REPLACEMENT OF FOSSIL FUELS BY REFUSED DERIVED FUEL AT CEMENT PLANT

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ABSTRACT: *Cement is viewed as one of the significant structure material around the world. Cement creation is a vitality concentrated assembling process expending thermal energy of the order 3.3 GJ/tone of clinker delivered. Historically the essential fuel utilized in the cement industry is coal. Fossil fuel is expensive and emission of greenhouse gases is more as compared to the non-fossil fuel. The use of alternative fuel such as spent tire, municipal solid waste (MSW), rice husk, organic and inorganic material waste in cement industries would ultimately increase the total revenue and reduction of greenhouse gases. A large portion of the work achieved in advancement zone in the cement industry is addressing to solve the issue simply thinking about just a single variable, overlooking that it incorporates such a large number of factors and they act in the meantime. Among the principal factors, it very well may be referenced the nature of the definite item, the ecological ones, the expenses along with the procedure and decrease of non-renewable energy sources (essential) utilized using elective energize (optional), amongst others. The present research means to assemble a mathematical model utilizing optimization tools pursuing to enhance the cement generation process anticipating what can occur with the clinker and the emissions when alternative fuels are utilized. In the improvement procedure, a new methodology called simplex minimization technique is utilized, which depends on linear programming considering a few procedure confinements, such as the particular fuel utilization, cement quality and ecological effect. It is additionally conceivable to assess the dimension of primary fuels substitution through the option or auxiliary ones.*

Key Words: Cement plant; Fossil fuel; Reused; Derived fuel; Environment.

1. INTRODUCTION

Fuels such as coal, petroleum, oil and gaseous petrol give the greater part of the vitality desires of the present reality. Natural gas and coal are utilized in their characteristic structures, yet oil and other petroleum derivatives, for example, bituminous and shale sands require refining and refinement to give usable powers. These fuels exist in any of the accompanying structures: solid, liquid and gas. The limited idea of worldwide petroleum product assets, high costs and in particular, their harming impact on nature emphasize the need to create elective fuels for some industrial frameworks that depend on non-renewable energy sources. Expanded utilization of renewable and alternative fuels can broaden petroleum derivative supplies and help settle air contamination issues related to the utilization of conventional fuels. Fuel is, for the most part, partitioned into two sorts' renewable energy source and non-renewable energy source [1, 2].

Fossil Fuels (Non-Renewable Energy)

The non-sustainable power source is the vitality from petroleum products (coal, unrefined petroleum, gaseous petrol and uranium). Fossil fuels are hydrocarbons, principally coal, fuel oil or flammable gas, framed from the remaining parts of dead plants and creatures. In like manner discourse, the term non-renewable energy source likewise incorporates hydrocarbon-containing normal assets that are not gotten from creature or plant sources. These are now and again referred to rather as mineral energizes. There are essential kinds of petroleum derivatives [3].

Coal is a flammable dark or brownish-black sedimentary rock made generally out of carbon, oxygen, hydrogen, nitrogen and fluctuating measures of sulfur. Coal is made of the remaining parts of antiquated trees and plants that developed swampy wildernesses in warm, soggy atmospheres a huge number of years back. The chemical and organic procedure that these dead life forms experience to move toward becoming coal is known as Carbonization. The most punctual known utilization of coal was in China. The Chinese idea of coal was a stone that could consume. Coal is mined out of the ground utilizing different strategies. Some coal mineshafts are burrowed by sinking vertical or flat shafts profound underground, and coal diggers travel by lifts or prepare profound underground to burrow the coal. Another coal is mined in strip mines where immense steam scoops strip away the top layers over the coal. At the opposite end, the coal is utilized to fuel control plants and different industrial facilities. Crude petroleum is another non-renewable energy source which is thick, dark fluid likewise called oil. It is found in deposits in rock formations inside the Earth and separated for use as fuel oil, gas, and different items, for example, wax, assembling of plastics, oils and so forth. Like coal, it was likewise framed more than 300 million years back. A few researchers state that minor diatoms are the source of oil. They complete one thing simply like plants; they can change over daylight straightforwardly into put away vitality [3, 4].

The old Sumerians, Assyrians and Babylonians utilized unrefined petroleum and asphalt "pitch" gathered from enormous leaks. A leak is a spot on the ground where the oil spills up from subterranean. The old Egyptians utilized fluid oil as a medication for wounds, and oil has been utilized in lights to give light. It is made out of different hydrocarbons like straight-chain paraffin, cyclo paraffin or naphthenic, olefins, and aromatics together with a little measure of natural mixes containing oxygen nitrogen and sulfur. The normal organization of unrefined oil is C = 79.5 to 87.1%; H = 11.5 to 14.8%; S = 0.1 to 3.5%, N and O = 0.1 to 0.5% [5].

Natural gas is an odorless, shapeless and colorless in its pure form. Dissimilar to other non-renewable energy sources flammable gas is spotless consuming and transmits lower level conceivably hurt side-effects into the air. It is in this manner called clean gas. Gaseous petrol is lighter than air. Flammable gas is generally comprised of a gas called methane which makes of 80–95% of its substance. Different gases included might be butane, ethane and propane. Flammable gas is, for the most part, connected with oil stores and is gotten from wells delved in the oil-bearing regions. Natural comes in two primary sorts: the first and ordinary sort is found in penetrable sandstone repositories. The second and eccentric sort is found in different places, for example, in coal stores or shale rock formation. Natural gas supplies about 23.8 percent of the world's vitality. The calorific values differ from 12,000 to 14,000 kcal/m^3. It is an amazing household fuel and is passed on in pipelines over huge distances [6, 7].

In 2018, world vitality utilization was 86% non-renewable energy sources or their subordinates. This included 22.9% natural gas, 26.6% coal, and 36.8% petroleum [8]. The rest of the vitality was provided by non-petroleum product, for example, hydroelectric, atomic vitality, geothermal vitality, and vitality created by sunlight based power, tides, and wind. World vitality utilization rises yearly. Since there is a limited measure of petroleum products accessible, their consumption is a wellspring of concern. The way that these energizes discharge pollutants, for example, carbon monoxide, when burned is another wellspring of concern. The likelihood that their consuming adds to worldwide environmental change or a dangerous atmospheric deviation has been the subject of heated debate. For a certain something, it is significant basically because these substances still assume such a vital job in our lives. They give us the way to get around, to keep our homes warm, to cook our meals, and that's only the tip of the iceberg. Given the condition of the development toward elective vitality, petroleum derivatives will keep on assuming these key jobs for quite a long time or even decades still to come. To put it plainly, their significance isn't diminishing presently

Non-Fossil Fuels (Renewable Energy)

Non-petroleum derivatives are elective wellsprings of vitality that don't depend on consuming constrained supplies of natural gas, oil, or coal. Instances of these powers include atomic vitality, wind or water produced vitality, and sun oriented power. These will, in general, be sustainable power sources or methods for creating power that can be used inconclusively. Non-renewable energy sources are considered by numerous individuals to be critical to the eventual fate of intensity creation. This is because they are normally sustainable power sources that could be tapped for a long time and not run out. What's more, vitality creation utilizing non-fossil-based fuel, as a rule, produces substantially less contamination than other vitality sources. This is viewed as essential by numerous administrations who are searching for approaches to decrease the measure of pollution delivered by their nations [9].

The consuming of petroleum products creates a great deal of vitality rapidly and effectively. Numerous individuals currently trust that given the enormous effect on the earth; in any case, non-non-renewable energy sources are a vastly improved approach to produce vitality. Different activities currently exist, particularly in Western nations, to empower organizations and vitality organizations to put resources into strategies for delivering vitality from sustainable sources [10].

Petroleum derivative impediments incorporate pollution. At the point when a petroleum derivative material, for example, coal is scorched to make vitality, carbon dioxide is discharged. This carbon dioxide contaminates the environment and adds to the greenhouse impact. Non-renewable energy sources don't have this weakness. While there are presently strategies for consuming gas and comparative items in all respects effectively, as perfect non-renewable energy sources, a specific measure of pollution is still produced [10].

The historical backdrop of non-renewable energy sources is that these materials were made more than a great many years from stores made up of the remaining parts of ancient plants, creatures, and micro-organisms. Non-renewable energy sources, then again, don't depend on constrained assets. Sustainable power sources incorporate all fuel types and vitality transporters, not the same as the fossil ones. Sustainable power sources incorporate sun based vitality, wind vitality, hydropower from water, biomass from plants, and geothermal vitality are likewise sustainable power sources.

The most widely recognized approach to catch the vitality from biomass was to consume it, to make steam, heat, and electricity. In any case, propels as of late have appeared there are increasingly effective and cleaner approaches to utilize biomass. It very well may be changed over into fluid energizes, for instance, or cooked in a procedure called "gasification" to deliver flammable gases. What's more, certain harvests, for example, switch grass and willow trees are particularly fit as "vitality crops," plants developed explicitly for vitality age [11].

During the 1970s, oil deficiencies pushed the advancement of elective vitality sources. During the 1990s, the push originated from a restored worry for nature in light of scientific investigations showing potential changes to the worldwide atmosphere if the utilization of petroleum products keeps on expanding. Wind vitality offers a suitable, efficient option in contrast to regular power plants in numerous regions of the nation. The wind is a perfect fuel; wind ranches produce no air or water contamination because no fuel is scorched [11].

Waves are brought about by the breeze blowing over the outside of the sea. There is colossal vitality in the sea waves. The complete intensity of waves breaking the world over coastlines is evaluated at 2-3 million megawatts. One approach to tackle wave vitality is to twist or center the waves into a thin channel, expanding their capacity and size. The waves would then be able to be diverted into a catch bowl or utilized legitimately to spin turbines. There are no huge business wave energy plants, yet there are a couple of little ones. Little, on-shore destinations have the best potential for the prompt future; they could deliver enough vitality to control nearby networks. Japan, which imports practically the majority of its fuel, has a functioning wave-energy program. Hydropower is a sustainable power source that doesn't cause a worldwide temperature alteration since it doesn't discharge hazardous ozone-depleting substances. China is the biggest maker of hydroelectricity, trailed by Canada, Brazil, and the United States [12].

