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STUDYING THE COST VARIATION OF BRICKS MANUFACTURED IN TWO TYPES OF BRICK KILN AND EFFECT OF CARBON DIOXIDE EMISSION ON HEALTH

The project paper is submitted to the department of Civil Engineering of World University of Bangladesh (WUB) in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering.

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Letter of Transmittal

To
Engr. Mr. Shubhra Pramanik
Lecturer, Department of Civil Engineering
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Dear Sir,

We have the honor to state that, we have been given an assignment for conducting project work on "Studying the cost variation of bricks manufactured in two types of brick kiln and effect of carbon dioxide emission on health".

Please find enclosed herewith the project paper which we have prepared in partial fulfillment of the requirement for the Degree of Bachelor of Science in Civil Engineering. The project paper is being submitted for your kind action. We would be very happy to provide any assistance in interpreting any part of the project paper whenever necessary.

Thanking you

Sincerely yours

Md. Abul Khair Sikder

Roll No: - 830

Batch: 29th - A
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Declaration

We hereby declare that, this project paper on "Studying the cost variation of bricks manufactured in two types of brick kiln and effect of carbon dioxide emission on health" is an original work done by us. It has not been submitted to any other University or Institution for the award of any degree. This project report does not breach any provision of copy right act.

We further undertake to indemnity the University against any loss or damage arising from breach of the forgoing obligation.

Md. Abul Khair Sikder.

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Certification

This is to certify that, the project paper on "Studying the cost variation of bricks manufactured in two types of brick kiln and effect of carbon dioxide emission on health" is a bona-fide record of project work done by **Md. Abul Khair Sikder,** (Roll No: 830), **Md. Al-Amin** (Roll No: 844), **Faysal Ahammad** (Roll No-842), Batch: 29th- A, for partial fulfillment of the requirement for the Degree of Bachelor of Science in Civil Engineering from World University of Bangladesh.

The project work has been carried out under my guidance and a record of the bona-fide work carried out successfully by the students.

Supervisor

Engr. Mr. Shubhra Pramanik
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His careful reading of the draft, valuable comments, and constructive suggestions was unstinting in the improvement of this project was the author greatly indebted to lecturer Engineer **Mr. Shubhra Pramanik** and our honorable Professor **Engr. Mr. A. F. M Abdur Rouf,** Associate Professor **Engr. Md. Sekander Ali,** Head of the Department **Engr. Mr. Rabindra Ranjan Saha** and others officials, Department of Civil Engineering, World University of Bangladesh (WUB), for giving support to the research work. The authors also express these special thanks for all instructions and cooperation in the field works.

The Authors

JAN -2013

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CHAPTER-3

NOTATIONS

BTK	Bull’s Trench Kiln
VSBK	Vertical Shaft Brick Kiln
FCK	Fixed Chimney Kiln
HHK	Hybrid Hoffman Kiln
PPM	Parts per million
FACE	Free-air carbon dioxide enrichment
CFC	Chlorofluorocarbons
CO	Carbon monoxide
SO_2	Sulphur dioxide
WHO	World health organization
KWH	kilowatt per hour
BDRC	Bangladesh Development Research Center
WEO	World energy outlook
BPDB	Bangladesh Power Development Board
ALGAS	Asia Least-cost Greenhouse Gas Abatement Strategy
DEA	Danish Energy Agency
BDRC	Bangladesh Development Research Center
BBMOA	Bangladesh Brick Manufacturing Owners Association
GCB	Global Change Biology

ABSTRACT

Variation of manufacturing cost of brick largely depends on the brick kiln as well as the manufacturing process. The effect of CO_2 emission from brick manufacturing factories and the CO_2 emission reduction is now global issue, and minimizing its impact by precautionary and preventive measures is now a challenge for the world leaders. As a third world country Bangladesh is not out of it. Flood, tropical cyclones, droughts, storm surges are most likely to become frequent and severe in coming years here. Globally, using fossil fuels, even in Bangladesh, to meet energy demand not only counteracts the need to prevent climate change but also has negative environmental effects locally. Brick manufacturing factories are emitting CO_2 in ways by producing CO_2 in fuel utilization, More than 6000 traditional and 2000 alternate brick works in average energy and fuel consumption, to evaluate effect of brick Kiln on Bangladesh are heavily polluting, and they are major reasons for air pollution in the country. Objective of this research work is to compare traditional manufacturing process with alternative processes those are energy efficient and utilize less coal, CO_2 emission from brick manufacturing factories. (Burning Wood emits 1.25-3.00 times as much more CO_2 than coal as per emission data from environment reports for proposed (Russel, Palmer), to recommend CO_2 reduction process for brick manufacturing factories, to evaluate impact of CO_2 and dust on health of the workers and the road side people. Bangladesh produces 4% of the total world brick production and is approximately 50 billion per year. As per the estimation in this study will contribute approximately 30.0 million tons CO_2 emission per year if all bricks are produced by Fixed Chimney Kiln (FCK) & also 50% reduction is possible by using alternate kiln such as Zigzag kiln.

CHAPTER-1
INTRODUCTION

1.1 GENERAL:

The first bricks in the English colonies in North America were probably made in Virginia as early as 1612. New England saw its first brick kiln erected at Salem, Massachusetts in 1629. The Dutch colonists in New Amsterdam imported yellow bricks from Holland, which imparted a Dutch character to the architecture of the city. The excellent quality and abundance of local clays in the colonies made it unnecessary to import bricks from across the Atlantic. Brick-making centers developed in Fort Orange (what is now Albany), New York; near Philadelphia, Pennsylvania; and Burlington and Trenton, New Jersey, as well as along the Raritan River. Brick makers in the country are looking to convert existing technologies into zigzag kilns for cost effectiveness and environment friendliness. “Zigzag kilns are relatively easier to install than Ancient Technology, such as Hoffman Kiln Technology, and Tunnel Kiln Technology**.** It is also environment-friendly,” says Ali Ashraf Iftekhar General Secretary of Bangladesh Brick Manufacturing Owners Association (BBMOA).He says there are generally six types of brick kilns in Bangladesh. Bull’s Trench Kiln, Fixed Chimney Kiln, Zigzag Kiln, Vertical Shaft Brick Kiln, Hybrid Hoffman Kiln and Tunnel Kiln. Experts say the zigzag, vertical and hybrid kilns use relatively modern technologies. They are more energy efficient than the bull's trench and fixed kilns, while the tunnel kiln is the most advanced and has the highest degree of mechanical automation and energy efficiency. In Bangladesh, around 95 percent of the brick fields are making bricks by the highly polluting fixed chimney kilns, as it requires low capital costs and has high investment returns.” We want to replace the existing fixed kilns to zigzag models to manufacture bricks as it is a viable and cost effective solution for the country,” says Iftekhar. Zigzag kilns do not use wood.

And hence it saves trees. Again, the black smoke produced in the kiln flows through a zigzag path over water and is finally transformed into eco-friendly 'white smoke' before being emitted into the environment, he adds. Iftekhar, who is in the brick business for over 22 years, says the individual investment to convert to a zigzag kiln will be around Tk 35 lac for the manual system and Tk 2 crore for the mechanized system. In addition, the installation cost will be around Tk 60 lac for the manual system and Tk 2.50 crore for the mechanized system. The hybrid and vertical kilns basically require to setup on high grounds for successful installation and operation. In our country, about 90 percent of the brick kilns are situated on low lying grounds, which makes it very difficult to setup and operate these models, he adds. “Even if we are to set up the vertical and hybrid kilns on selected high lands, a scarcity of mud will become crucial, given the topography of our country,” says Iftekhar “Our estimate is that only 10 percent of the existing fixed kilns may be converted to the hybrid or vertical models,” he adds. Iftekhar, who is the owner of AIM Brick Field, says the quality of bricks produced with Vertical Shaft Kiln is lower than those produced with fixed kilns.

For example, a second grade brick of fixed kilns is of higher quality than a first grade brick of vertical kilns. In practical operations, vertical kilns were found to consume much more fuel than predicted earlier, while the tunnel kilns have high installation costs. Most entrepreneurs are unlikely to be able to afford such conversions, even with bank finances, he adds. The general secretary of the association says banks provide loans worth up to 60 percent of the total project cost with collateral worth 1.5 times the loan. So, most entrepreneurs are unable to present this much collateral to obtain bank finance. The current lending rate of the state owned banks is 15 percent, and for private banks, it is 16 percent on an annual compounding basis, which is not favorable for a brick entrepreneur, says Iftekhar. He says brick entrepreneurs need long term bank loans covering at least 75 percent of total project costs at 5 percent a year on a simple interest basis. Iftekhar urged the government to modernize the rules and regulations regarding brick fields and speed up the process of issuing clearance and other relevant certificates. He says a brick field needs 11 to 12 government licences and certificates before going into operation. Some licences and clearance certificates are valid for one year and some for 3 years. The brick entrepreneur also faces difficulties in renewing these licences and certificates, says Iftekhar. We do not get renewal on time. When we apply for a particular licence or certificate at a government office, we are asked to submit another paper or certificate from another agency, which cannot be obtained beforehand," says Iftekhar. For example, the Department of Environment asks for certificates from Bangladesh Standards and Testing Institution before issuing their certificates. "We duly request concerned authorities to issue their papers without hassle or delay." He sought cooperation from all in making the brick-manufacturing sector of the country sustainable; however, these challenges are further aggravated by population pressures, lack of funds for appropriate adaptation measures, inadequate policy frameworks, and limited human and financial resources. Among the challenges energy utilization and carbon dioxide emission will be in forefront. Energy is a critical input parameter for economic development of any nation. In Bangladesh, energy demands are still met largely from fossil fuels such as coal, oil and natural gases. In 1980, the global primary energy demand was only 7228 **million tons of oil equivalent** (mtoe) but this had increased to 11429 mtoe by 2005 (WEO 2007). Further increases can be expected in developing countries like Bangladesh mostly due to increasing industrialization with inefficient uses. Fossil fuels provide energy in a cheap and concentrated form, and as a result they dominate the energy supply. In the worldwide total energy demand, the share of fossil energy is around 80%, while the remaining 20% are supplied by nuclear and renewable energy. In 2005, a total of 26.6 billion tons of CO_2 emissions were generated world-wide of which more than 41 % was from power generation based on fossil fuels (WEO). Bangladesh is facing daunting energy challenges: Security concerns over growing fuel imports, limited domestic energy resources for power generation. Electricity is a pre-requisite for the technological development and economic growth of a nation the future economic development of Bangladesh is likely to result in a rapid growth in the demand for energy with accompanying shortages and problems. Bangladesh has been facing a severe power crisis for about a decade. The commercial energy sources in Bangladesh are limited due to limited Natural gas and coal reserves in comparison to the needs of the country (Energy context in Bangladesh). Power generation in the country is almost entirely dependent on fossil fuels, mainly natural gas, that accounted for 81.4% of the total installed electricity generation capacity (5248 MW) in 2006 (BPDB 2006). In Bangladesh, the power sector alone contributes 40% to the total CO_2 emissions (ADB 1998)Increasing the use of fossil fuels to meet the growing worldwide energy demand, especially in developing countries, not only counteracts the need to prevent climate change globally but also has negative environmental effects locally. Rapid, inefficient and unplanned industrial development aggravates the situation. In the growing construction industry sector, brick manufacturing factories are contributing CO_2 in both ways by consuming electricity and producing CO_2 in fuel utilization. In efficient manufacturing process is contributing further. More than 6000 traditional and 2000 alternate brickworks in Bangladesh are heavily polluting, and they are major reasons air pollution in Dhaka city, one of the most polluted cities of the world (DEA). Therefore there is acute need for a more environmental friendly brick production.

