blades on the MSP Standard Mine-Duty Precleaner and MMP Medium Mine-Duty Precleaner are perfect for belts that may see more than 2 million tons of material a year. Due to the amount of material carried on this belt, multiple secondary cleaners may be used. Containing the wet, sticky clay on the belt is a challenge and requires cleanup time when spilled. Adjustable Idler Set with Impact Rolls support the belt while reducing belt drag in this low-impact area. Corrosion is occurring on the equipment that handles fly ash. Multiple transfers means the need for more sealing to combat dust and spillage. They will last longer and, in the case of the fasteners, provide longer life to the splice and belt. The conveyors in this area are often enclosed, which helps contain material and reduce fugitive dust, but servicing cleaners can be a challenge. Inspection doors are a great option for speeding up inspections and maintenance. The lower profile splice helps maximize the splice life. In Wet Processing, materials are fed into the mill and water is added and the mixture is crushed into a slurry. Mistracking is causing belt damage and material loss. Blade change-outs can be done in a matter of minutes and materials are effectively cleaned off the belt. If there are multiple load points on this belt, impact idler sets can be used between beds. Slurry or raw meal powder is conveyed to the pyroprocessing phase via bucket elevators or compressed air. Fuels for the kiln are conveyed in via drag chains or conveyor belts. ISSUES Coal dust carryback or spillage piles are considered an explosion hazard, which is dangerous and cause the cement plant to be fined. The kiln needs fuel to keep making clinker so downtime on these belts is costly. Depending on how close the head pulley is to the kiln, the MSP Precleaner with High Temp Blade may be required for finer materials like sawdust and chipped plastics. Impact beds may be needed to protect the belt for larger fuels like tires, although these belts may be completely flat and the impact low. Cooling the clinker in a timely manner allows it to be conveyed without damaging equipment and faster cooling enhances silicate reactivity in the cement. Clinker will still be hot after the clinker cooler, but in many instances it is cool enough to be conveyed on a belt. The abrasive nature of clinker is causing the idlers and cleaners to wear out quickly. Hardened clinker dust is building up on idlers causing belt mistracking. Hot clinker is causing cracks in the belt, making cleaning difficult and leaving crevices in which clinker fines is settling and traveling to other parts of the operation to fall. The carbide blade and high temp yellow urethane blade are both great for high temp and abrasive applications. Urethane Skirting lasts times longer than rubber and is perfect for the extremely-abrasive clinker being conveyed during this process. The impact is not extremely high on belts moving clinker, so sealing the load zone with low-resistance Flexco Slider Beds with Impact Idlers is a good option. The minimal exposed componentry makes it a good candidate where clinker dust often settles and hardens. Clinker transfers are often completely enclosed chutes, so inspections and maintenance can be difficult unless Inspection Doors are used. The abrasive nature of clinker is wearing out skirting and idlers quickly, especially when it gets in the bearings. Enclosed belts need to be opened to inspections, which is difficult and time consuming. Round clicker nodules are rolling around the belt and bouncing off, especially on inclines. A horizontal finish mill requires frequent inspections as the mills take a lot of abuse. The steel balls that crush the clinker into fine powder are wearing out and breaking internal components in the mill. To minimize gypsum and clinker dust escaping when brought from storage, the load zone needs to be properly supported utilizing Flexco Impact Beds, Slider Beds, and Impact Idlers. The impact likely will not be high in this area, but it does require support. We use cookies to give you the best possible experience with our website. If you continue without changing your settings, you are agreeing to our use of cookies to improve your user experience. You can click the cookie settings link on our website to change your cookie settings at any time.

Chapter 6 : Cement | Climate Technology Centre & Network

the solution to this problem is Totally Integrated Automation. Pyroprocessing of raw meal to form cement clinker Clinker production The pyroprocessing system.