Geothermal vitality offers various focal points over customary petroleum derivative-based sources. From a natural stance, the vitality tackled is spotless and alright for the encompassing condition. It is likewise reasonable because the high-temperature water utilized in the geothermal procedure can be re-infused into the ground to deliver more steam. Furthermore, geothermal power plants are unaffected by changing climate conditions. Geothermal power plants constantly work, day and night, making them. From a financial view, geothermal vitality is very cost-focused in certain regions and diminishes dependence on petroleum derivatives and their natural value unusualness. It additionally offers a level of adaptability; an enormous geothermal plant can control whole urban communities while littler power plants can supply increasingly remote locales, for example, country towns [11].

As the worldwide interest for vitality develops and regular vitality assets become progressively exorbitant to remove, individuals are looking to the intensity of the sun. Power can be delivered straightforwardly from sun based vitality utilizing photovoltaic gadgets or by implication from steam generators utilizing sun based warm gatherers to warm a working liquid. Sun oriented warm vitality alludes to saddling the daylight to deliver heat. The real utilization of sun based warm vitality at present are warming pools, warming water for residential use, and space warming of structures. For these reasons, the general practice is to utilize level plate sunlight based vitality authorities with a fixed direction. The significant disadvantages or issues are the irregular and variable way wherein it touches base at the world's surface and the huge region required gathering it at a valuable rate [13].

Energy Generation from Waste Sources

Solid squanders are by definition, any squanders other than fluids or gases that are never again regarded important, and accordingly discarded. Such squanders ordinarily begin from either the private network (metropolitan solid waste or MSW) or business and light-mechanical networks. Squanders created from assembling exercises of overwhelming modern and concoction enterprises are regularly named unsafe squanders. As guidelines keep on getting stricter with diminishing area accessibility, elective uses for the waste must be found to recuperate the remaining warming qualities just as to mitigate landfill-overburdening issues. As demonstrated from the warming qualities recorded in given Table 1, the age of waste-inferred powers gives off an impression of being promising from both the ecological and vitality perspectives. Methane is an exceptionally intense ozone-harming substance that is known to be multiple times more powerful than carbon dioxide. From this point of view, vitality age from MSW is viewed as one of the not very many alternatives to effectively adapt to the ozone-depleting substance emanation issue from landfills [14].

Even though refuse-derived fuel (RDF) is appealing from the angles of asset preservation just as waste decrease, there are severe worries that squander treatment for vitality age may include origin new ecological issues. The majority of the handling troubles emerge from the heterogeneous and non-uniform nature of the waste feed like this creates an in all respects broadly changing the range of treated intermediates and by-products [14].

Table 1: Comparison of heating values of various waste-derived fuels

Fuel Source	Btu/lb
Yard wastes	3000
Spent tires	13000-15000
Combustible paper products	8500
Textiles and plastics	8000
Municipal solid waste	6000
Bituminous coal (average)	11300
Anthracite coal (average)	12000
Crude oil (average)	17000
Natural gas	13500

Energy Recovery from Municipal Solid Waste (MSW)

The recuperation of vitality from MSW has been rehearsed for quite a long time. The consuming or burning, of squanders, for example, wooden boards and various household products were used to create warmth. This thought has turned into the reason for vitality age from the present MSW. The warming estimation of this MSW cremation is around 33% the warming estimation of coal ignition [12, 15].

One strategy for recuperating usable vitality from MSW is gasification. The Texaco gasification process produces a medium-Btu gas from MSW. An improved Texaco process gasifies the MSW under high weight by the infusion of steam and air with the simultaneous gas/strong stream, as appeared in Figure 1.

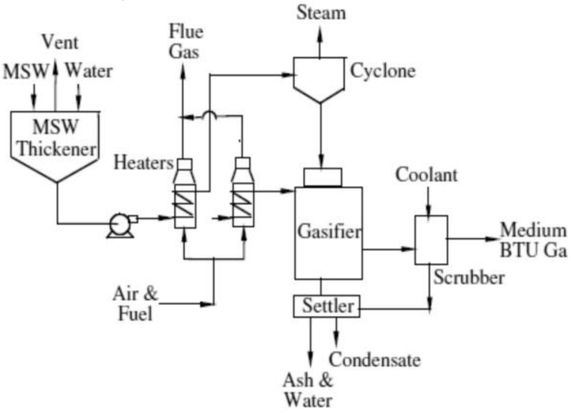

Figure 1: Simplified Texaco gasification process for the conversion of MSW to a medium-Btu gas.

Anaerobic absorption of strong squanders a procedure fundamentally the same as that utilized at wastewater treatment offices and furthermore to that utilized in biogas generation. Anaerobic microorganisms, without oxygen, are utilized to separate the natural matter of the waste [16].

A moderately novel innovation of landfill gas recuperation has been created to help in the accumulation of gases produced by anaerobic assimilation of solid squanders.

Table 2: Composition of the final product from the pyrolysis of 1 Ton of municipal solid waste

Component	Mass or Volume
Char	154-424 lb
Tar	0.5-6 gal
Light Oil	1-4 gal
Liquor	97-133 gal
Gas	7.38-18 scf

Pyrolysis of MSW was predominantly used to create a vaporous fuel. Table 2 represents the composition of the final product from the pyrolysis of 1 Ton of municipal solid waste. All the pyrolysis products have the capability of being helpful energizes for creating profitable items to use in the petrochemical business. A rearranged diagram of the pyrolysis procedure is demonstrated in Figure 2 [17].

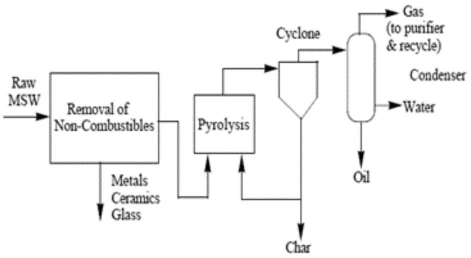

Figure 2: A simplified process schematic for the pyrolysis of MSW

Even though there are various MSW-derived fuel frameworks in full activity or being begun up all through the world. The money-saving advantage investigation alongside the natural effect examination must be painstakingly directed for any picked procedure and site.

Fuel Production from Spent Tires

Scrap tire transfer has turned into a worldwide issue of pestilence extents. Customary treatment of the piece tires was via landfills; in any case, the intense deficiency of suitable landfills has everything except wiped out this as a method for transfer. This has constrained scientists to locate a prudent and productive option for the spent tires [18].

Tire-derived fuels (TDFs) can be acquired by a few strategies. The first is by incineration Britain’s tire incinerator consumes around 90,000 tons of elastic a year. With this sum, the office will create 25 MW of vitality, which is sufficient to control a community. Different procedures, for example, thermal cracking and de-polymerization, recuperate the oil, singe, and gases from the tires as isolated "item" streams. Be that as it may, the most notable strategy for the age of TDFs is from pyrolysis [19].

The recuperation of vitality from spent tires is certifiably not another procedure. In 1974, the principal tests to recuperate vitality from spent traveler tires directed. As research proceeded, it was discovered that the last bottoms product is char, could be additionally treated for the assembling of initiated carbon as appeared in Figure 3 [20].

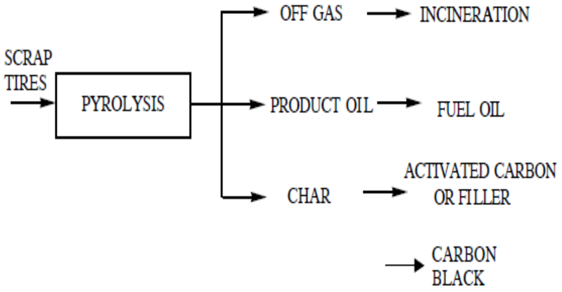

Figure 3: Pyrolysis of spent tires

Like different pyrolysis forms, the FTC procedure consumes squander with high ignition productivity; in any case, it has a couple of other included points of interest. Since it is a fluidized bed process, there is a quick blending of solid particles, which empowers uniform temperature appropriation; in this manner, the activity can be just controlled. Fluidization likewise improves the warmth and mass exchange rates, which like this diminishes the measure of CO emitted. Analysts have had the option to modify the FTC working conditions to diminish the SO_x and NO_x discharges [21].

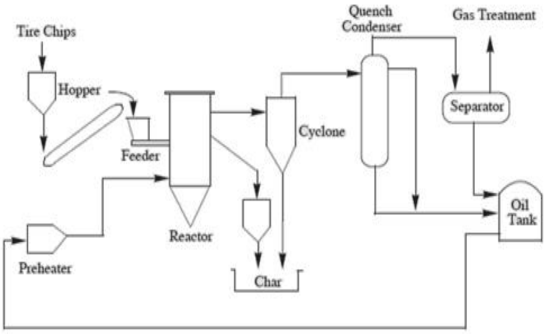

Figure 4: Fluidized thermal cracking

The uncondensed gas is sent to a treatment procedure to expel the hydrogen sulfide. A simplified process appears in Figure 4. An average final result circulation of the FTC procedure as appeared in Table 3. All the final results delivered could either be utilized straightforwardly as a supplemental fuel source at the plant for oil and chemical industries.

Table 3: A typical end product distribution of the FTC process

End product distribution for tires cracked at 450°C		
Product	**Amount Produced (kg)**	**Percent**
Char	166	33.6
Oil	257	52
Gas	72	14.4
Total	495	100

The method of reasoning behind the utilization of tire elastic as an auxiliary fuel to customary coal in power age depends on the superb burning attributes and high warming quality, lower cost and great accessibility, generally low sulfur content, particularly on a Btu premise and decreasing the ecological weight and wellbeing impacts of tire reserves.