1.2 OBJECTIVES OF THIS PROJECT:

The following are the major objective of the project work:

1. To compare traditional manufacturing process with alternative processes that is energy efficient and utilizes less coal.
2. To estimate average energy and fuel consumption.
3. To evaluate effect of brick Kiln on Manufacturing
4. To estimate CO_2 emission from brick manufacturing factories.
5. To recommend CO_2 reduction process for brick manufacturing factories.
6. To evaluate impact of CO_2 and dust on health of the workers and the road side people.

CHAPTER -2

LITERATURE REVIEW

2.1 SOME COMMON BRICK KILN :

The following kilns are most commonly in use today:

Clamp Kiln Ancient Technology: - 4,000 B.C. The most commonly used kiln in the developing world. These kilns have a devastating impact both on the environment and workers. Generally built with four brick walls like a room, then green bricks are stacked inside. They are inefficient in fuel, labor intensive and highly polluting. They are only operated in intermittent mode. To produce higher brick production clamp kilns are frequently built, grouped and operated in clusters.

Hoffman Kiln – INVENTED GERMANY 1858 – KNOWN ALSO AS CHINESE HYBRID HOFFMAN OR FIXED CHIMNEY KILN these kilns have a large permanent arched masonry and an expensive tall masonry chimney of about 30 meters. They must operate in continuous mode used in Australia from 1883 until approximately 1985.

Tunnel Kiln – INVENTED GERMANY 1877 Most common in developed countries, since their invention tunnel kilns have now become highly automated and are for large brick production. Bricks move mechanically through a long stationary fire zone. They have minimal labor requirements but a very high capital cost. They must be operated in continuous mode and require a guaranteed electricity supply. One such plant built in New South Wales in 1993 cost $40 million, one currently proposed for Perth will be over $75 million.

Bull's Trench Kiln – INVENTED ENGLAND 1876 Movable Bull's Trench Kiln is commonly used in India and many developing countries. This kiln uses movable metal chimneys which are lifted and man-handled by a team of workers into different positions as the fire moves through the kiln. Has very high emissions, dispersed over a wide area, working conditions are hazardous. Although banned in many areas is still used. Brick chimney over 30 meters high. The chimney requires skilled bricklayers to construct and is costly to build.

Vertical Shaft Kiln – INVENTED CHINA 1958 reasonably fuel efficient however the kiln is limited due to a low throughput. Green bricks are loaded into the shaft and therefore must be hauled up a ramp to the top of the kiln.

2.2 ALTERNATIVE TYPES OF BRICK KILN USED IN BANGLADESH:

The basic concept of brick kiln technology in developing countries has changed little over the past thousands of years. Brick making is an ancient technology. Bricks are made, dried, fired and cooled. Kilns first started in pits, walls were then added. The addition of a chimney stack, improved the air flow or draw of the kiln, thus burning the fuel more completely. Several variations have been invented over the years with varying degrees of efficiency and cost.

Alternative types of brick kiln used in Bangladesh are as follows:

01. Bull’s Trench Kiln (BTK), fixed or movable chimney
02. Zigzag Kiln
03. Hoffman Kiln
04. Vertical Shaft Brick Kiln (VSBK)
05. The Preferred Alternative: The Hybrid Hoffman Kiln

2.3 BULL'S TRENCH KILN (BTK):

The kiln can be made circular or elliptical in shape. It is constructed on dry land, by digging a trench, 6 - 9 m wide, 2 - 2.5 m deep, and 100 - 150 m long. An alternative method is to build up the sides of the kiln with bricks, especially where drainage is a problem. Gaps are left in the outer wall for easy assess to the trench during setting and drawing of bricks. The green bricks to be fired are set in rows, two to three bricks wide, with holes in between that allow feeding of coal and a sufficient flow of air through the setting. A linking layer of bricks is made across the width of the kiln and half way up, to stabilize the setting. On top of the bricks, two layers of bricks, covered with ash or brick dust, seal the setting. A large piece of canvas, paper or metal sheet is placed vertically across the brick setting to block air from entering from the wrong side of the chimneys. The trench contains 200 - 300,000 bricks at a time. Chimneys, 6 - 10 m high, made of sheet metal, are placed on top of the brick setting. They are moved around as the firing progresses and they have to be light, so that the firing crew can carry them. Wires attached to the top of the steel chimneys support them. The need for lightness and the cost of replacing the chimneys often have the effect that the height of the chimneys becomes too low. That means the exhaust temperature has to be higher in order to maintain sufficient draught and the chimneys are placed closer to the firing zone. Thereby, less heat of the exhaust gases can be reutilized. Small circular Bull's trench kilns use only one chimney, whereas the larger elliptical kilns need two chimneys. The firing in a Bull's trench kiln is continuous, day and night. Green bricks are loaded and finished bricks are drawn all the time. The fuel saving is achieved by reusing part of the energy that is otherwise lost in periodic kilns.

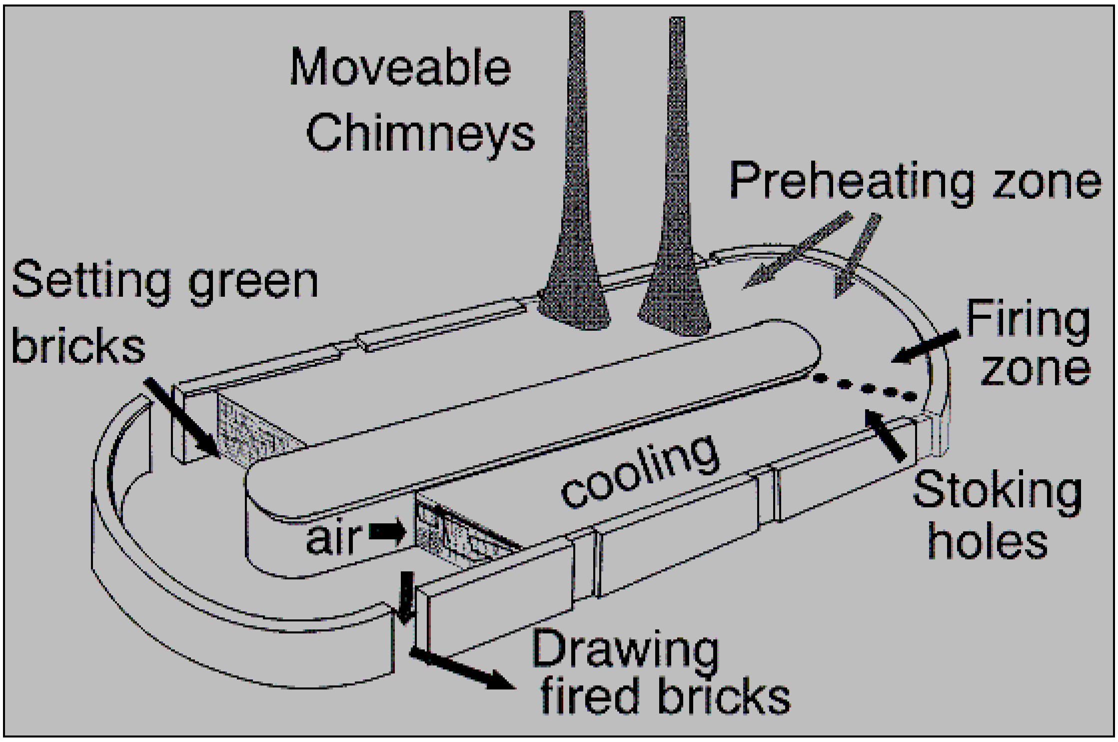


Fig: 2.1 - Design of a Bulls trench kiln

The air for combustion is drawn through the already fired but still hot bricks. The cooling bricks transfer their heat to the combustion air, pre-heating it before it enters the firing zone. After combustion, the hot exhaust gases pass through the yet unfired bricks on their way to the chimneys. This pre-heats the bricks, so less fuel is needed to bring the bricks to the maximum temperature. Once every 24 hours the chimneys are moved forward 5 to7 m. Daily output is 15 - 25,000 bricks

Manpower and fuel Requirement:

Normally, the firing crew consists of six men organized in two teams, who take turns stoking the kiln. When the chimneys are moved, all six men are needed. The whole operation of shifting the chimneys forward takes about one hour.

The firemen stoke the fire through removable cast iron holes at the top of the brick setting. Ideally, stoking should be done 3 - 4 times per hour, but especially at night, the workers tend to stoke large amounts of fuel at long intervals, causing an increase in fuel consumption. The firing of the kiln demands great skill, which may take years to master well. The fuel can be any combustible material or a combination of them; coal, lignite, peat, firewood, saw dust, agricultural waste, such as rice husk, brand or coffee shells. Natural gas or oil can also be used, but such fuel is normally too expensive. Old tires cut into pieces are more commonly used, but the combustion gases are very toxic, and in many countries the use of tires has been banned.

Chimney:

There are two main drawbacks with moveable chimneys;

- The metal sheets are eaten up by corrosion within 1.5 - 2 months, and
- During the time it takes to move the chimneys, the temperature drops.

FCK – Assessment

- Simple and convenient technology is constructed in low lying land.(cheap and abundant)
- Profitability – High, IRR > 30%
- Pollution – Very polluting

2.4 HEBLA OR ZIGZAG KILN:

The Zigzag Kiln is the most fuel-efficient kiln yet invented Germany-1927 and the cheapest to build. It features a long fire zone advanced by a suction fan. The Zigzag Kiln consumes less fuel, uses less mechanical energy and requires far less capital outlay with almost no maintenance. It also has a roof resulting in improved working conditions, the potential of water being collected and longer operational time during monsoon conditions. The Zigzag Kiln is ideally suited to both large scale continuous brick making operations and to small semi-continuous village applications in developing countries. Brick makers in the country are looking to convert existing technologies into zigzag kilns for cost effectiveness and environment friendliness.

Zigzag kilns are relatively easier to install and use than other technologies. It is also environment-friendly. Experts say the zigzag, vertical kilns use relatively modern technologies. They are more energy efficient than the bull's trench and fixed kilns.

While the tunnel kiln is the most advanced and has the highest degree of mechanical automation and energy efficiency. Zigzag kilns do not use wood; hence it saves trees.