The counter flow of raw materials and exhaust gases in the raw mill and preheater act as an inherent semi-dry raw mill and dry scrubber preheater to control SO2 emissions. Some SO2 may also be dry scrubbed in the baghouse particulate control system. Created CaSO3 and CaSO4 either pass directly with the raw materials to the burning zone or are collected by the main baghouse and recirculated back into the raw material feed system. In a properly operated cement kiln system with a reasonable alkali balance, sulfur from fuel exits in the clinker. Sulfur in raw materials is split, some exiting with clinker and the rest in stack emissions. First the control technology must succeed at controlling the pollutant of intent, preferably at control levels that are in the same range as traditional end-of-pipe technologies. Second, the emissions control technology must not create another pollution problem. Systems that require wastewater treatment or land disposal reduce emissions at a cost to another portion of the environment. Likewise, decreasing one pollutant, for example NOx, at the cost of increasing another, condensable particulate, can not be considered viable and certainly not process compatible. Finally, the emission control technology can not negatively impact the cement product or process. Is this too much to ask? Calcium hydroxide has also been injected at various points with similar control efficiency results. One cement plant uses a hydrated lime spray dryer absorber to control SO2 emissions. As a process compatible application this system returns all effluent to the raw mill to avoid any waste disposal issues. It is important to understand that any of these options can have the initial appearance of very high control efficiencies which then drop over time as higher recirculating loads of sulfur shift the equilibrium inside the kiln system and, at times, create process control and operating problems in the kiln system. Such system bleeds have been used for chloride, mercury and other metals but can also play a critical role in SO2 emission controls, especially in conjunction with the aforementioned process compatible control technologies. One technology not mentioned in the PCA report but discussed in the Babcock and Wilcox paper is circulating dry scrubbers. The PCA report did not mention this technology probably because of its newness and lack of exposure in the cement industry. A CFBA system installed in advance of the primary particulate control baghouse in a cement kiln system in contrast with the Babcock and Wilcox approach coupled with a continues bleed of dust from the baghouse to the finish mill should provide an unprecedented control of SO2 as well as other selected pollutants. In-line raw mills, however, are typically shut down about once a week for maintenance. Bleeding this material to the finish mill will reduce the amount of gypsum which needs to be added to the cement in the finish mill. Coupling an appropriate bleed with a CFBA may be the ultimate process compatible SO2 control emission technology that will actually improve kiln operations and also control other emissions. Enders, Holcim Group Support Lid. Haeseli, Holcim Schweiz A.

Chapter 7 : Ment Clinker Processing Technology

/ Cement / Pyroprocessing ; The highest standard in cement clinker cooling technology. ABC Cooler Inlet. The ABC Inlet is a minor upgrade that eliminates snowmen.

Effect of the starting compostion was studied in bone cement containg coarse b-tricalcium phosphate b-TCP granules which was very dense and round. With respect to the mixing ratio between b-tricalcium phosphate and monocalcium monophophate T: M , the properties such as setting time, density and compressive strength were measured. The properties of bone cement prepared from normal powdery b-TCP was strongly dependent on the initial mixing ratio T: Though the compressive strength as well as density was maximum at T: On the contrary, in the specimens from granular b-TCP, compressive strength was much less deependent on the initial mixing ratio. Range of optimum compressive strength covered from T: Therefore, granular groups provided more degree of freedom to control other properties such as setting time while maintaing its compressive strength. Eco-cement produced from waste concrete was proved to be feasible in early research. The seed crystal of ground granulated blast furnace slag GGBS was utilized in this research to lower the sintering temperature of eco-cement clinker. Four main cement minerals were all observed in eco-cement clinker and the compressive strength of the eco-cement pastes can approach to about 66 MPa at 28 curing days. The results showed that GGBS seed crystal was favourable for the formation of cement minerals at a lower temperature. Combining with the utilization of waste, an new idea of using the waste to prepare high-strength artificial aggregates was put forward in this paper. The concrete was also prepared by using these aggregates. The demolished concrete could be recovered and used as cement raw meal to produce new cement clinker. In this study, the feasibility of making cement clinker with this kind of demolished concrete was studied. The concrete aggregates composed of steel slag, blast furnace slag, coal gangue and fly ash were prepared. The concrete was prepared using these aggregates with the water-cement ratio of 0. The compressive strength of the concrete in 28 days is In accordance with the ratio of cement raw meal, the cement clinker is produced by adding appropriate limestone, clay and other correction materials. After hydrated for 3 days, 7 days and 28 days, the cement paste compressive strength is Through determining Ca OH 2 content and chemically combined water content, hydration degree of cement with added-calcium thermal activated coal gangue may be analyzed. Variation of mineral composition during hydration process of system was analyzed by X-ray diffraction XRD method. Simultaneously, specific strength index was applied to study pozzolanic effect of activated coal gangue.