Co-ignition of tire and TDF may change the discharge attributes of the burning ability. A few examinations demonstrated that utilizing TDF brought about slight increments in poison emanations, while others indicated slight declines in the mass discharge rates of these contaminations. There is no steady pattern. Given the trials looking at unadulterated coal ignition and burning of coal (95%) + TDF (5%), the environmental outflows of most follow metals increment when TDF is co-combusted with coal [22].

Hence, the consequences of one plant study ought not to be generalized to another because the predominant conditions may contrast in all respects broadly. Natural effects and wellbeing impacts of tire co-burning should be deliberately evaluated for each plant with every significant factor considered, in particular, the ignition procedure itself, burning conditions, plant configuration, control equipment and its proficiency concerning explicit follow components, feed material properties, mix proportions, and examination systems.

2. METHODOLOGY

2.1. Cement Manufacturing Process Phases

Production of cement finishes after going of raw materials from the six stages. These are raw material extraction/Quarry, pounding, proportioning and mixing, pre-radiator stage, oven stage, cooling and last crushing, then packing and shipping.

Phase1: Extraction of Raw Material

Cement utilizes raw materials that spread aluminum, iron, calcium and silicon. Such crude materials are limestone, mud and sand. Limestone is for calcium. This releases the additional fuel cost and makes concrete more efficient. There are additionally different raw materials used for the cement plant. Before transportation of crude materials to the cement plant, huge size rocks are squashed into small size rocks with the help of smasher at the quarry. Smasher decreases the span of enormous rocks to the extent of rock [11].

Phase II: Proportioning, Grinding and Blending

The raw materials from quarry are directed toward plant research facility where they are dissevered and suitable composition of limestone and clay are making plausible before crushing. For the most part, limestone is 80% and 20% staying is dirt. Presently concrete plant beat the raw blend with the assist of overwhelming wheel type rollers and pivoting table. Rotating table constantly turns under the roller and got the crude blend to interact with the roller. Roller squashes the material into a fine powder and completes the process [6].

Phase III: Pre-Heating Raw Material

Afterward definite crushing, the material is arranged to meet the pre-heating chamber. Pre-radiator chamber involves the procedure of violent vertical wind from where the raw material goes before opposing the furnace as appeared in Figure 5. Pre-heating chamber usages the emanating hot gases from kiln. Pre-heating of the material saves the vitality and make plant environmental well disposed of [6].

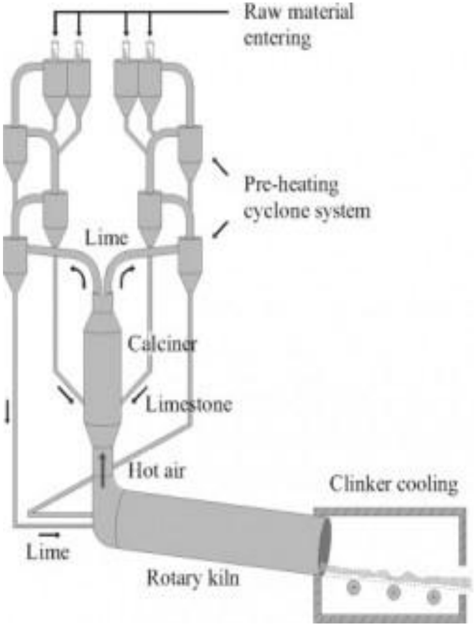

Figure 5: Preheating of raw material Vertical cyclone

Phase IV: Kiln Phase

Figure 6 demonstrates the kiln is a colossal turning heater known as the core of the cement-making process. The raw material is heated up to 1450 ^{0}C. This temperature starts a chemical response named as de-carbonation. In this response, limestone material discharges the CO_2. The high temperature of kiln creates a slurry of the material [7].

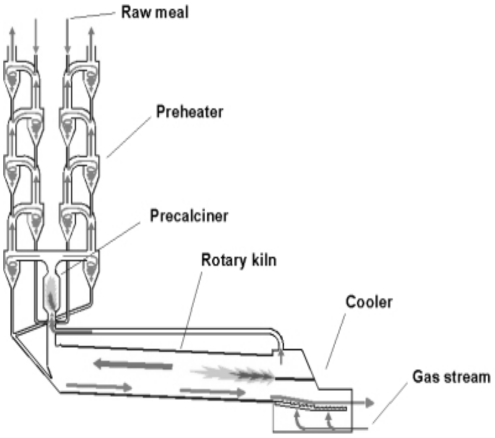

Figure 6: Rotary kiln

The chain of chemical reactions among Ca and SiO_2 blend structure, the vital elements of cement that are Ca_2SiO_4. The kiln is warming up from the left side by the utilization of coal and natural gas. At this point, material attains the lower part of the furnace; it forms the shape of clinker [6].

Phase V: Cooling and Final Grinding

After passing out the kiln, constrained air is cooled the clinkers. Clinker discharged the absorb heat and cool down the temperature. Discharged heat by clinker is recycled by distribution back to the kiln; this also saves vitality. In the fifth stage, the last step is the final grinding. There is a horizontal loaded up with steel balls. Clinker reach in this rotating drum in the rouse of cooling. Then the steel balls tumble and squash the clinker into a fine powder, known as cement. During crushing gypsum is added into the blend in small percentage that controls the setting of concrete [6].

Phase VI: Packing and Shipping

Material is legitimately passed on to the silos from the crushing plants. Additional, it is stuffed to around 20-40 kg sacks. A small amount of cement is gathered in the sacks for the clients who need is extremely little. The rest of the cement is delivered by rails, trucks or ships.

Cement is viewed as a standout amongst the most significant structure materials around the globe. Cement generation is a vitality escalated process devouring thermal vitality of the request of 3.3GJ/ton of clinker delivered. Electrical vitality utilization is around 90-120 KW/ton of bond. Historically the essential fuel utilized in the cement industry is coal. A wide scope of different powers, for example, gas, oil, fluid waste materials and oil coke have all been effectively utilized as a wellspring of vitality for terminating bond making ovens. The bond producing industry is additionally under expanding strain to diminish discharges. Cement fabricating discharges a ton of outflows, for example, carbon dioxide and nitrogen oxide. It is assessed that 5 % of worldwide carbon dioxide outflows begin from cement generation. Utilization of second rate elective fills in some furnace frameworks diminishes NO_x outflow because of responses. There is an expanded net worldwide decrease in CO_2 discharges when squander is combusted in the concrete oven frameworks rather than devoted incinerators [6, 9].

2.2. Benefits of Using Alternative Fuels in Cement Industry

Every year, the energy could be compared to around 25 million tons of coal is required. This is a huge utilization of non- renewable primary fossil fuel, and in this manner, the industry is focused on searching out more vitality effective methods for creating concrete just as an option, increasingly practical vitality sources [15].

The utilization of alternative fuels is an all-around demonstrated and established innovation in the vast majority of the cement industry and this has been the situation for over ten years. In 2018 about 10% of the thermal vitality utilization in the cement industry began from elective fills. This is comparable to 2.5 million tons of coal. The extent is progressively expanding and figures above half are as of now accomplished in specific districts [15].

Squander materials which the cement industry has used as elective energizes incorporate utilized tires, elastic, paper squander, squander oils, squander wood, paper slime, sewage sludge, plastics and spent solvents. The utilization of waste as elective fills in the cement industry has various ecological advantages. Decrease of the utilization of nonrenewable petroleum derivatives, for example, coal just as the natural effects related to coal mining. Commitment towards a bringing down of discharges, for example, ozone-depleting substances by supplanting the utilization of non-renewable energy sources with materials that would somehow or another must be burned with comparing emanation sand last buildups. Boost of the recuperation of vitality from waste. All the vitality is utilized legitimately in the kiln for clinker generation. Amplification of the recuperation of the non-ignitable piece of the waste and end of the requirement for transfer of slag or ash, as the inorganic part substitute's crude material in the cement [22].

Tire Derived Fuel (TDF)

TDF plant has been imported from Denmark for preparing of scrap tires. Scrap tires will comprise of vehicle tires, light truck tires and truck tires. The scrap tires (crude material contribution to the TDF plant) will be free of combustible liquids and foreign bodies, for example, stones. This plant will reuse scrap tires by changing over them into tire determined fuel (TDF) which will be utilized in the kilns E, F and G instead of coal. The TDF plant involves three sections: multi-purpose rasper, super chopper and magnetic separators.

Super Choppers

Scrap tires will be sustained into the super choppers (SC) where it is cleaved down into little bits of about 100 mm breadth. Low speed, high torque empowering preparing of intense material. Begins up when completely stacked with the material – lessening personal time after shutdown. Adjustable knife clearance optimizing the cutting capacity. The knives can be reground on different occasions on a "flat-bed" grinder ensuring long life. The machine is intended for the brisk and simple difference in knives. Interesting rotor produced and intended for least wear.

Multi-Purpose Rasper

The yield of the super chopper is fed into the Multi-purpose rasper. The MPR further decreases the measure of tires from 100 mm to 25 mm distance across. The high inertia from the flywheel gives an all the more even heap of the machine, and accordingly a higher cutting force. Friction clutches shield the machine from material over-burden.

Magnetic Separators

The yield of the MPR is then fed into the magnetic separator (MS). This magnetic separator isolates the rubber and the wires from the TDF. The yield of MS is then fed into the kiln for clinker generation. The over band magnets are utilized to separate magnetic materials from nonmagnetic materials. The over band magnets are built on an edge. The casing is mounted with a drum engine toward one side and a transporter move at the opposite end. A perpetual magnet is set in the edge. The over band magnets are set so far over the outlet conveyors that the magnetic material can't go by them.

Refused Derived Fuel (RDF)

Refuse-derived fuel (RDF) is a fuel delivered by destroying and getting dried out solid waste (MSW) with a Waste converter innovation. RDF generally comprises of burnable parts of city waste. RDF handling offices are ordinarily situated almost a wellspring of MSW and, while a discretionary ignition office is typically near the preparing office, it might likewise be situated at a remote area [22].