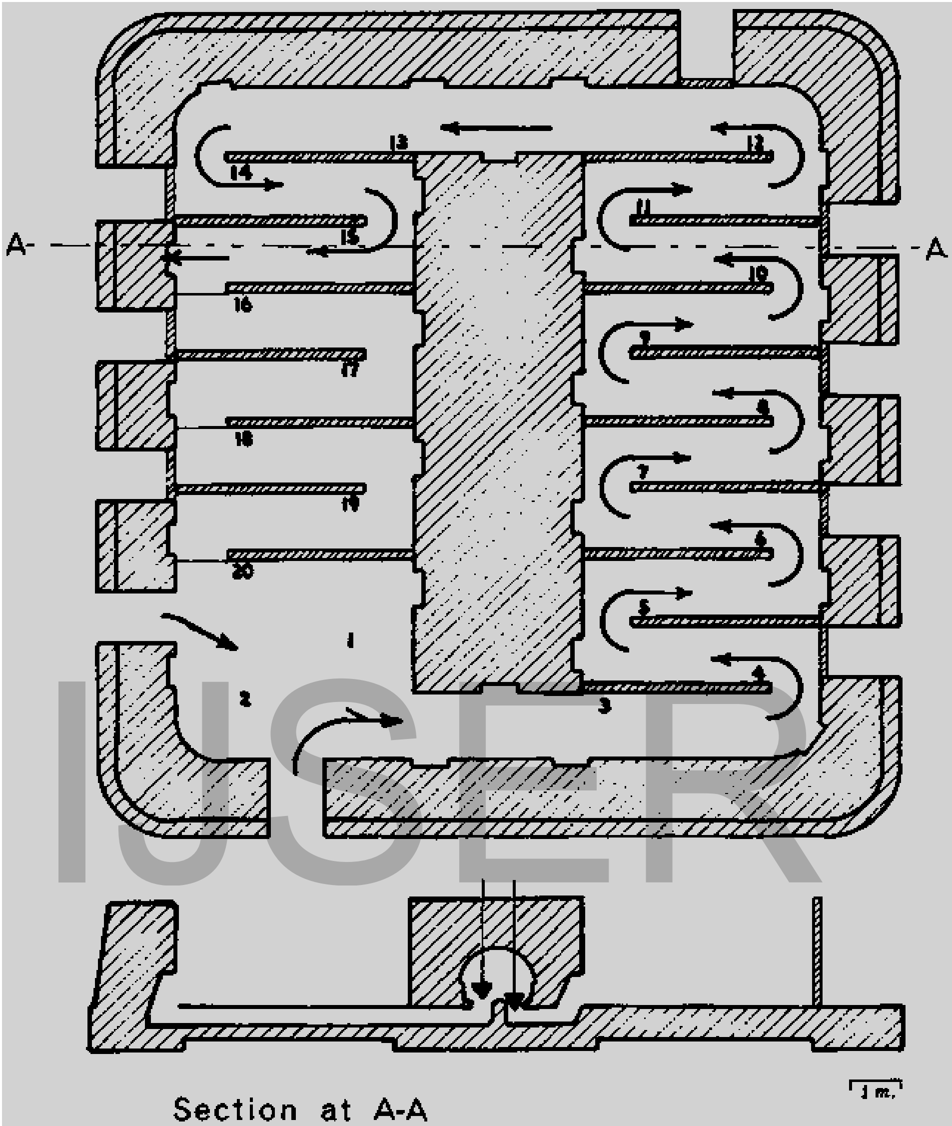


Fig -2.2 Design of a zigzag kiln

Zigzag Kiln – Assessment:

- The construction technology is not readily available, and expertise has to be procured from Scrubbing water is not changed regularly
- Operation procedure is more sophisticated than FCK – a badly operated kiln has the same energy
- Consumption and hence pollution
- Requires electricity and standby diesel generator
- Pollution – 50% less assuming good design and proper operation

2.5 HOFFMAN KILN:

The Hoffmann kilns are the most common kiln used in production of bricks and some other ceramic products.

Each room is connected to the next room by a passageway carrying hot gases from the fire. In this way, the hottest gases are directed into the room that is currently being fired. Then the gases pass into the adjacent room that is scheduled to be fired next. There the gases preheat the brick. As the gases pass through the kiln circuit, they gradually cool as they transfer heat to the brick as it is preheated and dried. This is essentially a counter-current heat exchanger, which makes for a very efficient use of heat and fuel. This efficiency is a principal advantage of the Hoffmann kiln, and is one of the reasons for its original development and continued use throughout history. In addition to the inner opening to the fire passage, each room also has an outside door, through which recently-fired brick is removed, and replaced with wet brick to be dried and then fired in the next firing cycle.

In a classic Hoffmann kiln, the fire may burn continuously for years, even decades; in Iran, there are kilns that are still active and have been working continuously for 35 years. Any fuel may be used in a Hoffmann kilns, including gasoline, natural gas, heavy petroleum and wood fuel. The dimensions of a typical Hoffmann kiln are completely variable, but in average about 5 m (height) x 15 m (width) x 150 m (length).

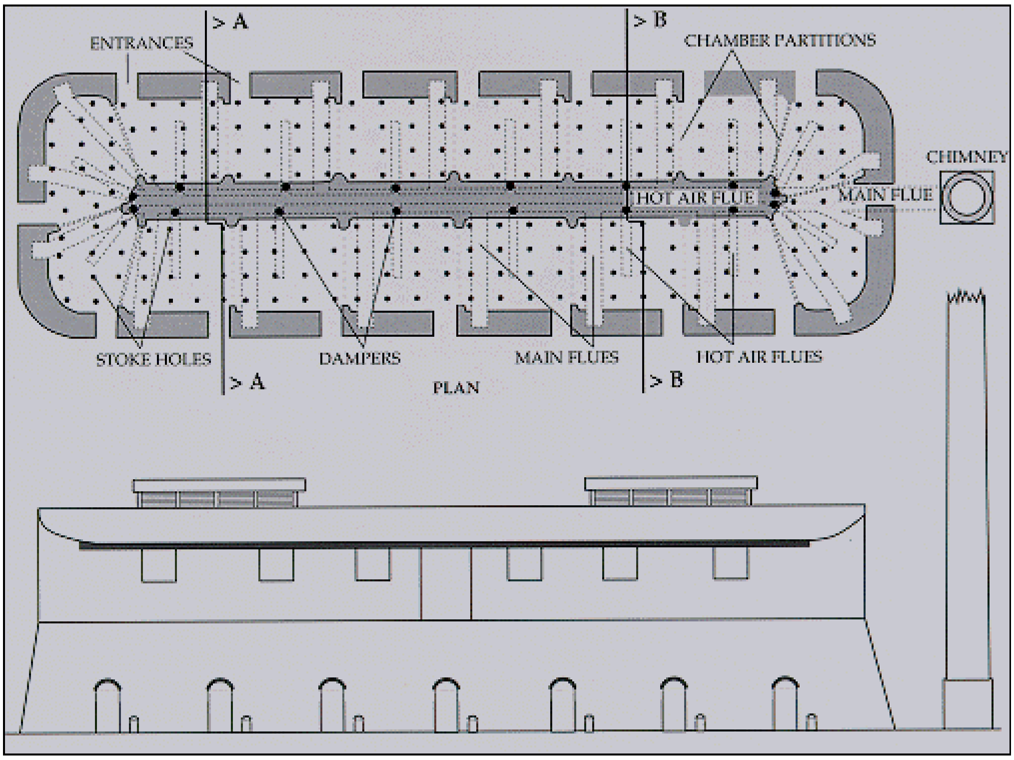


Fig: 2.3 –Design of a Hoffman Kiln

Hoffman - Assessment:

- Initial investment 10 times that of the FCK (50% for land)
- Requires high land, natural gas connection, electricity and standby generator
- Requires more land compared to the FCK or Zigzag (at least 5 acres of high land close to a main road)
- Profitability low (IRR ~ 20%, 12-months operation needed to recover costs)
- Pollution 80-90% reduction compared to the FCK.

2.6 VERTICAL SHAFT BRICK KILN (VSBK):

In a Vertical Shift Brick Kiln the green bricks are loaded on the top platform and move slowly down to the central firing zone the fresh air coming from below cools the fired bricks before unloading. The kiln works as a counter-current heat exchanger, with heat transfer taking place between the upward moving airs (continuous flow) a downward.

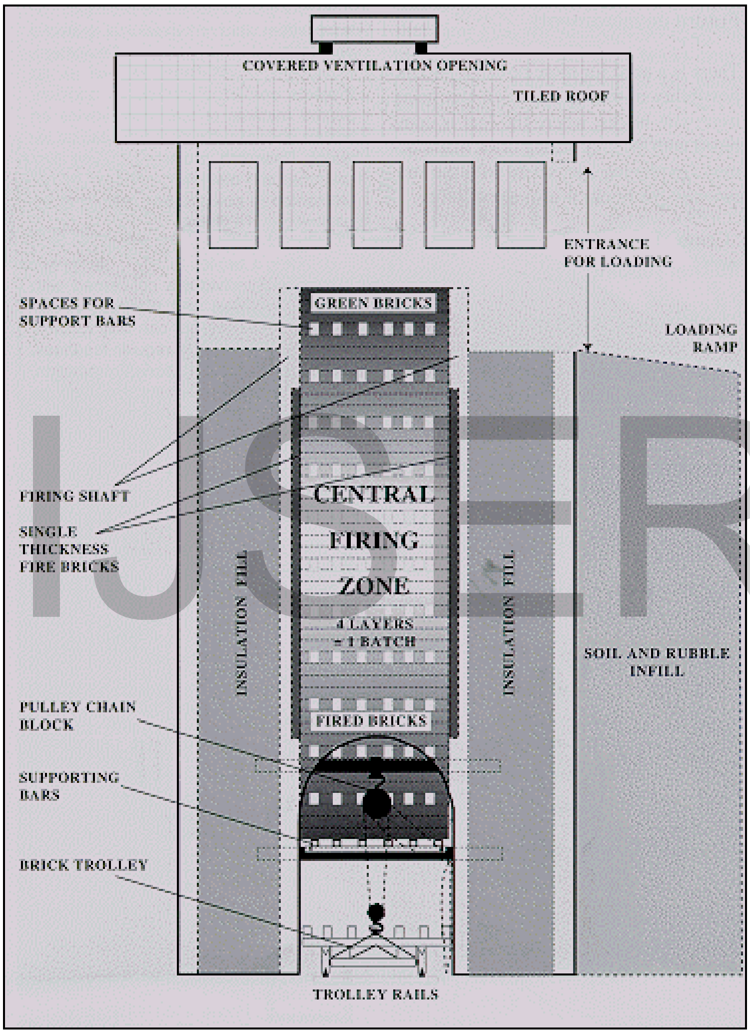


Fig-2.4 Design of a Vertical shaft Brick Kiln

The maximum temperature is achieved in the middle of the shaft where fire is maintained. At an interval of 2 to 3 hours, a batch of fired bricks is unloaded at the bottom. A batch of bricks consists of four or six layers of bricks. To understand why the VSBK is the most efficient kiln, we will have to understand that in a brick kiln only a small part of the heat is utilized for the firing and drying operations and most of the heat is lost. Efficient heat transfer process and lower heat losses makes VSBK more efficient. There are thus excellent reasons to promote such an energy-efficient kiln, however, the VSBK has also its limitations and it may not be the best solution for all situations. Due to its relatively short firing period of around 24 hours the green brick is suitable to withstand fast heating and cooling to produce high quality bricks and the firing process needs skilled personnel. BTK and intermittent kilns are much less sensitive to green brick quality as the bricks take several days to be fired.

VSBK – Assessment:

- According to available literature sources the bricks are of good quality. But, Bangladeshi brick makers have the following perception problems:
  - Existence of cracks in bricks
  - Bricks do not make a good ringing sound when banged
- About 70-80% reduction in emission compared to the FCK.

2.7 THE ALTERNATIVE: HYBRID HOFFMAN KILN (HHK):

Hybrid Hoffman Kiln (HHK) is used for baking clay brick

Hybrid Hoffman Kiln, this picture is the humid exhausting fan of drying chamber.