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Chapter 8 : Process Compatible SO2 Control In Cement Kilns

In the cement industry pyroprocessing (processing the raw material into cement under a high temperature, e.g., above C) is a very common technological procedure, which accounts for 74% of the energy consumption in global cement/concrete industries.

Chemical and other hazardous waste Cement kilns are an attractive way of disposing of hazardous materials, because of: A notable example is the use of scrapped motor-vehicle tires, which are very difficult to dispose of by other means. Whole tires are commonly introduced in the kiln by rolling them into the upper end of a preheater kiln, or by dropping them through a slot midway along a long wet kiln. The steel and zinc in the tires become chemically incorporated into the clinker, partially replacing iron that must otherwise be fed as raw material. A high level of monitoring of both the fuel and its combustion products is necessary to maintain safe operation. However, burning any fuels, especially hazardous waste materials, can result in toxic emissions. If the reaction is incomplete, excessive amounts of free calcium oxide remain in the clinker. Regular measurement of the free CaO content is used as a means of tracking the clinker quality. As a parameter in kiln control, free CaO data is somewhat ineffective because, even with fast automated sampling and analysis, the data, when it arrives, may be 10 minutes "out of date", and more immediate data must be used for minute-to-minute control. Conversion of belite to alite requires partial melting, the resulting liquid being the solvent in which the reaction takes place. The amount of liquid, and hence the speed of the finishing reaction, is related to temperature. To meet the clinker quality objective, the most obvious control is that the clinker should reach a peak temperature such that the finishing reaction takes place to the required degree. A further reason to maintain constant liquid formation in the hot end of the kiln is that the sintering material forms a dam that prevents the cooler upstream feed from flooding out of the kiln. The feed in the calcining zone, because it is a powder evolving carbon dioxide, is extremely fluid. Cooling of the burning zone, and loss of unburned material into the cooler, is called "flushing", and in addition to causing lost production can cause massive damage. However, for efficient operation, steady conditions need to be maintained throughout the whole kiln system. The feed at each stage must be at a temperature such that it is "ready" for processing in the next stage. To ensure this, the temperature of both feed and gas must be optimized and maintained at every point. The external controls available to achieve this are few: Independent control of fuel to kiln and calciner Independent fan controls where there are multiple preheater strings. The independent use of fan speed and fuel rate is constrained by the fact that there must always be sufficient oxygen available to burn the fuel, and in particular, to burn carbon to carbon dioxide. If carbon monoxide is formed, this represents a waste of fuel, and also indicates reducing conditions within the kiln which must be avoided at all costs since it causes destruction of the clinker mineral structure. The assessment of the clinker peak temperature has always been problematic. Contact temperature measurement is impossible because of the chemically aggressive and abrasive nature of the hot clinker, and optical methods such as infrared pyrometry are difficult because of the dust and fume-laden atmosphere in the burning zone. The traditional method of assessment was to view the bed of clinker and deduce the amount of liquid formation by experience. As more liquid forms, the clinker becomes stickier, and the bed of material climbs higher up the rising side of the kiln. It is usually also possible to assess the length of the zone of liquid formation, beyond which powdery "fresh" feed can be seen. Cameras, with or without infrared measurement capability, are mounted on the kiln hood to facilitate this. On many kilns, the same information can be inferred from the kiln motor power drawn, since sticky feed riding high on the kiln wall increases the eccentric turning load of the kiln. Further information can be obtained from the exhaust gas analyzers. The formation of NO from nitrogen and oxygen takes place only at high temperatures, and so the NO level gives an indication of the combined feed and flame temperature. SO2 is formed by thermal decomposition of calcium sulfate in the clinker, and so also gives in indication of clinker temperature. Modern computer control systems usually make a "calculated" temperature, using contributions from all these information sources, and then set about controlling it. As an exercise in process control , kiln control is extremely