Non-flammable materials are expelled amid the post-treatment handling cycle with an air blade or some other mechanical separation process. Progressed RDF handling techniques (pressurized steam treatment in a waste autoclave) can expel or essentially lessen hurtful contaminations and heavy metals for use as a material for an assortment of assembling and related employments. RDF is extricated from municipal solid waste utilizing mechanical heat and organic treatment or waste autoclaves. The creation of RDF may include size screening; preliminary liberation; magnetic separation; refining separation and coarse shredding [19].

3. RESULT AND DISCUSSION

3.1 Model Description for Optimization Problem

The objective of modeling will use optimization algorithms, to guarantee a superior steadiness of the kiln operation, vitality utilization decrease and ecological effect minimization. The perspectives will be modeled impacts that the utilization of substitute fuels can cause in the clinker quality, through the material and fuel chemical composition in the environment. Through the crude material and fuel discharges of SO_2 and CO_2; in the clinker creation cost, allowing for the crude material and powers costs; getting as result, a composition of crude material and powers for the clinker generation.

Another perspective will be demonstrated impacts the expense and electric power utilization mentioned in the crushing procedure for the Portland cement production. The pounded product ought to be inside a certain granulometry limit in such an approach to enhanced conditions for the solidifying procedure. To achieve the demonstrating it is important to know the info parameters information (crude materials, energizes and crude materials costs), and these ought to be tended to in the capacity of the proposed target attaining as results the costs enhancement, ecological effect minimization, amid others. A flowchart is introduced, which demonstrates the technique that will be important to achieve to display the proposed framework, as appeared in Figure 7. So, as to construct the streamlining model, it is important to acquire information just as to recognize the more significant choice factors that characterize the blend. These can be acquired beginning from raw material and fuels chemical composition.

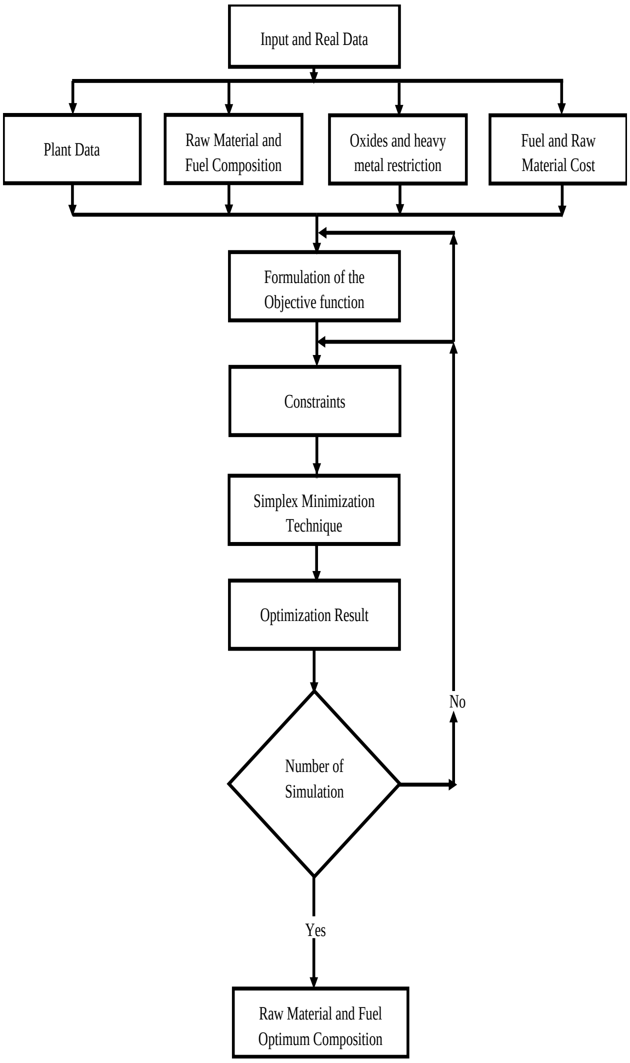

Figure 7: Flow chart for optimization

The blend optimization should deliberate the stable operation of the rotated kiln, the quality of the clinker formed and least cost of the used composition. All these variables are measured in the linear model proposed through the objective function, are as follow [22].

$p=.05x_1+.410x_2+1.565x_3+12.348x_4+8.380x_5+3.2x_6$

x_1=Limestone kg / kg of clinker

x_2=Clay kg / kg of clinker

x_3=Iron ore Laterite kg / kg of clinker

x_4=Coal kg / kg of clinker

x_5=Tire kg / kg of clinker

x_6=Rice Husk kg / kg of clinker

Constraint for calcium oxide

$51.73x_1+3.22x_2+12.09x_3+4.83x_4+41.75x_5+23.14x_6 \geq 62$

$51.73x_1+3.22x_2+12.09x_3+4.83x_4+41.75x_5+23.14x_6 \leq 67$

Constraint for silica oxide

$4.71x_1+61.62x_2+27.63x_3+31.7x_4+24.82x_5+69.18x_6 \geq 19$

$4.71x_1+61.62x_2+27.63x_3+31.7x_4+24.82x_5+69.18x_6 \leq 22$

Constraint for aluminum oxide

$.88x_1+15.27x_2+9.47x_3+36.69x_4+2.66x_5+2.16x_6 \geq 7$

$.88x_1+15.27x_2+9.47x_3+36.69x_4+2.66x_5+2.16x_6 \leq 18$

Constraint for ferric oxide

$.76x_1+5.71x_2+41.65x_3+27.65x_4+1.49x_5+1.02x_6 \geq 5$

$.76x_1+5.71x_2+41.65x_3+27.65x_4+1.49x_5+1.02x_6 \leq 15$

Constraint for magnesium oxide

$.58x_1+1.74x_2+.81x_3+1.29x_4+6.39x_5+0.3x_6 \leq 6.5$

For the production of 1kg of clinker

$6640x_4+7200x_5+2800x_6=780$

Optimal solution

$p = 1.40242$; $x_1 = 1.13712$, $x_2 = 0.205901$, $x_3 = 0.0240978$, $x_4 = 0.0683137$, $x_5 = 0.0453329$, $x_6 = 0$

3.2 MATERIAL BALANCE:

Mixing Station Silos

Table 4 and 5 represent the percentages of material components and fuel analysis composition, respectively.

m_1 = mass flow rate of limestone at inlet of mixing station

m_2 = mass flow rate of clay at mixing station

m_3 = mass flow rate of iron ore at mixing station

m_4 = mass flow rate of mixture out of mixing station (Silos)

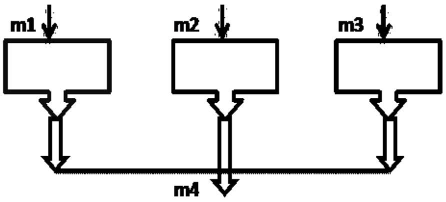

Figure 8: Mixing station silo

Figure 8 show the mixing station silo.

Input = Output

m_1 = 43.43 kg/sec

m_2 = 7.86 kg/sec

m_3 = 0.92 kg/sec

m_4 = 52.21 kg/sec

Percentage of limestone in the feed = 83.1833 %

Percentage of clay in the feed = 15.0545 %

Percentage of iron ore in the feed = 1.76211 %

43.43/52.21 * 100 = 83.1833 %

7.86/52.21 * 100 = 15.0545 %

0.92/52.21 * 100 = 1.76211 %

Vertical Roller Mill

Figure 9 represent the vertical roller mill.

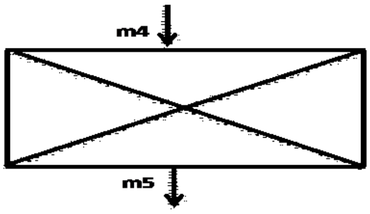

Figure 9: Vertical roller mill

Table 4: Percentages of material components

S.No.	Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Cl
1	Limestone	4.71	0.88	0.76	51.73	0.58	0.01	0.14	0.14	0.04
2	Shell clay	61.62	15.27	5.71	3.22	1.74	0.01	0.71	2.60	0.13
3	laterite	27.63	9.47	41.65	12.09	0.81	0.13	0.07	0.28	-

Table 5: Fuel analysis

S.No.	Fuel sample	Total moisture %	Ash %	Net calorific value Kcal/kg
1	Coal	7.91	14.57	6640
2	Rice husk	5.58	13.65	2800
3	Tire	1.37	4.76	7200

Table 6 represents the chemical analysis of ash.

Table 6: Chemical analysis of ash

S.No.	Fuel	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Cl
1	Coal	31.70	36.59	27.65	4.83	1.29	5.42	0.00	0.00	0.00
2	Rice husk	69.18	2.16	1.02	23.14	0.30	1.08	0.26	2.81	0.04
3	Tire	24.82	2.66	1.49	41.75	6.39	9.91	0.46	11.64	0.12

m_4 = mass flow rate of mixture out of mixing station
m_5 = mass flow rate at outlet of roller mill
Input = Output
$m_4 = m_5$
m_5 = 52.21 kg/sec

Assuming that 2% moisture in raw meal at the outlet of the vertical roller mill.

$m_w= 0.02 *m_5$
m_w= 1.0442 kg/sec
Now,
m_6 = mass flow rate of moisture free raw meal
$m_6 = m_5-m_w$
m_6= 51.1658 kg/sec

Dust Collecting Cyclones

Assuming that 99% efficiency of cyclones (the top dust is just 1% of the bottom coarse material collected at the bottom) =1%.

m_7 = mass flow rate of raw meal dust at top of cyclone
m_8 = mass flow rate of raw meal at bottom of cyclone
$m_7 = 0.01 *m_8$
The mass balance is,
$m_6 = m_7 + m_8$
$m_6 = 0.01m_8 + m_8$
$m_6= 1.01\ m_8$
m_8 = 51.1658 kg/sec

Raw Meal Silo (Homogenization Silo)

Input = Output
$m_8 = m_9$
m_9 = mass flow rate of raw meal at the inlet of cyclone pre-heater system
m_9 = 50.6592 kg/sec

Pre-Heater Cyclone Section

Assuming that efficiency of cyclone system is 99.5%.