Hybrid Hoffman Kiln,

To make good use of the waste heat and gas in the kiln, use the fan machine to extract waste heat and gas, and send it to drying chamber for green bricks drying.

The HHK with the advantages of eco friendly & energy saving, high work efficiency and it is the best choice for baking clay bricks.

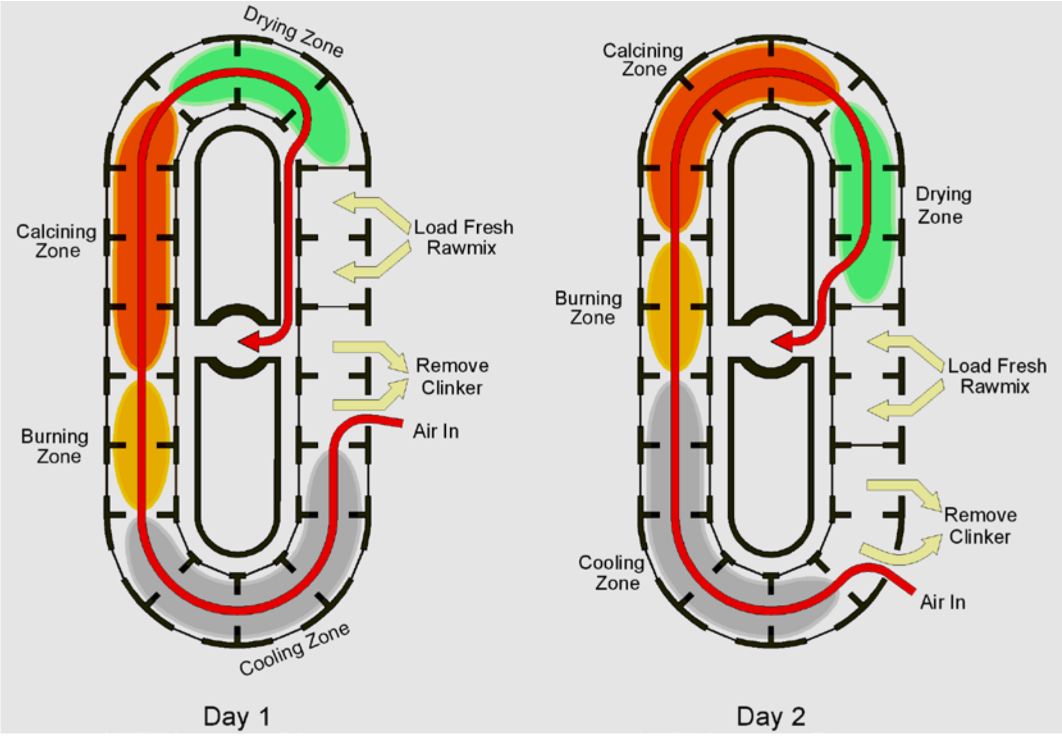


Fig -2.5 Design of a Hybrid Hoffman Kiln

Hoffman Coal (HHK) –Assessment:

- The technology provider claims 80% coal can be mixed with clay. This needs to be demonstrated
- Operational and maintenance issues from Bangladesh perspective is not known yet
- Technology provider claims that the quality of the brick is better than FCK 1st class brick (but using extruder and drying chamber)
- It is claimed that Hoffman (coal) can reduce pollution by 50% to 80% compare the FCK.

2.8 EFFECT OF CARBON DIOXIDE:

2.8.1 INTRODUCTION:

In the Earth's timeline, it has been shown that our environment heals itself. As long as the natural environmental cycles are not disrupted, all will be well in due time. Sometimes it takes eons of years to restore the face of the environment as with the case of the fallen meteor that wreak havoc and killed all the prehistoric dinosaurs on earth. But the 21st century catastrophe is not about the impact of fallen meteors anymore. It is about the destruction of the environment caused by pollutants. The major pollutant is the harmful carbon dioxide gas which is emitted during the burning of fossil fuels. This may not kill us immediately but it is killing us slowly, without us knowing it.

2.8.2 PROPERTIES OF CARBON DIOXIDE:

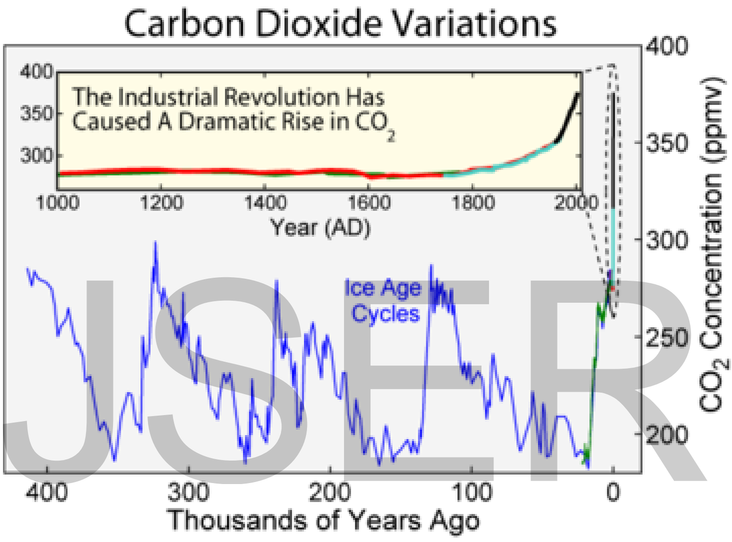
There are several physical and chemical properties, which belong to carbon dioxide. Here we will sum them up in a table.

Physical and chemical properties of CO_2

Property	**Value**
Molecular weight	44.01
Specific gravity	1.53 at 21 ^{o}C
Critical density	468 kg/m^3
Concentration in air	3.703×10^{10} pp m (Parts per million)
Stability	High
Liquid	Pressure < 415.8 k Pa
Solid	Temperature < -78 ^{o}C
Henry constant for solubility	298.15 mol/ kg * bar
Water solubility	0.9 vol / vol at 20 ^{o}C

2.8.3 PAST VARIATION OF CARBON DIOXIDE:

The most direct method for measuring atmospheric carbon dioxide concentrations for periods before direct sampling is to measure bubbles of air (fluid or gas inclusions) trapped in the Antarctic or Greenland ice caps. The most widely accepted of such studies come from a variety of Antarctic cores and indicate that atmospheric CO_2 levels were about 260–280 pp mv **(Parts per million by volume)** immediately before industrial emissions began and did not vary much from this level during the preceding 10,000 years (10 ka). In 1832 Antarctic ice core levels were 284 pp mv(Parts per million by volume).



CO_2 concentrations over the last 400,000 years

Fig:-2.6 co_2 vs. time graph

Changes in carbon dioxide during the Paleozoic (the last 542 million years) the recent period is located on the left-hand side of the plot, and it appears that much of the last 550 million years has experienced carbon dioxide concentrations significantly higher than the present day. One study disputed the claim of stable CO_2 levels during the present interglacial of the last 10 ka. Based on an analysis of fossil leaves, Wagner et al. argued that CO_2 levels during the period 7-10 ka were significantly higher (~300 ppm) and contained substantial variations that may be correlated to climate variations. Others have disputed such claims, suggesting they are more likely to reflect calibration problems than actual changes in CO_2. Relevant to this dispute is the observation that Greenland ice cores often report higher and more variable CO_2 values than similar measurements in Antarctica. However, the groups responsible for such measurements (e.g. H. J Smith et al) believe the variations in Greenland cores result from in situ decomposition of calcium carbonate dust found in the ice. When dust levels in Greenland cores are low, as they nearly always are in Antarctic cores, the researchers report good agreement between Antarctic and Greenland CO_2 measurements. The longest ice core record comes from East Antarctica, where ice has been sampled to an age of 800 ka. During this time, the atmospheric carbon dioxide concentration has varied by volume between 180–210 ppm during ice ages, increasing to 280–300 ppm (Parts per million) during warmer interglacial. The beginning of human agriculture during the current Holocene epoch may have been strongly connected to the atmospheric CO_2 increase after the last ice age ended, a fertilization effect raising plant biomass growth and reducing stomata conductance requirements for CO_2 intake, consequently reducing transpiration water losses and increasing water usage efficiency (AMBIO).On long timescales, atmospheric CO_2 content is determined by the balance among geochemical processes including organic carbon burial in sediments, silicate rock weathering, and volcanism. The net effect of slight imbalances in the carbon cycle over tens to hundreds of millions of years has been to reduce atmospheric CO_2. The rates of these processes are extremely slow; hence they are of limited relevance to the atmospheric CO_2 response to emissions over the next hundred years.

Various proxy measurements have been used to attempt to determine atmospheric carbon dioxide levels millions of years in the past. These include boron and carbon isotope ratios in certain types of marine sediments, and the number of stomata observed on fossil plant leaves. While these measurements give much less precise estimates of carbon dioxide concentration than ice cores, there is evidence for very high CO_2 volume concentrations between 200 and 150 Ma of over 3,000 ppm and between 600 and 400 Ma of over 6,000 ppm.**(Parts per million)** In more recent times, atmospheric CO_2 concentration continued to fall after about 60 Ma. About 34 Ma, the time of the Eocene-Oligocene extinction event and when the Antarctic ice sheet started to take its current form, CO_2 is found to have been about 760 ppm, and there is geochemical evidence that volume concentrations were less than 300 ppm by about 20 Ma. Carbon dioxide decrease, with a tipping point of 600 ppm, was the primary agent forcing Antarctic glaciations. Low CO_2 concentrations may have been the stimulus that favored the evolution of C4 plants, which increased greatly in abundance between 7 and 5 Ma (Clean Air Task Force, 2010)

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2.8.4 RELATIONSHIP WITH OCEANIC CONCENTRATION:

The Earth's oceans contain a huge amount of carbon dioxide in the form of bicarbonate and carbonate ions - much more than the amount in the atmosphere. The bicarbonate is produced in reactions between rock, water, and carbon dioxide. One example is the dissolution of calcium carbonate: $CaCO_3 + CO_2 + H_2O \rightleftharpoons Ca^{2+} + 2$ HCO3

Reactions like this tend to buffer changes in atmospheric CO_2. Since the right-hand side of the reaction produces an acidic compound, adding CO_2 on the left-hand side decreases the pH of sea water, a process which has been termed ocean acidification (even though pH remains alkaline). Reactions between carbon dioxide and non-carbonate rocks also add bicarbonate to the seas. This can later undergo the reverse of the above reaction to form carbonate rocks, releasing half of the bicarbonate as CO_2. Over hundreds of millions of years this has produced huge quantities of carbonate rocks (G. Kiely).

Ultimately, most of the CO_2 emitted by human activities will dissolve in the ocean; however, the rate at which the ocean will take it up in the future is less certain. Even if equilibrium is reached, including dissolution of carbonate minerals, the increased concentration of bicarbonate and decreased or unchanged concentration of carbonate ion will give rise to a higher concentration of un-ionized carbonic acid and dissolved carbon dioxide gas. This, along with higher temperatures, would mean a higher equilibrium concentration of carbon dioxide in the air.