challenging, because of multiple inter-related variables, non-linear responses, and variable process lags. Computer control systems were first tried in the early s, initially with poor results due mainly to poor process measurements. Since , complex high-level supervisory control systems have been standard on new installations. Cement kiln emissions[edit] Emissions from cement works are determined both by continuous and discontinuous measuring methods, which are described in corresponding national guidelines and standards. Continuous measurement is primarily used for dust, NOx and SO2, while the remaining parameters relevant pursuant to ambient pollution legislation are usually determined discontinuously by individual measurements. The following descriptions of emissions refer to modern kiln plants based on dry process technology. Carbon dioxide[edit] During the clinker burning process CO2 is emitted. CO2 accounts for the main share of these gases. CO2 emissions are both raw material-related and energy-related. Use of fuels with higher hydrogen content than coal and use of alternative fuels can reduce net greenhouse gas emissions. In this process, the steps of raw material processing, fuel preparation, clinker burning and cement grinding constitute major emission sources for particulate components. Nitrogen oxides NOx [edit] The clinker burning process is a high-temperature process resulting in the formation of nitrogen oxides NOx. Without reduction measures, process-related NOx contents in the exhaust gas of rotary kiln plants would in most cases considerably exceed the specifications of e. European legislation for waste burning plants 0. Reduction measures are aimed at smoothing and optimising plant operation. High process temperatures are required to convert the raw material mix to Portland cement clinker. For reasons of clinker quality the burning process takes place under oxidising conditions, under which the partial oxidation of the molecular nitrogen in the combustion air resulting in the formation of nitrogen monoxide NO dominates. This reaction is also called thermal NO formation. At the lower temperatures prevailing in a precalciner, however, thermal NO formation is negligible: Staged combustion is used to reduce NO: This causes CO to form. The CO then reduces the NO into molecular nitrogen: Hot tertiary air is then added to oxidize the remaining CO. Sulfur dioxide SO2 [edit] Sulfur is input into the clinker burning process via raw materials and fuels. Depending on their origin, the raw materials may contain sulfur bound as sulfide or sulfate. Most of the sulfides are pyrite or marcasite contained in the raw materials. Given the sulfide concentrations found e. In some cases, injected calcium hydroxide is used to lower SO2 emissions. The sulfur input with the fuels is completely converted to SO2 during combustion in the rotary kiln. In the preheater and the kiln, this SO2 reacts to form alkali sulfates, which are bound in the clinker, provided that oxidizing conditions are maintained in the kiln. Carbon monoxide CO and total carbon[edit] The exhaust gas concentrations of CO and organically bound carbon are a yardstick for the burn-out rate of the fuels utilised in energy conversion plants, such as power stations. By contrast, the clinker burning process is a material conversion process that must always be operated with excess air for reasons of clinker quality. In concert with long residence times in the high-temperature range, this leads to complete fuel burn-up. The emissions of CO and organically bound carbon during the clinker burning process are caused by the small quantities of organic constituents input via the natural raw materials remnants of organisms and plants incorporated in the rock in the course of geological history. These are converted during kiln feed preheating and become oxidized to form CO and CO2. In this process, small portions of organic trace gases total organic carbon are formed as well. In case of the clinker burning process, the content of CO and organic trace gases in the clean gas therefore may not be directly related to combustion conditions. Kiln feed and rotary kiln exhaust gases are conveyed in counter-flow and mixed thoroughly. Thus, temperature distribution and residence time in rotary kilns afford particularly favourable conditions for organic compounds, introduced either via fuels or derived from them, to be completely destroyed. For that reason, only very low concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans colloquially " dioxins and furans " can be found in the exhaust gas from cement rotary kilns. PCB may be introduced into the process via alternative raw materials and fuels. The rotary kiln systems of the cement industry destroy these trace components virtually completely. The rotary kiln systems of the cement industry destroy virtually completely the PAHs input via fuels.