The mass balance is,
$m_9 = m_{10} + m_{11}$
m_{10} = mass flow rate of raw meal dust at the top of cyclone preheating System
m_{11} = mass flow rate of raw meal at the inlet of pre-calciner
By using efficiency:
m_{10}= 0.50% m_{11}
Then,
$m_9 = 0.005m_{11} + m_{11}$
$m_9 = 1.005\ m_{11}$
m_{11} = 50.4071 kg/sec
Whereas the mass flow rate of dust:
$m_{10} = 0.005 *m_{11}$
m_{10} = 0.2520 kg/sec

Pre-Calciner

In pre-claciner, 90% of calculations is accomplished.

$CaCO_3 \rightarrow CaO + CO_2$
100 → 56 + 44
First we calculate the amount of $CaCo_3$ in raw meal
Percentage of $CaCO_3$ In raw meal =83.1833%
The amount of calcium oxide form is
100kg of $CaCO_3$ → 56kg of CaO
1kg of $CaCO_3$ → 56/100kg of CaO
0.8318*0.9*50.407kg of $CaCO_3$ → 56/100*0.8318*0.9*50.407kg of CaO
m_{12} = 21.1329 kg/sec
m_{12} = mass flow rate of CaO formed in pre-calciner
The amount of unreacted $CaCO_3$ = 0.1
m_{13}= (1-0.9)*0.8318*50.407
m_{13} = 4.193035 kg/sec
m_{13}= mass flow rate of $CaCO_3$ unreacted in pre-calciner
By optimization:
The mass flow rate of coal = 2.6092 kg/sec
The mass flow rate of tire = 1.7314 kg/sec
m_{14} = mass flow rate of CO_2 formed in pre-calciner due to calcination.
56kg of CaO → 44kg of CO_2
1kg of CaO → 44/56kg of CO_2
21.1329kg of CaO → 44/56*21.1329kg of CO_2
m_{14} = 16.60442 kg/sec

25% of total coal burnt in pre-calciner while 75% burnt in rotary kiln

m_{15} = mass flow rate of CO_2 formed in pre-calciner due to the combustion of coal
$C + O_2 \rightarrow CO_2$
12 + 32 → 44
12 kg of C → 44 kg of CO_2
1 kg of C → 44/12 kg of CO_2
2.6092*0.25*0.639kg of C → 44/12*0.639*2.6092*0.25 kg of CO_2
m_{15} = 1.528339 kg/sec
m_{16} = mass flow rate of CO_2 formed in pre-calciner due to the combustion of tire.
$C + O_2 \rightarrow CO_2$
12 kg of C → 44 kg
1 kg of C → 44/12 kg of CO_2
1.7314*0.7215kg of C → 44/12*1.7314*0.7215kg of CO_2

m_{16} = 4.5804 kg/sec

m_{17} = mass rate of SO_2 formed in pre-calciner due to combustion of coal

$S + O_2 \rightarrow SO_2$

$32 + 32 \rightarrow 64$

32 kg of S → 64 kg of SO_2

1kg of S → 64/32 kg of SO_2

1.7314*0.25*0.046 kg of S → 64/32*1.7314*0.25*0.046 kg of SO_2

m_{17} = 0.0600 kg/sec

m_{18} = mass flow rate of SO_2 due to the combustion of tire in pre-calciner

1kg of S → 64/32 of SO_2

1.7314*0.0123 kg of S → 64/32*1.7314*0.123 kg of SO_2

m_{18} = 0.04259 kg/sec

m_{19} = mass flow rate of N_2 formed in pre-calciner due to coal

m_{19} = 0.25*2.6092*0.018

m_{19} = 0.01174 kg/sec

m_{20} = mass flow rate of N_2 formed in pre-calciner due to tire

m_{20} = 1.7314*0.0036

m_{20} = 0.006233 kg/sec

m_{21} = mass flow rate of H_2O in pre-clanciner due to coal

$2H_2 + O_2 \rightarrow 2H_2O$

$2 + 16 \rightarrow 18$

2 kg of H → 18kg of H_2O

1 kg of H → 18/2 kg of H_2O

0.25*2.6092*0.036 kg of H → 18/2*0.25*2.6092*0.036 kg of H_2O

m_{21} = 0.211345 kg/sec

m_{22} = mass flow rate of H_2O in pre-calciner due to tire

1 kg of H → 18/2 kg of H_2O

1.7314*0.0674 kg of H → 18/2*1.7314*0.0674 kg of H_2O

m_{22} = 1.0502 kg/sec

Now,

m_{23} = total amount of solid stream going out of pre-calciner.

$m_{23} = m_{13} + (1-0.8656)\, m_{11} + m_{12}$

m_{23} = 4.193 + (1-0.8656)50.4071 + 21.1329

m_{23} = 33.80275kg/sec

Rotary Kiln

Overall conversion $CaCO_3$ is = 98% remaining = 2%.

Out of which 90% part is achieved in pre-calciner the remaining will be achieved in Rotary Kiln =8%

Total amount of calcium carbonate to be calculated is = 0.98*0.8318*51.1658

Total amount of calcium carbonate to be calculated is =41.7101 kg/sec

Amount of $CaCO_3$ to be calcined in rotary kiln = 0.08*0.8318*51.1658

Amount of $CaCO_3$ to be calcined in rotary kiln = 3.40491 kg/sec

m24 = mass flow rate of CaO formed in Rotary Kiln

$CaCO_3 \rightarrow CaO + CO_2$

$100 \rightarrow 56 + 44$

1 kg of $CaCO_3$→ 56/100 kg of CaO

3.404 kg of $CaCO_3$→ 56/100*3.404 kg of CaO

m_{24} = 1.906751 kg/sec

m_{25} = mass flow rate of unreacted calcium carbonate from rotary kiln

m_{25}= 0.02*0.8318*51.1658

m_{25} = 0.851228 kg/sec

m_{26} = mass flow rate of clinker formed

$m_{26} = m_{23} - m_{13} + m_{24} + m_{25}$

m_{26} = 32.3677 kg/sec

The amount of coal burnt in kiln is = 0.75*2.6092

The amount of coal burnt in kiln is = 1.9569kg/sec

m_{27} = mass flow rate of CO_2 formed in Rotary kiln due to calcinations.