2.8.5 IRREVERSIBILITY AND UNIQENESS OF CO_2 :

Carbon dioxide has unique long-term effects on climate change that are largely "irreversible" for one thousand years after emissions stop (zero further emissions) even though carbon dioxide tends toward equilibrium with the ocean on a scale of 100 years. The greenhouse gases methane and nitrous oxide do not persist over time in the same way as carbon dioxide. Even if carbon emissions were to completely cease, atmospheric temperatures are not expected to decrease significantly (AMBIO).

2.8.6 EFFCT OF RISING ATMOSPHERIC COCENTRATION OF CARBON DIOXIDE ON PLANTS:

Atmospheric concentrations of carbon dioxide have been steadily rising, from approximately 315 ppm (parts per million) in 1959 to a current atmospheric average of approximately 385 ppm (Keeling *et al.* 2009). Current projections are for concentrations to continue to rise to as much as 500–1000 ppm by the year 2100(IPCC 2007).

While a great deal of media and public attention has focused on the effects that such higher concentrations of CO_2 are likely to have on global climate, rising CO_2 concentrations are also likely to have profound direct effects on the growth, physiology, and chemistry of plants, independent of any effects on climate (Ziska 2008). These effects result from the central importance of CO_2 to plant metabolism. As photosynthetic organisms, plants take up atmospheric CO_2, chemically reducing the carbon. This represents not only an acquisition of stored chemical energy for the plant, but also provides the carbon skeletons for the organic molecules that make up a plants' structure. Overall, the carbon, hydrogen and oxygen assimilated into organic molecules by photosynthesis make up ~96% of the total dry mass of a typical plant (Marschner 1995). Photosynthesis is therefore at the heart of the nutritional metabolism of plants, and increasing the availability of CO_2 for photosynthesis can have profound effects on plant growth and many aspects of plant physiology.

Our knowledge of plant responses to future CO_2 concentrations rests on the results of experiments that have experimentally increased CO_2 and then compared the performance of the experimental plants with those grown under current ambient CO_2 conditions. Such experiments have been performed in a wide variety of settings, including greenhouses and chambers of a variety of sizes and designs. However plants grown in chambers may not experience the effects of increasing CO_2 the same way as plants growing in more natural settings. For this reason, techniques of Free-Air Carbon dioxide Enrichment (FACE) have been developed that allow natural or agricultural ecosystems to be fumigated with elevated concentrations of CO_2 in the field without use of chambers. As these experiments are the most naturalistic, they should provide the best indication of the responses of plants to increased CO_2 under the real-world conditions of the future. This article therefore focuses on data from FACE experiments wherever these are available. Whenever possible, to ensure the generality of conclusions, reference is made to analyses that have incorporated data from multiple experiments independently conducted at various research facilities.

One of the most consistent effects of elevated atmospheric CO_2 on plants is an increase in the rate of photosynthetic carbon fixation by leaves. Across a range of FACE experiments, with a variety of plant species, growth of plants at elevated CO_2 concentrations of 475- 600 ppm increases leaf photosynthetic rates by an average of 40% Carbon dioxide concentrations are also important in regulating the openness of stomata, pores through which plants exchange gasses, with the external environment. Open stomata allow CO_2 to diffuse into leaves for photosynthesis, but also provide a pathway for water to diffuse out of leaves. Plants therefore regulate the degree of stomatal opening (related to a measure known as stomatal conductance) as a compromise between the goals of maintaining high rates of photosynthesis and low rates of water loss. As CO_2 concentrations increase, plants can maintain high photosynthetic rates with relatively low stomatal conductance. Across a variety of FACE experiments, growth under elevated CO_2 decreases stomatal conductance of water by an average of 22%. This would be expected to decrease overall plant water use, although the magnitude of the overall effect of CO_2 will depend on how it affects other determinants of plant water use, such as plant size, morphology, and leaf temperature. Overall, FACE experiments show decreases in whole plant water use of 5–20% under elevated CO_2. This in turn can have consequences for the hydrological cycle of entire ecosystems, with soil moisture levels and runoff both increasing under elevated CO_2 (Leakey et al 2009).

Since photosynthesis and stomatal behavior are central to plant carbon and water metabolism, growth of plants under elevated CO_2 leads to a large variety of secondary effects on plant physiology. The availability of additional photosynthetic enables most plants to grow faster under elevated CO_2, with dry matter production in FACE experiments being increased on average by 17% for the aboveground, and more than 30% for the belowground (Ainsworth & Long 2005; de Graff *et al.* 2006)., portions of plants. This increased growth is also reflected in the harvestable yield of crops, with wheat, rice and soybean all showing increases in yield of 12–14% under elevated CO_2 in FACE experiments (Ainsworth 2008; Long *et al.* 2006).

Elevated CO_2 also leads to changes in the chemical composition of plant tissues. Due to increased photosynthetic activity, leaf nonstructural carbohydrates (sugars and starches) per unit leaf area increase on average by 30–40% under FACE elevated CO_2 Leaf nitrogen concentrations in plant tissues typically decrease in FACE under elevated CO_2, with nitrogen per unit leaf mass decreasing on average by 13%. This decrease in tissue nitrogen is likely due to several factors: dilution of nitrogen from increased carbohydrate concentrations; decreased uptake of minerals from the soil, as stomatal conductance decreases and plants take up less water (Taub & Wang 2008) and decreases in the rate of assimilation of nitrate into organic compounds. Protein concentrations in plant tissues are closely tied to plant nitrogen status. Changes in plant tissue nitrogen are therefore likely to have important effects on species at higher tropic levels. Performance is typically diminished for insect herbivores feeding on plants grown in elevated CO_2 this can lead to increased consumption of plant tissues as herbivores compensate for decreased food quality. Effects on human nutrition are likely as well.

2.8.7 THE GREEN HOUSE EFFECT:

The troposphere is the lower part of the atmosphere, of about 10-15 kilometers thick. Within the troposphere there are gasses called greenhouse gasses. When sunlight reaches the earth, some of it is converted to heat. Greenhouse gasses absorb some of the heat and trap it near the earth's surface, so that the earth is warmed up. This process, commonly known as the greenhouse effect, has been discovered many years ago and was later confirmed by means of laboratory experiments and atmospheric measurements.

Life as we know it exists only because of this natural greenhouse effect, because this process regulates the earth's temperature. When the greenhouse effect would not exist, the whole earth would be covered in ice.

The amount of heat trapped in the troposphere determines the temperature on earth. The amount of heat in the troposphere depends on concentrations of atmospheric greenhouse gasses and the amount of time these gasses remain in the atmosphere. The most important greenhouse gasses are carbon dioxide, CFC's (Chlorofluorocarbons), nitrogen oxides and methane. Since the industrial revolution in 1850 began, human processes have been causing emissions of greenhouse gasses, such as CFC's and carbon dioxide. This has caused an environmental problem: the amounts of greenhouse gasses grew so extensively, that the earth's climate is changing because the temperatures are rising. This unnatural addition to the greenhouse effect is known as global warming. It is suspected that global warming may cause increases in storm activity, melting of ice caps on the poles, which will cause flooding of the inhabited continents, and other environmental problems (Clean Air Task Force, 2010).

Together with hydrogen, carbon dioxide is the main greenhouse gas. However, hydrogen is not emitted during industrial processes. Humans do not contribute to the hydrogen amount in the air, this is only changing naturally during the hydrological cycle, and as a result it is not a cause of global warming. Increasing carbon dioxide emissions cause about 50-60% of the global warming. Carbon dioxide emissions have risen from 280 ppm in 1850 to 364 ppm in the 1990 (**G**. Kiely).

In the previous paragraph various human activities that contribute to the emission of carbon dioxide gas have been mentioned. Of these activities fossil fuel combustion for energy generation causes about 70-75% of the carbon dioxide emissions, being the main source of carbon dioxide emissions. The remaining 20-25% of the emissions are caused by land clearing and burning and by emission from motor vehicle exhausts (A.H. Mondol) Most carbon dioxide emissions derive from industrial processes in developed countries, such as in the United States and in Europe. However, carbon dioxide emissions from developing countries are rising. In this century, carbon dioxide emissions are expected to double and they are expected to continue to rise and cause problems after that. Carbon dioxide remains in the troposphere about fifty up to two hundred years. The first person who predicted that emissions of carbon dioxide from the burning of fossil fuels and other burning processes would cause global warming was Savant Arrhenius, who published the paper "On the influence of carbonic acid in the air upon the temperature of the ground" in 1896.

In the beginning of the 1930 it was confirmed that atmospheric carbon dioxide was actually increasing. In the late 1950s when highly accurate measurement techniques were developed, even more confirmation was found. By the 1990s, the global warming theory was widely accepted, although not by everyone whether global warming truly caused by increasing Carbon dioxide.

2.8.8 EFFECT OF CARBON DIOXIDE ON HEALTH:

Carbon dioxide is essential for internal respiration in a human body. Internal respiration is a process, by which oxygen is transported to body tissues and carbon dioxide is carried away from them. Carbon dioxide is a guardian of the pH of the blood, which is essential for survival. The buffer system in which carbon dioxide plays an important role is called the carbonate buffer. It is made up of bicarbonate ions and dissolved carbon dioxide, with carbonic acid. The carbonic acid can neutralize hydroxide ions, which would increase the pH of the blood when added.

The bicarbonate ion can neutralize hydrogen ions, which would cause a decrease in the pH of the blood when added. Both increasing and decreasing pH is life threatening.

Apart from being an essential buffer in the human system, carbon dioxide is also known to cause health effects when the concentrations exceed a certain limit.
The primary health dangers of carbon dioxide are:

- <u>Asphyxiation</u>. Caused by the release of carbon dioxide in a confined or unventilated area, this can lower the concentration of oxygen to a level that is immediately dangerous for human health.

- <u>Frostbite</u>. Solid carbon dioxide is always below -78^{o} C at regular atmospheric pressure, regardless of the air temperature. Handling this material for more than a second or two without proper protection can cause serious blisters, and other unwanted effects. Carbon dioxide gas released from a steel cylinder, such as a fire extinguisher, causes similar effects.

- <u>Kidney damage or coma</u>. This is caused by a disturbance in chemical equilibrium of the carbonate buffer. When carbon dioxide concentrations increase or decrease, causing the equilibrium to be disturbed, a life threatening situation may occur

Table 2.1: Characteristics of Fixed Chimney Kiln (FCK).

Items	Value
Number of kiln surveyed	25 number of FCK kiln
Fuel	Coal, firewood and others
Amount of coal	5.0 ± 0.5* tons/day
Amount of wood	1.0±0.2* tons/day
Others	0.1±0.05* tons/day
Production duration	November to April ± 15 days*
Amount of production	15000 brick/day or 2.5±0.3 million bricks per season
Burned coal after uses	40.0±10.0* per season
Chimney height	130.0±10.0* ft

Table 2.2: Characteristics of Zigzag Chimney Kiln.

Items	Value
Number of kiln surveyed	25 number of Zigzag kiln
Fuel	Coal
Amount of coal	3.0 ± 0.5* tons/day
Amount of wood	N/A
Production duration	November to April ± 15 days*
Amount of production	18000 brick/day or 3.00±0.4 million bricks per season
Chimney height	55.0±5.0* ft

CHAPTER-3
METHODOLOGY

3.1 WORK PROCEDURES:

(1) Field visit and questionnaire field survey was conducted to a total 50 brick manufacturing factories in order to identify total fuel, energy, production, manufacturing process of each factory.