Emissions are generated from organic constituents in the raw material. Benzene, toluene, ethylbenzene, xylene BTEX [edit] As a rule benzene , toluene , ethylbenzene and xylene are present in the exhaust gas of rotary kilns in a characteristic ratio. BTEX is formed during the thermal decomposition of organic raw material constituents in the preheater. Gaseous inorganic chlorine compounds HCl [edit] Chlorides are a minor additional constituents contained in the raw materials and fuels of the clinker burning process. They are released when the fuels are burnt or the kiln feed is heated, and primarily react with the alkalis from the kiln feed to form alkali chlorides. This cycle in the area between the rotary kiln and the preheater can result in coating formation. A bypass at the kiln inlet allows effective reduction of alkali chloride cycles and to diminish coating build-up problems. During the clinker burning process, gaseous inorganic chlorine compounds are either not emitted at all or in very small quantities only. Ultra-fine dust fractions that pass through the measuring gas filter may give the impression of low contents of gaseous fluorine compounds in rotary kiln systems of the cement industry. Trace elements[edit] The emission behaviour of the individual elements in the clinker burning process is determined by the input scenario, the behaviour in the plant and the precipitation efficiency of the dust collection device. Depending on the volatility and the operating conditions, this may result in the formation of cycles that are either restricted to the kiln and the preheater or include the combined drying and grinding plant as well. Trace elements from the fuels initially enter the combustion gases, but are emitted to an extremely small extent only owing to the retention capacity of the kiln and the preheater. Under the conditions prevailing in the clinker burning process, non-volatile elements e. Elements such as lead and cadmium preferentially react with the excess chlorides and sulfates in the section between the rotary kiln and the preheater, forming volatile compounds. In this way, the volatile elements accumulated in the kiln-preheater system are precipitated again in the cyclone preheater, remaining almost completely in the clinker. As a consequence, a cycle can be formed between preheater, raw material drying and exhaust gas purification. Mercury and its compounds are not precipitated in the kiln and the preheater. They condense on the exhaust gas route due to the cooling of the gas and are partially adsorbed by the raw material particles. This portion is precipitated in the kiln exhaust gas filter. Owing to trace element behaviour during the clinker burning process and the high precipitation efficiency of the dust collection devices, trace element emission concentrations are on a low overall level. References[edit] Wikimedia Commons has media related to Cement kilns.

Chapter 9 : Clinker substitute (slag, natural pozzolans, synthetic pozzolans) | ClimateTechWiki

The clinker raw-mixture was made of pure compounds and calculated to have the same proportion of main phases as a Portland cement clinker at the end of the clinkering process. Since chlorine is commonly found in real cement clinker raw-mixture [1], [2], [3], the chlorine influence in the incorporation ratio of ZnO was evaluated.