1 kg of CaO → 44/56 kg of CO_2

1.906 kg of CaO → 44/56*1.906 kg of CO_2

m_{27} = 1.4981 kg/sec

m_{28} = mass flow rate of CO_2 formed in Rotary kiln due to combustion of coal

$C + O_2 \rightarrow CO_2$

1 kg of C 44/12kg of CO_2

1.9569*0.639 kg of C → 44/12*0.639*1.9569 kg of CO_2

m_{28} = 4.5850 kg/sec

m_{29} = mass flow rate of SO_2 in kiln due to coal

$S + O_2 \rightarrow SO_2$

1 kg of S → 64/32 kg of SO_2

1.9569*0.046 kg of S → 64/32*0.046*1.9569 kg of SO_2

m_{29} = 0.180035 kg/sec

m_{30} = mass flow rate of N_2 in kiln due to coal

m_{30} = 0.018*1.9569

m_{30} = 0.035224 kg/sec

m_{31} = mass flow rate of H_2O in kiln due to coal

$2H_2 + O_2 \rightarrow 2H_2O$

1 kg of H → 18/2 kg of H_2O

1.9569*0.036 kg of H → 18/2*1.9569*0.036 kg of H_2O

m_{31} = 0.6340 kg/sec

m_{32} = mass flow rate of O_2 in kiln due to coal

m_{32} = 1.9569*0.009

m_{32} = 0.017612 kg/sec

Primary Air Calculations for Rotary Kiln

$m_{\text{primary air}}$ = mass flow rate of primary air

O_2 required for C = 1.9569*0.639*32/12

O_2 required for C = 3.3345 kg/sec

O_2 required for H = 1.9569*0.036*16/2

O_2 required for H = 0.5635 kg/sec

O_2 required for S = 1.9569*0.046*32/32

O_2 required for S = 0.090 kg/sec

Total O_2 required = 3.334 + 0.563 + 0.090

Total O_2 required = 3.9881 kg/sec

Air contains = 77 % N_2 and 23 % O_2

Now,

23 kg of O_2 → 100 kg of air

1 kg of O_2 → 100/32 kg of air

3.988 kg of O_2 → 100/23*3.988 kg of air

1kg of O_2 → 17.339 kg/sec of air

We provide,

12 %excess air = 0.12*17.339 = %excess air = 2.080 kg/sec

Total O_2 required = $m_{\text{primary air}}$ = 17.339+2.08

$m_{\text{primary air}}$= 19.4206 kg/sec

m_{33} = mass flow rate of N_2 from air in Rotary kiln

m_{33} = 0.77*19.426

m_{33} = 14.95387 kg/sec

m_{32} = mass flow rate of O_2 from the air

m_{32}= 0.23*2.08

m_{32} = 0.47857 kg/sec

Primary Air Calculations for the Coal Used In Pre-Calciner

Mass flow rate of coal used in pre –calciner

= 0.25*2.6092

The mass flow rate of coal used in pre-calciner

= 0.6523 kg/sec

O_2 required for C = 0.6523*0.639*32/12

O_2 required for C = 1.111 kg/sec

O_2 required for H = 0.6523*0.036*16/2

O_2 required for H = 0.1878 kg/sec

O_2 required for S = 0.6523*0.046*32/32

O_2 required for S = 0.3000 kg/sec

Total O_2 required = 1.111 + 0.18 + 0.0300

Total O_2 required = 1.3298kg/sec

Now,

23 kg of O_2 → 100 kg of air

1 kg of O_2 → 5.16 kg/sec of air

1.329 kg of O_2 → 100/23*1.329 kg of air

$m_{primary\ air}$ = 5.7799 kg/sec

Primary air required for the tyre used in pre-calciner

Mass flow rate of tyre used in pre -calciner

=1.7314 kg/sec

O_2 required for C = 1.7314*0.7215*32/12

O_2 required for C = 3.331214 kg/sec

O_2 required for H = 1.7314*0.0674*16/2

O_2 required for H = 0.9335 kg/sec

O_2 required for S = 1.7314*0.0123*32/32

O_2 required for S = 0.0212 kg/sec

Total O_2 required = 3.331 + 0.933 + 0.021

Total O_2 required = 4.28608 kg/sec

Now,

1 kg of O_2 → 100/23 kg of air

4.286 kg of O_2 → 100/23*4.286 kg of air

$m_{primary\ air}$ = 18.6351 kg/sec

Total Primary Air Requirement for Pre-Calciner

m_{TPA} = 18.63+5.77

$_{TPA}$ = 24.415 kg/sec

We provide 12% excess air of minimum requirement = 0.12*24.415

Excess Air = 2.9298 kg/sec

m_{35} = mass flow rate of air for the pre-calciner

m_{35} = 24.415+2.9298

m_{35}= 27.3448 kg/sec

m_{36} = mass flow rate of N_2 from the air in pre-calciner

m_{36} = 0.77*27.3448

m_{36} = 21.0555 kg/sec

m_{37} = mass flow rate of O_2 from the air in pre-calciner

m_{37} = 0.23*2.929

m_{37} = 0.67385 kg/sec

Material Balance Over Tire Derived Fuel (TDF)

m_1 = mass flow rate at the inlet of the super chopper

m_2 = mass flow rate at the raspers (inlet).

The mass balance is;

Input = Output

$m_1 = m_2$

m_1 = 18 ton/hr

m_2 = 18 ton/hr

Balance on rasper 1

$m_3 = m_2 *1/3$

m_3 = 6 ton/hr

Balance on rasper 2

$m_4 = m_2 *1/3$

m_4 = 6 ton/hr

Balance on rasper 3

$m_5 = m_2 *1/3$

m_5 = 6 ton/hr

Assuming that 5% of the total tire is metal which is separated by magnetic separator 0.05

$m_3 + m_4 + m_5 = m_6 + m_T$

$6+6+6 = m_6+0.05m_T$

$1.05\ m_6 = 18$

m_6 = 17.14285714 ton/hr

m_T = 0.05*17.14

m_T = 0.857142857 ton/hr

3.3. ENERGY BALANCE

Energy Balance on Tire Derived Fuel (TDF)

According to the Bond's equation:

$w/m = wi\ (10/\sqrt{x_2}-10/\sqrt{x_1})$ (1)

Where,

x_2 = final product size (mm)

x_1 = initial feed size (mm)

wi = work index (Kwh/ton)

m = mass (ton/hr)

w = energy input requirement (Kwh)

From the experimental data:

Work index = wi

wi = 10.1298 Kwh/ton

Capacity of crusher = m = 18 ton/hr

x_1 = 1900 mm (average)

x_2 = 120 mm (average)

$w = m*wi*(10/\sqrt{x_2} -10/\sqrt{x_1})$

$w = m*wi*(10/\sqrt{120}-10/\sqrt{1900})$

$w = 10.1298*18*(10/\sqrt{120}-10/\sqrt{1900})$

w = 124.6187599 Kwh

Three raspers are placed each having 6 ton/hr capacity which reduce the size from 120mm to 25mm on average,

Then energy requirement for each rasper is

x_1 = 25 mm

x_2 = 120 mm

wi = 10.1298 Kwh/ton

m = 6 ton/ hr

$w/m = wi\ (10/\sqrt{x_2} -10/\sqrt{x_1})$

$w = m*wi*(10/\sqrt{x_2} -10/\sqrt{x_1})$

$w = 10.1298*6*(10/\sqrt{25}-10/\sqrt{120})$

w = 66.07440037 Kw

66.07 Kw power requirement for each rasper.

Total power requirement to crush to the requirement is = 124.6 + 3(66.07)

Total power required = 322.841961 Kw

Energy Required to Lift Material to Super Chopper

Height (h) = 4.2672 m (given)

Mass (m) = 18 ton/hr

Mass (m) = 5 kg/sec

Gravity (g) = 9.8 m/sec²

Then,

P = m*g*h (2)

P = 5 kg/sec*9.8m/sec²*4.2672m

P = 209.0928 Kwatt

Energy Required to Lift Material to Rasper

Height (h) = 2.7432 m (given)

Mass (m) = 6 ton/hr

Mass (m) = 1.6667 kg/sec

Gravity (g) = 9.8 m/sec²

Then,

P = m*g*h

P = 1.66kg/sec*9.8m/sec²*2.7432m

P = 44.8056 Kwatt

Energy Balance on Pre-Heater, Pre-Calciner and Kiln

Heat Input as Sensible Heat of Raw Meal (Dry)

Conversion Factor= 1.6 kg of raw meal/ kg of clinker
T ref = 25 ^{0}C
T inlet = 95 ^{0}C
Heat Capacity Of raw Meal:
Cp = 0.291 kcal/kg ^{0}C
Q = m*Cp*ΔT (3)
Q = 1.6*0.291*(95-25)
Q = 32.592 kcal/ kg of clinker
For 3300 ton of clinker,
Q = 32.592 kcal/ kg of clinker *3300000 kg of clinker
Q = 1.076 exp 08 Kcal

Heat Input as a sensible heat of raw meal moisture

Moisture = 0.25%
Cp of water = 1 kcal/kg ^{0}C
T ref = 25 ^{0}C
T inlet = 95 ^{0}C
Q = m*Cp*ΔT
Q = 0.25/100*1.6*1* (95-25)
Q = 0.28 kcal/ kg of clinker
For 3300 ton of clinker,
Q = 0.28 kcal/ kg of clinker *3300000 kg of clinker
Q = 924000 Kcal

Heat Input as a sensible heat of fuel moisture

For coal:
Coal = 0.069 kg of raw meal/ kg of clinker
Moisture = 7.91 %
Cp of water = 1 kcal/kg ^{0}C
T ref = 25 ^{0}C
T inlet = 40 ^{0}C
Q = m*Cp*ΔT
Q = 0.0791*0.069*1*(40-25)
Q = 0.0818 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.0818 kcal/ kg of clinker *3300000 kg of clinker
Q = 270166.05 Kcal
For tire:
Tire = 0.045 kg of raw meal/ kg of clinker
Moisture = 1.37 %
Cp of water = 1 kcal/kg ^{0}C
T ref = 25 ^{0}C
T inlet = 40 ^{0}C
Q = m*Cp*ΔT
Q = 0.0137*0.045*1*(40-25)
Q = 0.00924 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.00924 kcal/ kg of clinker *3300000 kg of clinker
Q = 30516.75 Kcal
Heat Input as a sensible heat of fuel in pre-calciner.
Coal = 0.069 kg/kg of clinker
For Coal:
Cp of coal = 0.1455 kcal/ kg ^{0}C
T ref = 25 ^{0}C
T inlet = 40 ^{0}C
25% coal is used in pre-calciner
Q = m*Cp*ΔT
Q = 0.25*0.069*0.1455*(40-25)
Q = 0.0376 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.0376kcal/ kg of clinker *3300000 kg of clinker
Q = 124238.81 Kcal
For tire:
Tire = 0.045 kg of raw meal/ kg of clinker
Cp of tire = 0.1572 kcal/ kg ^{0}C
T ref = 25 ^{0}C
T inlet = 40 ^{0}C
Q = m*Cp*ΔT
Q = 0.045*0.1572*(40-25)
Q = 0.1061 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.1061 kcal/ kg of clinker *3300000 kg of clinker
Q = 350163 Kcal
7.2.1.5 Sensible heat of fuel in Kiln
75 % coal is used in Kiln
Q = m*Cp*ΔT
Q = 0.75*0.068*0.1455*(40-25)
Q = 0.1129 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.1129 kcal/ kg of clinker *3300000 kg of clinker
Q = 372716.44 Kcal

Heat input as caloric heat from fuel

For Pre-calciner:
For Coal,
25 % coal burnt in pre-calciner:
Calorific value = 6640 kcal/kg
Coal = 0.069 kg/kg of clinker
Q = 0.25*0.069*6640
Q = 114.54 kcal/kg of clinker
For 3300 ton of clinker,
Q = 114.54 kcal/ kg of clinker *3300000 kg of clinker
Q = 3.77 exp 08 kcal
For Tire,
Calorific value = 7200 kcal/kg
Tire = 0.045 kg/kg of clinker
Q = 0.045*7200
Q = 324 kcal/kg of clinker
For 3300 ton of clinker,
Q = 324 kcal/ kg of clinker *3300000 kg of clinker
Q = 1.07 exp 09 kcal

Heat input as a calorific heat from fuel for kiln

75 % coal burnt in Kiln
Coal = 0.069 kg/kg of clinker
Calorific value = 6640 kcal/kg
Q = 0.069*0.75*6640
Q = 343.62 kcal/kg of clinker
For 3300 ton of clinker,
Q = 343.62 kcal/ kg of clinker *3300000 kg of clinker
Q = 1.13 exp 09 kcal

Heat Output Calculations

Heat formation of clinker:

The heat of formation takes in to account all main reaction which occur when raw meal is transformed to clinker as follows:

Raw meal to Clinker
Heat of dehydration of clay (endothermic)
Heat of de carbonization of $CaCO_3$ + $MgCO_3$ (endothermic)
Heat of formation of clinker (exothermic)

In most of the practical cases it is sufficient to assume a constant value of:

H = 418.25 kcal/kg of clinker
Sensible heat of pre-heater exhaust gases:
m = 3.35 kg/kg of clinker
Cp of exhaust gases = 0.2626 kcal / kg .^{0}C
T exit = 398 ^{0}C
T ref = 25 ^{0}C
Q = m*Cp*ΔT

Q = 3.35*0.2626*(398-25)
Q = 328.131 kcal/kg of clinker
For 3300 ton of clinker,
Q = 328.131 kcal/ kg of clinker *3300000 kg of clinker
Q = 1.08 exp 09 kcal

Evaporation of moisture in raw meal:
Conversion Factor = m = 1.6 kg of raw meal/ kg of clinker
Moisture = 0.25%
Heat of vaporization of water = λ = 0.510 Kcal / kg
Cp of water = 1 kcal/kg ^{0}C
T ref = 25 ^{0}C
T exit = 398 ^{0}C
Q = m*Cp*ΔT + mλ
Q = 1.6*1*0.0025*(398-25) + 1.6*0.0025*0.510
Q = 1.49404 kcal/kg of clinker
For 3300 ton of clinker,
Q = 1.49404 kcal/ kg of clinker *3300000 kg of clinker
Q = 4.93 exp 06 kcal

Evaporation of moisture in coal:
m = 0.069 kg/kg of clinker
Heat of vaporization of water = λ = 0.510 Kcal / kg
Cp = 1 kcal/kg.^{0}C
Moisture = 7.91%
T ref = 25 ^{0}C
T exit = 398 ^{0}C
Q = m*Cp*ΔT + mλ
Q = 0.069*0.0791*1*(398-25) + 0.069*0.0791*0.510
Q = 2.037 kcal/kg of clinker
For 3300 ton of clinker,
Q = 2.037 kcal/ kg of clinker *3300000 kg of clinker
Q = 6.72 exp 06 kcal

Evaporation of moisture in tire:
m = 0.045 kg/kg of clinker
Heat of vaporization of water = λ = 0.510 Kcal / kg
Cp = 1 kcal/ kg ^{o}C
Moisture = 1.37 %
T ref = 25 ^{0}C
T exit = 398 ^{0}C
Q = m*Cp*ΔT + mλ (4)
Q = 0.045*0.0137*1*(398-25) + 0.045*0.0137*0.510
Q = 0.23 kcal/kg of clinker
For 3300 ton of clinker,
Q = 0.23 kcal/ kg of clinker *3300000 kg of clinker
Q = 7.59 exp 05 kcal

Heat loss by calcinations of bypass dust:
Q = 15.61 kcal/kg of clinker
For 3300 ton of clinker,
Q = 15.61 kcal/ kg of clinker *3300000 kg of clinker
Q = 5.15 exp 07 kcal

ΔH by convection at 140^{0}C:
ρ = 0.8824 kg/m^3
K = 0.00003365 Kw/m
ν = 0.00002591 m^2/s
Cp = 1.0135 KJ/kg.^{0}C
Pr = Cp*ν/ K
Pr = 0.78
Grashoff Nunmber = (g*B*(Ts-T∞)*ds^3)/V^2 (5)
B is approx to 1/T
where,
g = gravity = 9.8 m/s^2
B = volumetric exp. = 0.00312 1/^{o}C
D s = diameter = 4.3 m
V = kinematic viscosity = 0.00002591 m^2/s
Ts = wall mean temperature = 140 ^{o}C
T∞ = bulk temperature = 25 ^{o}C
L = length of kiln = 64 m
G r = 9.8*0.00312(140-25)*(4.3)^3/ 2.59E-05^2
G r = 4.16 exp 11
Now,
Ra = G r * Pr (6)
Ra = Rayleigh number
Ra = 3.25 exp 11
Nu = [(0.6+ (0.387(Ra) ⅙/ (1+ (0.559/Pr)^{9} ⁄$_{16}$)^8/27)))^2]/788.36
Nu = Nusselt number
h = Heat transfer co-efficient
Nu = 9.7
Nu = h ds/K
h = (Nu*K)/d s
h = 1.814 exp -5 kcal/hr.m^2.^{o}C
Q = ∏*ds*l*h (Ts-To) (7)
Q = 1.802 kcal/kg of clinker
Approximately,
Q = 2 kcal/kg of clinker

ΔH by radiation:
e = 0.3
l = 64 m
T_1 = 250 ^{o}C
T_2 = 25 ^{o}C
Cr = 5.67 w/m^{2}K^4
T avg = (250+25)/2 = 137.5 ^{o}C
ΔT = 250-25 = 225 ^{o}C
h = Cr*e*(4/100) (Tavg/100)^3[1+ (1/4) (ΔT/Tavg) ^{2}]
h = 0.2952 kcal/hr.m^2.^{o}C
A = ∏*ds*L
A = 864.128 m^2
Q = h*A*ΔT (8)
Q = 35.35 Kcal/kg of clinker

Table 7 represent the heat input in the system.

Table 7: Heat input

Heat Input			
Sr. No.	**Raw Material**	**Kcal/Kg of clinker**	**Percentage %**
1	Sensible heat of raw meal	32.59	4.0297
2	Sensible heat of raw meal moisture	0.28	0.0346
3	**Sensible heat of fuel moisture**		
a	Coal	0.081	0.01001
b	Tire	0.00924	0.00114
4	**Sensible heat of fuel in pre calciner**		
a	Coal	0.037	0.00457
b	Tire	0.106	0.01310
5	**Sensible heat of fuel in kiln**		
a	Coal	0.111	0.0137
6	**Caloric heat from fuel in pre-calciner**		
a	Coal	112.88	13.957
b	Tire	324	40.062
7	**Caloric heat of from fuel in kiln**		
a	Coal	338.64	41.872
8	Total heat input	808.7342	100%

Table 8 represents the heat output in the system.

Table 8: Heat output

Heat Output		
Raw material	**Kcal/Kg of**	**Percentage**

		Clinker	%
1	Heat of formation of clinker	418.25	51.764
2	Sensible heat of preheated exhaust gases	328.22	40.621
3	Evaporation of moisture in raw meal	1.492	0.1846
4	Evaporation in coal	2.01	0.248
5	Evaporation of moisture in tire	0.22992	0.0284
6	Heat losses by calculations of bypass dust	15.61	1.9319
7	Heat losses by convection	1.8	0.2227
8	Heat losses by radiation	30.36	3.757
9	Other losses	10.02	1.240
	Total heat output	807.9919	100%

3.4. EQUIPMENT DESIGNING

Sizing of a Cyclone Separator

Figure 10 represent the cyclone separator.

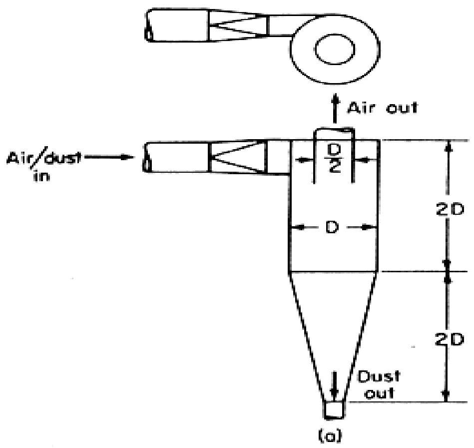

Figure 10: Cyclone separator

The mass flow rates of flue gases which are evolved from Rotary kiln are:

Mass fraction of CO_2 = 4.981kg/sec (from calciner)

Mass fraction of CO_2 = 4.585 kg/sec (from fuel combustion)

Mass fraction of N_2 = 0.035 kg/sec

Mass fraction of N_2 = 14.953 kg/sec

Mass fraction of SO_2 = 0.18 kg/sec

Mass fraction of H_2O = 0.653 kg/sec

Mass fraction of O_2 = 0.0157 kg/sec

Mass fraction of Total = 25.4027 kg/sec

Percentage of CO_2 = 37.65741%

Percentage of N_2 = 59.00160%

Percentage of SO_2 = 0.70858 %

Percentage of H_2O = 2.57059 %

Percentage of O_2 = 0.06180%

Average Density of Flue Gases

Density of flue gases at 900 ^oC:

CO_2 = 0.476 kg/m³

N_2 = 0.303 kg/m³

SO_2 = 2.5 kg/m³

H_2O = 0.1948 kg/m³

O_2 = 0.3452 kg/m³

Average Density = (0.37*.476) + (.59*0.303) + (0.0070*2.5) + (0.025*0.1948) + (0.0006*0.3452)

Average Density = 0.38095 kg/m³

Volumetric flow rate

Volumetric flow rate = total mass flow rate/ avg. density

Volumetric flow rate = 25.4027/0.38095

Volumetric flow rate = 66.68081 m³/s

Average Viscosity

Viscosity of flue gases at 900 ^oC:

CO_2 = 0.00004471 kg/m-s

N_2 = 0.00004402 kg/m-s

SO_2 = 0.00004473 kg/m-s

H_2O = 0.00003387 kg/m-s

O_2 = 0.00005523 kg/m-s

Average Viscosity = (0.37*0.00004471) + (.59*0.00004402) + (0.0070* 0.00004473) + (0.025*0.00003387) + (0.0006*0.00005523)

Average Viscosity = 4.39365E-05 kg/m-s

Average Density of Raw Meal

Density of limestone = 2768 kg/m³

Density of laterite = 2500 kg/m³

Density of clay = 1200 kg/m³

Percentage of limestone in the feed = 83.1833 %

Percentage of laterite in the feed = 15.0549 %

Percentage of clay in the feed = 1.7621 %

Average density = (0.8318*2793) + (0.1505*2500) + (0.0176*1200)

Average density = 2700.023 kg/m³

Characteristic Velocity

Assume pressure drop = 2000 Pa

For stair mend high efficiency:

Eu (Euler's number) = 320

Stk_{50}= 0.00014

ρ_f = 0.3653 kg/m³

ρ_f = density of gas

By using equation:

$$E_u = 2\Delta P/\rho_f *\nu^2 \quad (9)$$

Euler number is the ratio of pressure forces to the inertial forces

$320=2(2000)/0.3653\nu^2$

ν^2 = 34.21845059 m/s

ν = 849653886 m/s

Number of Cyclone Separator Required

Suppose we have "n" cyclones in parallel, then assuming distribution of gas between cyclones, then the flow rate to each cyclone is

$q = Q/n$

$\nu = 4*q/\pi D^2$

$\nu = 4*Q/n/\pi D^2$

$$D^2 = 4*Q/ \pi*n*\nu \quad (10)$$

Q = total volumetric flow rate

q = volumetric flow rate i.e. divided in n-cyclone separator

D = diameter of separator

$D = 4Q/\pi*n*\nu$

$D = \sqrt{}4*53.55/\pi*n*5.8496$

$D = 3.81066/\sqrt{n}$

The Stokes's number Stk_{50} is defined as:

$$Stk_{50} = x_{50}^2\rho p\nu/18\mu D \quad (11)$$

x_{50} = equiprobable size the equal probability to appear dust or in coarse particle

x_{50} = 3.51E-06 m

μ = viscosity of flue gases

ρ_p = density of particle

$0.00014=(3.5*10E\text{-}6m)^2*2700.02kg/m^3*5.84m/sec$ / $18*(0.0000438Pa.s)*3.810/\sqrt{n}$

$\sqrt{n}$ = 4.23E-07 / 1.95E-07

$\sqrt{n}$ = 2.17

n = 4.72

Diameter of Cyclone Separator

Now for diameter = D = $3.8106/\sqrt{4.72}$

D = 1.75m

Diameter where gases are evolved = D/2 = 1.75/2
= 0.875m

For Length:

L = 4D

Therefore,

L = 4*1.75

L = 7 m

Actual Cut Size

Now for cut size, using same formula and to back-calculation:

$0.00014 = (x_{50})^2*2700.02kg/m^3*5.84m/sec$

$18*(0.0000438Pa.s)*3.8106/\sqrt{n}$

x_{50}^2 = 1.95E-07 / 15794.20

x_{50} = 0.00000351 m (cut size)

SIZING OF A BELT CONVEYOR

Figure 11 shows the belt conveyor.

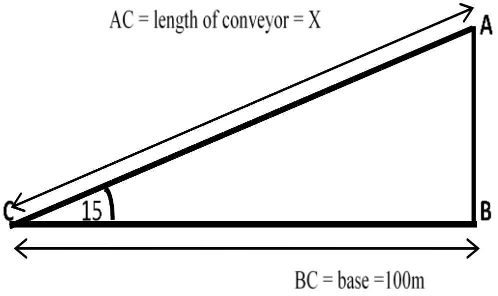

Figure 11: Belt conveyor

Length of the Conveyor

Consider a triangle ABC where,

AC = length of conveyor (one side) = X

BC=base=100m

To find the length of conveyor

$\cos\alpha$ = Base/Hypotenuse

Therefore,

$\cos 15^{o}$= 100/X

X = 100/$\cos 15^{o}$

X = 103.4778943

103.5m is only half the length of the conveyor

Therefore, the total length = 206.9557886 m

Volume of the Material Transported

From Material Balance:

Time taken to complete total length is = 150 sec

Flow rate of $CaCO_3$ = 46.45 kg/sec

Mass = 6967.5 kg

Density of $CaCO_3$ = 2768 kg/m³

Volume = mass/density

Volume = 2.517160405 m³

Total volume of the material transported in one revolution of belt = 2.517160405 m³

Width of the Belt

Volume= Length*Width*Height (12)

Since, the half-length of the conveyor
= 103.4778943 m

where, the height of the material = 0.055 m

Therefore,

Width = V/L*H

Width = 0.44228338 m

Rpm of the Pulley

s = r*Θ

Where,

s = length of the conveyor = 206.9558 m

r.Θ = radius of pulley one = 0.3 m

Θ = 689.8526667 radian

Rpm = $\Theta/2\pi$

Rpm = 109.7934619

Now,

r.Θ = radius of pulley two =0.2 m

s = length of the conveyor = 206.9558 m

Θ = 1034.779 radian

Rpm = $\Theta/2*\pi$

Rpm = 164.6901929

Velocity of Conveyor

Velocity = Distance/Time

Velocity = 1.379705257 m/sec

Following are the design parameters have been found from the above calculations:

1) Total length of the conveyor = 206.9557886 m
2) Total volume of the material transported in one revolution of the belt = 2.517160405 m³
3) Total width of the conveyor belt = 0.44228338 m
4) Total number of rpm of the pulley one
= 109.7934619
5) Total number of rpm of the pulley two
= 164.6901929
6) Velocity of the conveyor = 1.379705257 m/sec

Sizing of hammer crusher

Figure 12 shows the hammer crusher.

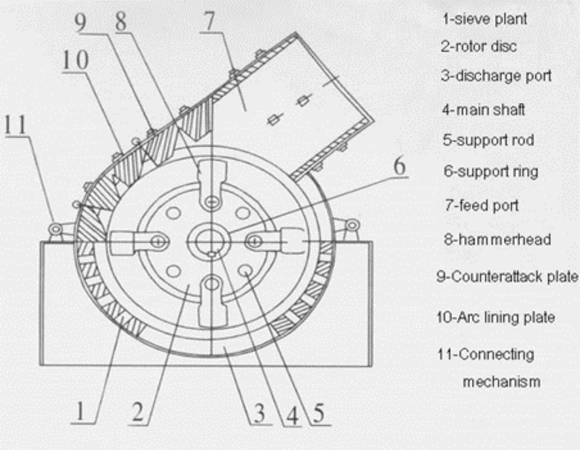

Figure 12: Hammer crusher

Power Required For Crushing:

According to bond equation:

According to the Bond's equation:

$w/\dot{m} = \quad wi\ (10/\sqrt{x_2}-10/\sqrt{x_1})$ (13)

Where,

x_2 = final product size = 25 mm (approx)

x_1 = initial feed size = 400 mm (approx)

wi = work index for raw meal = 1.6 Kwh/ton

$\dot{m}$ = mass (ton/hr) = 200 ton/hr

$w = \dot{m}*wi*(10/\sqrt{x_2}-10/\sqrt{x_1})$

w = 200 ton/hr *1.6 kwh/ton * $(10/\sqrt{25}-10/\sqrt{400})$

w = 480 Kw

And,
Flow rate of material to be crushed=m1 = 43.43 kg/s
Capacity of crusher = 200 ton/hr
Number of shaft = s = 5 shaft
Number of hammer per shaft = N = 9
Total number of hammer = e =5*9 = 45
Number of revolution per minute = n = 250 rpm
Diameter of rotar = R = 1 m

Rim Speed

$V = 2*\prod*R*n/60$ (14)
$V = 26.16666667$ m/s

At this rim speed, the design factor f is given by the property table as f = 0.008

Power input to motor

$P = G*R^2*n^3*e*f/8*100000*\upsilon$ (15)

Where,
G = Weight of one hammer = 132 kg
R = Rotor diameter of rotating hammer = 1 m
n = Number of revolutions of hammer rotor
= 250 rpm
e = Total number of hammers = 45 hammers
f = Design factor that if a function of rim velocity
= 0.008 hammers per shaft
υ = Power transition factor depending on rim speed and the value of f = 0.85

Thus,
$P = 132*1^2*250^3*45*0.008*/8*10^5*0.85$
P = 1091.911765 hp
P = 814.5661765 Kw

Efficiency

n = (power req/ power input)*100 (16)
n = (480*814.5)/100
n = 58.92707233 %

COST ESTIMATION

Cost Estimation over RDF

When 100% coal is used for the clinker production:
1 kg of coal = 6640 kcal
I kg of coal/6640 kcal = 1kcal
Energy required for 1 kg of clinker = 780 kcal
Kg of coal/6640 kcal *780kcal = 780 kcal
0.11746 kg of coal = 780 kcal
386100 kg of coal = 386.1 ton of coal

Now,
1 kg of coal = $ 0.081
Cost of coal consumption when 100% coal is used per line = 386.1*1000*0.081
Cost of coal consumption when 100% coal is used per line = $ 31274.1

When % of coal is replaced by tire:
Kg of coal required from the material balance
= 0.0683137 kg
Kg of tire required from the material balance
= 0.0453329 kg
225390 kg of coal = 225.39 ton of coal
149490 kg of tire = 149.49 ton of tire

Now,
1 kg of coal = $ 0.081
1 kg of tire = $ 0.055 Rs 8.38
Cost of coal consumption after optimization per line =225.39*1000*0.081 = $ 18256.59
Cost of tire consumption after replacement of coal by tire is per line =149.49*1000*0.055 = $ 8221.95
Total cost after replacement = cost of tire + cost of coal = 18256.59 + 8221.95 = $ 26478.54
Profit per line after replacement = cost when 100% coal is used – after optimization = 31274.1 – 26478.54 = $ 4795.96
Total profit per day from 3 kiln = 4795.96 * 3
= $ 14386. 68
Total profit per month from 3 kiln = $ 437574. 166 = $ 0.437574 million

4. CONCLUSION

Refuse-derived fuel is produced by dehydrating and grinding solid waste through waste converter technique. The use of alternative fuel such as coal, spent tire and inorganic material waste in cement industries would ultimately increase the total revenue and reduction of greenhouse gases. This research work focused on utilizing optimization tools seeking to improve the cement generation process and the emissions when alternative fuels are utilized. The goal is accomplished by modeled the cost impacts and electric power utilization requested in the crushing procedure for the Portland cement creation. The modeling includes optimization algorithms, to assure a better immovability of the kiln operation, vitality utilization decrease and natural effect minimization. The perspectives will be modeled impacts that the utilization of elective powers can cause in the clinker quality, through the material and fuel chemical composition. The estimated cost over refused dried fuel (coal and tire) in the cement industry is $ 26478.54 and total profit per month for three kilns is $ 0.437574 million.

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