(2) Most of the Brick kilns in Bangladesh are of the conventional type, Fixed Chimney Kiln, Zigzag chimney Kiln and use all kinds of combustible materials including, tires, coal, and firewood with some furnace oil to start and rejuvenate the flame.

(3) The air pollution contributed in this kiln due to both the type of fuel used and thermal inefficiencies of the kilns.

(4) This causes emissions like SOx, particulate matters, and volatile organic compounds that deteriorate air quality.

(5) Detailed estimates of carbon dioxide (CO_2) emissions at fine spatial scales are useful to both modelers and decision makers who are faced with the problem of global warming and climate change. Globally, transport related emissions of carbon dioxide are growing.

(6) This letter presents a new method based on the volume-preserving principle in the area interpolation literature to disaggregate transportation-related CO_2 emission estimates from the county-level scale to a 1 km^2 grid scale.

(7) The proposed volume-preserving interpolation (VPI) method, together with the distance-decay principle, were used to derive emission weights for each grid based on its proximity to highways, roads, railroads, waterways, and airports. The total CO_2 emission value summed from the grids within a county is made to be equal to the original county-level estimate, thus enforcing the volume-preserving property.

(8) The method was applied to downscale the transportation-related CO_2 emission values by county (i.e. parish) for the state of Louisiana into 1 km^2 grids. The results reveal a more realistic spatial pattern of CO_2 emission from transportation, which can be used to identify the emission 'hot spots' Of the four highest transportation-related CO_2 emission hotspots in Louisiana, high-emission grids literally covered the entire East Baton Rouge Parish and Orleans Parish, whereas CO_2 emission in Jefferson Parish (New Orleans suburb) and Caddo Parish (city of Shreveport) were more unevenly distributed.

3.2 QUESTIONARY SURVEY:

For questionnaire survey we have asked several type questions to the skilled worker of the brick kiln.
Following questions were asked to each people:-

1) Name of the company?
2) Type of the fuel?
3) Amount of fuel or materials used to product per million bricks?
4) Amount of wood required to product per million bricks for initial firing, if required?
5) Height of the chimney?
6) Diameter of the chimney?
7) Amount of production per season?
8) Weather condition during production period
9) Type of kiln?
10) Production period?
11) Average hampers working day due to rain or others per season?

3.3 EXAMPLE OF QUESTIONARY SURVEY AT DIFFERENT LOCATION:

Kishoreganj, Sadar

Type/Questionnaire	Fixed chimney kiln	Zigzag chimney kiln
Name of the company	MMB	DNB
Type of the fuel	Coal, fire wood	Coal
Coal used per day.	5 tons	3 tons
Wood required per day	1 ton	No
Type of coal	Conventional	Conventional
Height of the chimney	135 ft	55 ft
Diameter of the chimney	15 ft (bottom)	12 ft (bottom)
Amount of production per	15000	18100
loss of brick per day	150 nos	75no
Production period	6 months	6 months
Electricity required for	Lum -Sum	Lum -Sum
Diesel required per million	No	40 lit
Average hampered working	10 days	15 days

Kishoreganj, Sadar

Type/Questionnaire	Fixed chimney kiln	Zigzag chimney kiln
Name of the company	LKB	JBT
Type of the fuel	Coal, fire wood	Coal ,
Coal used per day	5.5 tons	3 tons
Wood required per day	1.2 ton	No
Type of coal	Conventional	Conventional
Height of the chimney	130 ft	55 ft
Diameter of the chimney	15 ft (bottom)	12 ft (bottom)
Amount of production per	15000	18100 nos
loss of brick per day	200 nos	150 nos
Production period	6.5 months	6.
Diesel required per day	No	45 lit
Average hampered working	10 days	15 days

Fig-3.1: Zigzag chimney (Firing condition)

Fig-3.2: Zigzag chimney (Firing condition)

Fig-3.3: Fixed chimney

Fig-3.4: Zigzag chimney

3.4. LISTS OF BRICK FIELDS:

3.4.1 ZIGZAG CHIMNEY:

01. Name of the Company: - M/S. Akkas Traders
Location: - Pakundia, Kishoreganj.
Brick Name: - **A.K.B**
Chimney Type: - Zigzag Chimney

02. Name of the Company: - M/S. Eddris Traders
Location: - Nilganj, Kishoreganj.
Brick Name: - **E.B.T**
Chimney Type: - Zigzag Chimney

03. Name of the Company: - M/S. Ishakha Traders
Location: - Nilganj, Kishoreganj.
Brick Name: - **Ishakha**
Chimney Type: - Zigzag Chimney

04. Name of the Company: - M/S. Zahid Traders
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **K.S.A**
Chimney Type: - Zigzag Chimney

05. Name of the Company: - M/S. Bashar Bricks
Location: - Karimgonj, Kishoreganj.
Brick Name: - **B.B.K**
Chimney Type: - Zigzag Chimney

06. Name of the Company: - M/S. Bulbul Traders
Location: - Karimgonj, Kishoreganj.
Brick Name: - **7.7.7**
Chimney Type: - Zigzag Chimney

07. Name of the Company: - M/S. Israil Mia Enterprise.
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **S.T.A.R**
Chimney Type: - Zigzag Chimney

08. Name of the Company: - M/S. Rashid Babul Mat.
Location: - Karimganj, Kishoreganj.
Brick Name: - **R.B.M**
Chimney Type: - Zigzag Chimney

09. Name of the Company: - M/S. Shamim Traders.
Location: - Hossainpur, Kishoreganj.
Brick Name: - **H.S.B**
Chimney Type: - Zigzag Chimney

10. Name of the Company: - M/S. Zihan Traders.
Location: - Austrogram, Kishoreganj.
Brick Name: - **J.B.T**
Chimney Type: - Zigzag Chimney

11. Name of the Company: - M/S. Egarosindur Traders.
Location: - Egarosindur, Kishoreganj.
Brick Name: - **M.R.B**
Chimney Type: - Zigzag Chimney

12. Name of the Company: - M/S. Monir & Brothers.
Location: - Karimganj, Kishoreganj.
Brick Name: - **M.B.S**
Chimney Type: - Zigzag Chimney

13. Name of the Company: - M/S. K.A Enterprise.
Location: - Kishoreganj.
Brick Name: - **K.A.K**
Chimney Type: - Zigzag Chimney

14. Name of the Company: - M/S. Hossainpur Bricks
Location: - Hossainpur, Kishoreganj.
Brick Name: - **H.P.B**
Chimney Type: - Zigzag Chimney

15. Name of the Company: - M/S. Star Bricks
Location: - Bhairab Kishoreganj.
Brick Name: - **STAR**
Chimney Type: - Zigzag Chimney

3.4.2 FIXED CHIMNEY:

01. Name of the Company: - M/S Tajul Islam Traders.
Location: - Karimganj, Kishoreganj.
Brick Name: - **R.A.B**
Chimney Type: - Fixed Chimney

02. Name of the Company: - M/S. B.B Traders.
Location: - Karimganj, Kishoreganj.
Brick Name: - **B.B.K**
Chimney Type: - Fixed Chimney

03. Name of the Company: - M/S. Hafiz Traders.
Location: - Karimganj, Kishoreganj.
Brick Name: - **H.B.F**
Chimney Type: - Fixed Chimney

04. Name of the Company: - M/S. Arif Traders.
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **S.B.M**
Chimney Type: - Fixed Chimney

05. Name of the Company: - M/S. Motiur Traders.
Location: - Karimganj, Kishoreganj.
Brick Name: - **M.R.B**
Chimney Type: - Fixed Chimney

07. Name of the Company: - M/S. Rahman Traders.
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **R.B.M**
Chimney Type: - Fixed Chimney

08. Name of the Company: - M/S. Toto Traders.
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **I.B.M**
Chimney Type: - Fixed Chimney

09. Name of the Company: - M/S. Nazmul Islam Traders.
Location: - Pakundia, Kishoreganj.
Brick Name: - **L.K.B**
Chimney Type: - Fixed Chimney

10. Name of the Company: - M/S. Azmal Hossain Traders.
Location: - Chowdoshow, Kishoreganj.
Brick Name: - **IFAT**
Chimney Type: - Fixed Chimney

11. Name of the Company: - M/S. Shohrab Uddin Traders.
Location: - Austrogram, Kishoreganj.
Brick Name: - **RIFAT**
Chimney Type: - Fixed Chimney

12. Name of the Company: - M/S. Basir Bricks Limited.
Location: - Kishoreganj.
Brick Name: - **B.S.K**
Chimney Type: - Fixed Chimney

13. Name of the Company: - M/S. Harun Bricks Limited.
Location: - Kishoreganj.
Brick Name: - **H.B.S**
Chimney Type: - Fixed Chimney

14. Name of the Company: - M/S. Gazi Bricks Limited.
Location: - Kishoreganj.
Brick Name: - **G.B.L**
Chimney Type: - Fixed Chimney

15. Name of the Company: - M/S. Juma Traders.
Location: - Pakundia, Kishoreganj.
Brick Name: - **A.B.F**
Chimney Type: - Fixed Chimney

16. Name of the Company: - M/S. Siraj Rasid Enterprise.
Location: - Bhairab, Kishoreganj.
Brick Name: - **S.R.B**
Chimney Type: - Fixed Chimney

3.4.3: Methods of Calculation of % of CO2 Emission of two types of kiln:

FIXED CHIMNEY:

Year	Fixed Chimney Kiln (FCK) %	Coal consumption per Brick (Kg)	CO_2 Emissions per Brick (Kg)
2005	80	0.80×0.24 = 0.192 Kg	0.192×2.82 = 0.541 Kg
2006	70	= 0.168 Kg	0.473 Kg
2007	60	= 0.144 Kg	0.406 Kg
2008	50	= 0.12 Kg	0.338 Kg
2009	45	= 0.108 Kg	0.304 Kg
2010	30	= 0.072 Kg	0.203 Kg
2011	20	= 0.048 Kg	0.135 Kg

ZIGZAG CHIMNEY:

Year	Zigzag Chimney Kiln %	Coal consumption per Brick (Kg)	CO_2 Emissions per Brick (Kg)
2005	20	0.20×0.20 = 0.040 Kg	0.040 ×2.82 = 0.113 Kg
2006	30	= 0.06 Kg	0.169 Kg
2007	40	= 0.08 Kg	0.225 Kg
2008	50	= 0.010 Kg	0.282 Kg
2009	40	= 0.08 Kg	0.225 Kg
2010	25	= 0.05 Kg	0.141 Kg
2011	15	= 0.03 Kg	0.085 Kg

Note:

01. Coal consumption per brick, FCK = **0.24 Kg**, Zigzag = **0.20 kg.**

02. Coal calorific value and emission co-efficient taken from the IPCC 1995.

03. One ton coal emitted = **2.82 Kg** CO_2.

Ref: - Emissions data from environmental reports for proposed Russell, Palmer, and Pioneer Renewable Energy plants (Massachusetts) Boardman coal fired plant in Portland, OR and the PVEC gas fired plant in Holyoke, MA.