A cement is a binder, a substance that sets and hardens and can bind other materials together. Cement is a global commodity, manufactured at thousands of plants. The principal and most visible market for cement is the construction industry in a multitude of applications where it is combined with water to make concrete. Most modern civil engineering projects, office buildings, apartments and domestic housing projects use concrete, often in association with steel reinforcement systems. In many developed countries, market growth is very slow, with cement used in bulk primarily for infrastructure construction, based on UNEPTIE. In developing country markets e. China , growth rates are more rapid. Because it is both global and local, the cement industry faces a unique set of issues, which attract attention from both local and international level. Large amounts of electricity are used grinding the raw materials and finished cement. The clinker-making process also emits CO2 as a by-product during the calcination of limestone. These process emissions are unrelated to energy use and account for about 3. Emissions from limestone calcination cannot be reduced through energy-efficiency measures or fuel substitution, but can be diminished through production of blended cement and raw material selection. Introduction Cement is a global commodity, manufactured at thousands of plants. Manufacturing industries in general account for one-third of global energy use. Direct industrial energy and process CO2 emissions amount to 6. Cement production involves the heating, calcining and sintering of blended and ground materials to form clicker. As a result, cement manufacturing is the third largest cause of man-made CO2 emissions due to the production of lime, the key ingredient in cement. Therefore, energy savings during cement production could lead to lower environmental impact. Changes in the chemical formulation of cement have been demonstrated to save energy and reduce CO2 emissions, but their widespread adoption has thus far been hampered by the fact that developing a new industrial standard is complex and requires time. This holds in particular for the cement industry which is a highly capital intensive and competitive sector with long economic lifetimes of existing facilities so that changes in the existing capital stock cannot easily be made. The largest opportunities for improving energy efficiency and reducing CO2 emissions can be achieved by improving the cement manufacturing process. In the cement industry pyroprocessing processing the raw material into cement under a high temperature, e. Grinding and milling account for 5. The following figure presents the cement production process. The potential opportunities for improving energy efficiency and lower CO2 emissions in raw material generation and production of concrete are smaller than in cement manufacturing. For instance, CO2 emissions during transport could be reduced by replacing diesel fuel with biodiesel. Normally, energy efficiency improvements proportionally reduce the emissions of CO2 generated from fossil fuel combustion and electricity generation. However, it should be noted that reducing CO2 emissions from cement manufacturing by a percentage proportional to energy efficiency improvements is not possible. For example, if a near-zero CO2 emitting fuel e. Another way to reduce emissions is to substitute fossil fuels with waste or biomass. Cement kilns are well suited for waste-combustion because of their high process temperature and because the clinker product and limestone feedstock act as gascleaning agents. Used tyres, wood, plastics, chemicals and other types of waste are co-combusted in cement kilns in large quantities. However, very high substitution rates can only be accomplished if a tailored pre-treatment and surveillance system is in place. Municipal solid waste, for example, needs to be pre-treated to obtain homogeneous calorific values and feed characteristics. Another potential source of energy is carpets: Although these alternative materials are widely used, their use is still controversial, as cement kilns are not subject to the same tight emission controls as waste-incineration installations. Worldwide, the sector consumed 2. From a technical perspective, the use of alternative fuels could be raised to 24 Mtoe to 48 Mtoe, although there would be differences among regions due to the varying availability of such fuels. This would yield CO2 reductions in the range of Mt to Mt a year. Yet another way to reduce energy and process emissions in cement production is to blend cements with increased proportions of alternative non-clinker feedstocks, such as volcanic ash, granulated blast furnace slag from iron production, or fly ash from coal-fired power generation. The use of such blended cements varies widely from country to country. In the United States and in China, other clinker substitutes are added directly at the concrete-making stage. Feasibility of technology and operational necessities In the cement pyroprocessing process it is important to keep in mind that waste materials combust and burn at different temperatures under different conditions. Therefore, solid waste fuels need to be introduced into the kiln in such a manner that they do not significantly change the temperature profile and chemical reactions in the overall pyroprocessing. Sometimes it is necessary to add solid waste through a hatch or valve structure in the kiln shell, which implies a technical challenge and which partly offsets the efficiency gains and CO2 emission reductions. Finally, receiving and handling of alternate or waste fuels can raise technical liability and political concerns. Cement manufacturing companies do not desire to be labeled as handlers of hazardous wastes and surrounding communities may have concerns about hazardous waste transport and handling in a nearby cement plant. Furthermore, blended cements offer a major opportunity for energy conservation and