3.4.4. Elaborated plan and sections of Brick kiln:

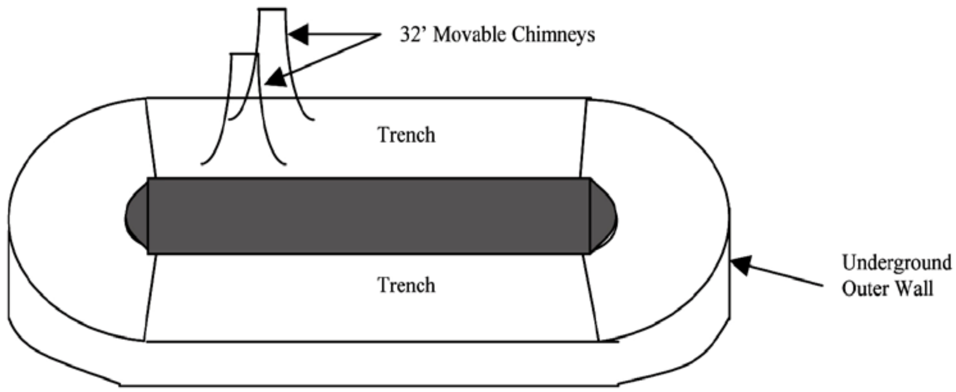

Figure 1 Schematic Diagram of a BTK

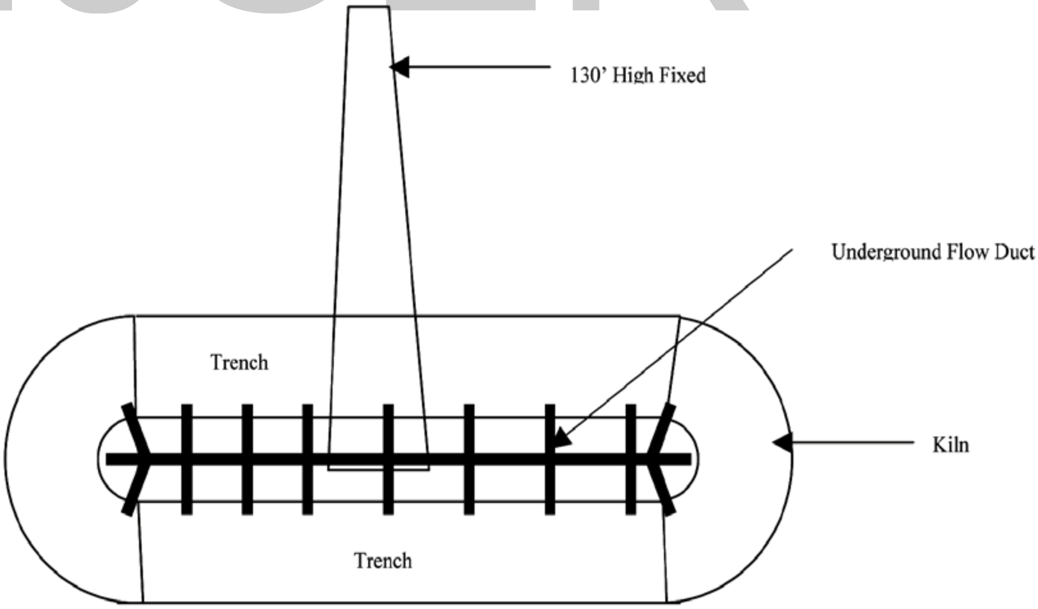

Figure 2 Schematic Diagram of a Fixed Chimney Kiln

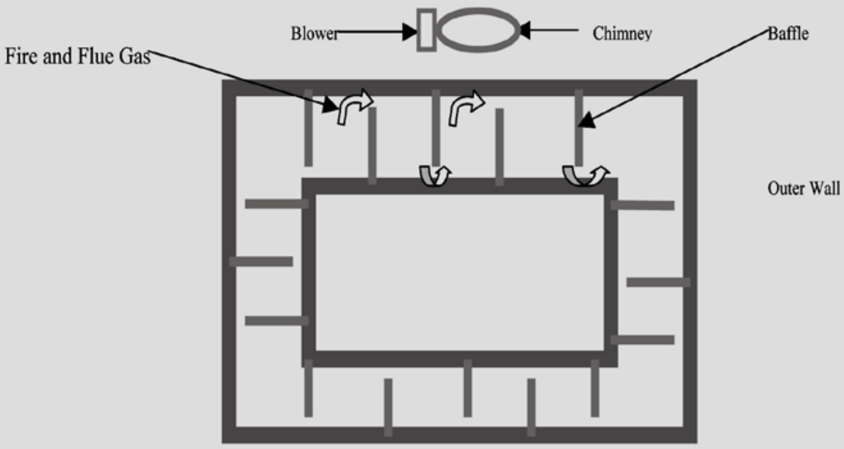

Figure 3 Schematic Diagram of a Zigzag Kiln

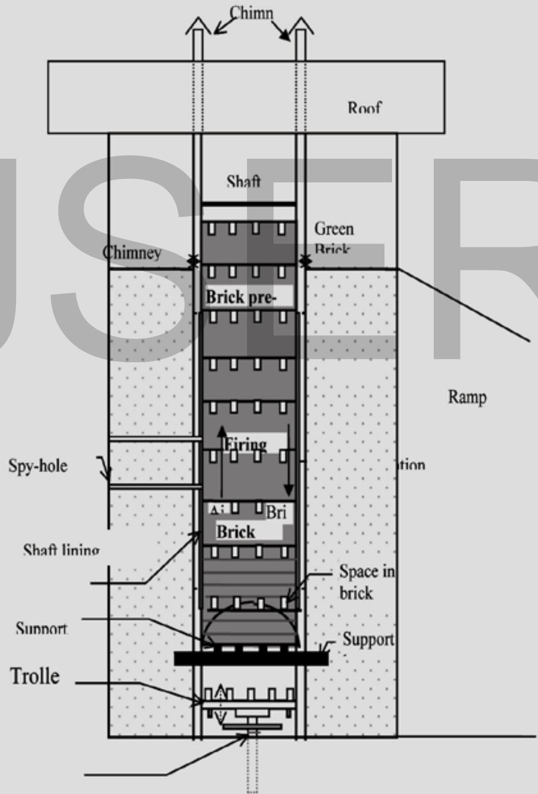

Fig. 4. Design of : Vertical Shaft brick kiln

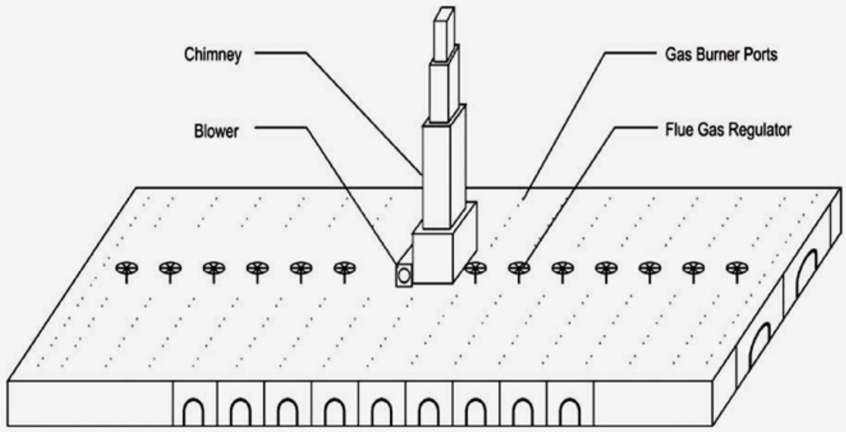

Figure 5 Schematic Diagram of a Hoffmann Kiln

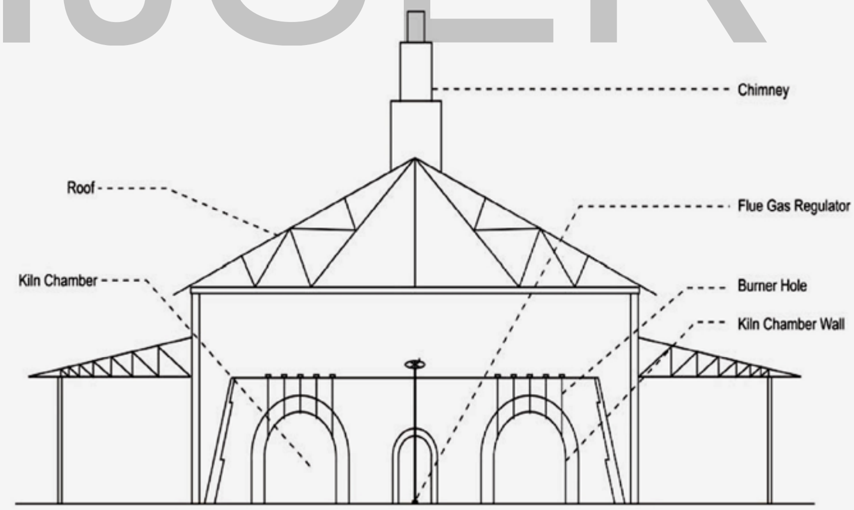

Figure 6 Cross Sectional View of a Hoffmann Kiln

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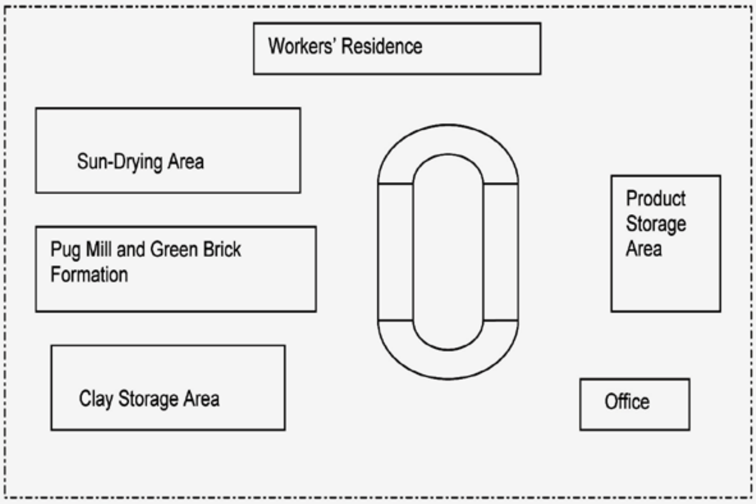

Figure 7 Plot Plan for a Bull's Trench Kiln (BTK)

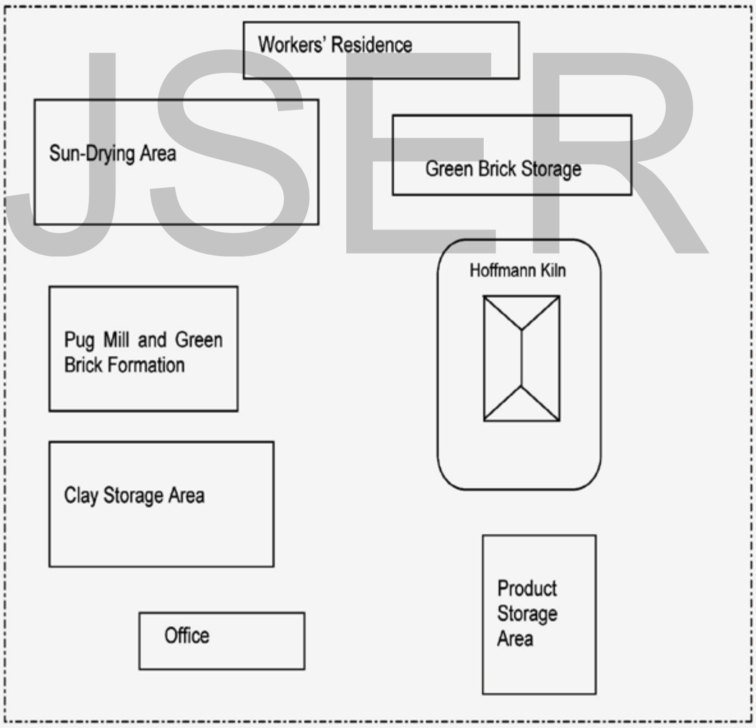

Figure 8 Plot Plan for a Hoffmann Kiln

CHAPTER- 4

RESULT AND DISCUSSION

4.1 GENERAL:

Under this study 50 numbers of brick fields: 25 numbers of fixed chimney kilns (FCK) and 25 numbers of Zigzag kilns has surveyed. Zigzag technology is truly traditional and simple. The advantages of Zigzag are that it is capable of satisfying the demand fully, very cost-effective, simple technology, payback period is less, other than FCK Kiln. Due to these advantages this is very popular. However, emission form Zigzag is very severe contributed low CO_2 emission.