emission reductions, but their use would in many cases require revisions to construction standards, codes and practices. Of the cement production chain steps, grinding and milling operations are rather energy inefficient. Energy improvement of grinding and milling could be increased by using modern mill systems which comprise several units of process equipment with high-pressure, twin-roll presses, tube mills, ball mills, and conventional or high-efficiency separators IEA, Pyroprocessing transforms the raw mix into clinkers. The wet process kilns operating in Europe are generally expected to be converted to dry process kiln systems when renewed, as are semi-dry and semi-wet processes kiln systems. The percentage is even lower for developing countries Karstensen, no date. These process improvements will come from better energy management, upgrading existing equipment e. Japan is the leading country when it comes to energy efficiency in the cement sector. The typical energy balances for the major pyroprocessing systems are shown below. These balances show where energy losses occur and which thus represent an opportunity for improving energy efficiency and lowering fuel-based CO2 emissions. In particular, the table shows that significant improvements can be made by switching from wet to dry cement processes. The individual energy use areas e. Through energy audits, including kiln system performance testing and calculation of mass and heat balances, specific opportunities for improving energy efficiency and lowering CO2 emissions can be identified. A cement manufacturing energy audit should at a minimum address the energy use and recommend potential actions, such as: Lower kiln exit gas losses install devices to provide better conductive heat transfer from the gases to the materials, e. Wet cement production involves mixing raw materials limestone and clay or loam with water in order to produce slurry. Further in the process, water is evaporated from the homogenized mixture and this step in the production requires significant amounts of energy. The raw meal dried slurry is subjected to high temperatures in a rotary kiln, where the reaction of calcination takes place its final products are lime and CO2. The lime is further influenced by the temperatures of 1, to 1, oC. This reaction, called sintering, results in clinker. The final stage of cement production is fine crushing of clinker and mixing the substance with mineral components, such as slag, fly ash or gypsum. In the case of dry cement production, the raw materials are mixed without water and therefore the evaporation process can be omitted. Existing technology in the cement industry can be upgraded in several ways. The Table shows that if all US plants would upgrade their pyroprocessing to the level of the best US plant i. In terms of new technologies in the cement sector, several technologies are being tested and demonstrated, such as fluidised-bed kilns. However, in comparison with older, fully capitalised kiln-based plants, the fluidised bed systems are relatively expensive so that they are likely to be considered only for future capacity expansion. Another barrier to adoption of fluidised-bed systems is the reluctance to invest in such large capital expenditures, as the systems have been demonstrated only at small-scale facilities. This could significantly improve the overall energy efficiency of some manufacturing operations. Presently, five cement manufacturing plants produce electricity on-site through co-generation US Department of Energy, Moreover, utilisation of waste heat in preheater heat exchange systems is usually more energy efficient than the co-generation of electricity with its inherently low conversion efficiency of thermal to electrical energy typically about 10, Jouls are required to produce 1 kWh. Although co-generation of steam at a cement plant is possible, cement plants typically require little steam and are located in isolated areas where markets for excess steam generation are often not available. Contribution of the technology to economic development including energy market support An important benefit of enhancing energy efficiency in the cement industry would be the reduction in energy costs. However, larger energy cost savings are still possible in other parts of the world. Energy efficiency tends to be lower in regions with low energy prices. In those processes where efficiency is close to the practical maximum, innovations in materials and processes would enable even further gains IEA, Climate Cement manufacturing produces CO_2 as it requires very high temperatures to burn raw materials and give the clinker its unique properties. CO_2 is generated from three independent sources: There are three central measures by which the cement industry may save direct CO_2 emissions in the immediate future: The main approaches to this are to use: Blast-furnace slag that has been cooled with water, rather than air. About half of all blast-furnace slag is already used for cement-making where the slag is water-cooled and where transport distances and costs are acceptable. Fly ash from coal-fired power plants. But the carbon content of fly ash can affect the concrete setting time, which determines the quality of the cement. To be used as clinker substitute, high-carbon fly ash must be upgraded. Technologies for this are just emerging. China and India have the potential to significantly increase the use of fly ash. In China, there are about 30 steel slag cement plants with a combined annual output of 4. However, steel slag quality varies and it is difficult to process, which limits its use. Further analysis is needed to validate the viability of this option. Other materials that could be used to a greater extent as clinker substitutes include volcanic ash, ground limestone and broken glass. In the long term, new cement types may be developed that do not use limestone as a primary resource. These new types are called synthetic pozzolans.