Table 4.1: Comparison with fixed and Zigzag chimney production:

Items	**Fixed Chimney**	**Zigzag chimney**
Height of Chimney	130.0±10.0* ft	55.0±5.0* ft
Coal uses	250±30.0* tons per million bricks	180±10.0* tons per million bricks
Wood uses	55.0±5.0* tons per million bricks	None
Electricity	None	1000±100.0 kwh per million bricks
Diesel	None	2000 lit per million bricks
Smoke	Black and very high	10-15% compared to fixed chimney
Quality of production	60-70% 1^{st} class brick	85-90% 1^{st} class brick
Total production	2.5±0.3 million bricks per season	3.0±0.4 million bricks per season

4.2: COST VARIATION ANALYSIS:

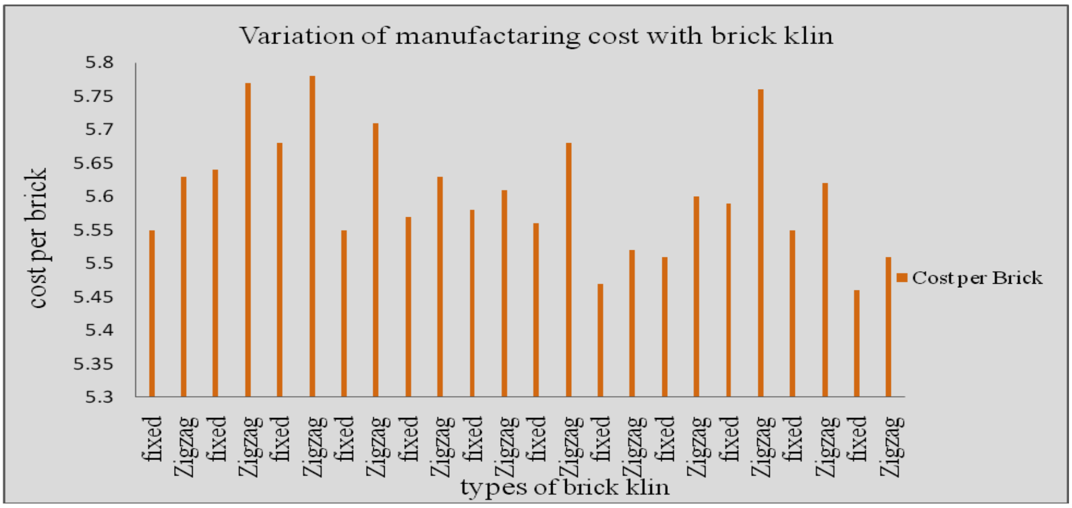

Fig: 4.1: Cost variation analysis of brick kilns.

Types of Brick Kiln	Cost per Brick (average of two brick kiln) in Tk
fixed	5.55
Zigzag	5.63
fixed	5.64
Zigzag	5.77
fixed	5.68
Zigzag	5.78
fixed	5.55
Zigzag	5.71
fixed	5.57
Zigzag	5.63
fixed	5.58
Zigzag	5.61
fixed	5.56
Zigzag	5.68
fixed	5.47
Zigzag	5.52
fixed	5.51
Zigzag	5.6
fixed	5.59
Zigzag	5.76
fixed	5.55
Zigzag	5.62
fixed	5.46

Table 4.1: Chart of cost per unit brick with Brick kiln.

4.3. DISCUSSION ABOUT COST VARIATION WITH ZIGZAG AND FCK KILN:

The production rate of bricks at Zigzags kiln is more than FCK bricks production rate. It is observed that the conventionally Zigzag production per day 18100 nos. and FCK production per day 15000 nos. coal use at Zigzag 3 ton per day, besides 5 ton coal use at FCK per day. Mostly we prefer Zigzag kiln, because it gives us more production in a day or a season than FCK. The Zigzag Kiln is ideally suited to both large scale continuous brick making operations and to small semi-continuous village applications in developing countries. Brick makers in the country are looking to convert existing technologies into zigzag kilns for cost effectiveness.

Zigzag kilns are easier to install and use than other technologies. Experts say the zigzags are more energy efficient than the fixed kilns. We also observed (25 numbers of Zigzag and 25 number of FCK) that the production rate of per bricks at Zigzag kiln is more than FCK. However we chose the Zigzag kiln, because it is friendlier than FCK to environment & society.

4.4: HEALTH EFFECT ANALYSIS:

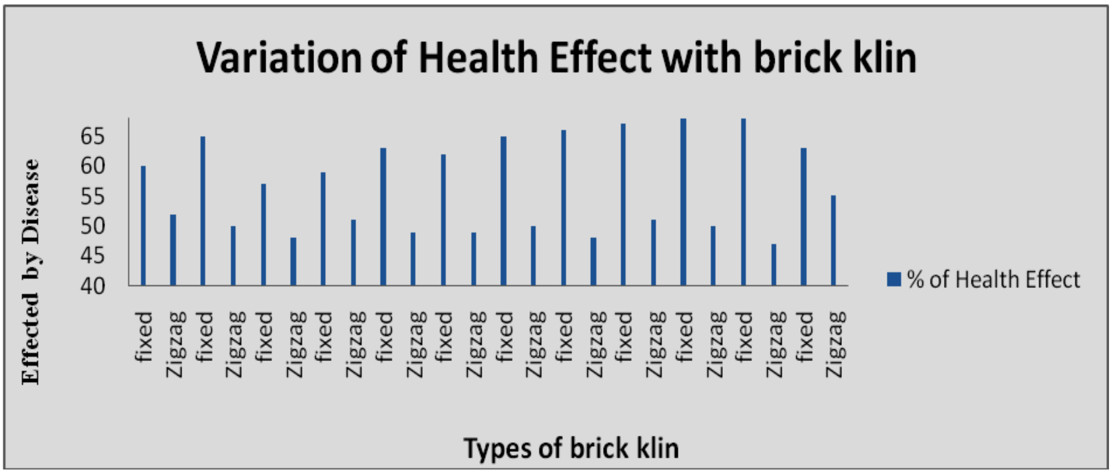

Fig:-4.2 health effect with Brick kiln

Types of Brick Kiln	Percent of health effect (average of two brick kiln)
fixed	60
Zigzag	52
fixed	65
Zigzag	50
fixed	57
Zigzag	48
fixed	59
Zigzag	51
fixed	63
Zigzag	49
fixed	65
Zigzag	49
fixed	65
Zigzag	50
fixed	66
Zigzag	48
fixed	67
Zigzag	51
fixed	69
Zigzag	50
fixed	68
Zigzag	47
fixed	63

Table 4.2: health effect chart with Brick kiln

4.5 DISCUSSION ABOUT HEALTH EFFECT WITH BRICK KILN:

- Fixed chimney kiln (FCK) produced “Black smoke” which is higher emission of carbon dioxide. As a result carbon dioxide concentration increase health effect on human body and causes badly diseases such as Eye irritation, Head headache, Asthma, Frostbite, Asphyxiation and also kidney diseases. Concentration of carbon dioxide rising are also greatly direct effects on the workers. So we should take care to reduce the emission of carbon dioxide by less using burning wood in fixed chimney kiln.

- On the other hand, A Zigzag kiln does not use burning wood, use only coal; hence it saves trees. Zigzag kiln produce “White smoke”. Emitted smoke from Zigzag kiln flows through a Zigzag path over water and is friendly “White smoke”; before being emitted into the environment. Which causes little crucial to the workers of kiln to prevent health effect.

4.6: FINAL DISCUSSION:

A) The estimated that the total CO_2 release from all primary fossil fuels used in Bangladesh amounted to 5.07 million tons (Mt) in 1977 and to 14.4 Mt in 1995. Then projected Bangladesh's CO_2 emission based on the 1977-1995 trends, which resulted in a projection of 293 Mt of CO_2 emission in 2010(AMBIO) a journal of human environment.

B) We observed that in Bangladesh 160 million people, which is about 2.4 percent of the world's population, Bangladesh emits 0.14 percent to the world's emission of carbon dioxide (CO_2) (Bernhard G. Gunter, " The Impact of Development on CO_2 Emissions). As per 2007 emission, World emission is 29,321.3 million tons per year while Bangladesh emission is 43.75 million tons. The reason for Bangladesh's low CO_2 emissions is due to Bangladesh's low energy consumption, amounting in per capita terms to only about one twentieth of the world average per capita electricity consumption, which is due to Bangladesh's low income per capita level of $ 470.3 (Bernhard G. Gunter, " The Impact of Development on CO_2 Emissions").

C) So we need to study two types of manufacturing brick kiln such as FCK & Zigzag kiln. We discuss that Black smoke emission reduction is not possible by using FCK, because of FCK is a very poor technology. The height of FCK chimney does not prevent the black smoke emission without only a few little particles. Black smoke emission reduction is possible by using Zigzag kiln, because of the black smoke flows over water drain in Zigzag path of Zigzag kiln.

CHAPTER- 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS:

- From this feasibility study, it is clear that brick industry is one of the potential sources of CO_2 emission in Bangladesh. Production is increased by about 5.6% annually - tracking urbanization rate of 6%. (2008 estimate) (Ellen Baum, "BLACK CARBON from BRICK KILNS" Clean Air Task Force, 2010).
- It is the high time to take necessary steps for the planned development of this sector by strictly following the ECR, 1997, and providing an environmental management framework during the operation for all industries.
- Fixed chimney kiln manufacturing technique is conventional and Zigzag manufacturing technique is more technical.
- Fixed chimney kiln (FCK) operation procedure is not sophisticated but Zigzag operation procedure is very sophisticated.
- FCK emits "Black smoke" and Zigzag kiln emits "White smoke".
- A zigzag kiln technology is more economical than other technologies.
- Zigzag Kiln can reduce 50% of CO_2 emission.
- Zigzag Kiln is more environmental friendly than fixed chimney kiln.
- Burning wood which is used in FCK emits 1.25-3.00 times more carbon dioxide than coal, so we can prefer Zigzag kiln to reduce CO_2 emission.

Finally we can say that, we should strictly follow the Zigzag operation to reduce more CO_2 emission than other technologies.

5.2 RECOMMENDATIONS:

The following are general recommendations made from the study:

1. Coal use should be reduced in brick manufacturing factory.
2. Wood use should be reduced in brick manufacturing factory.
3. Electrical energy use should be reduced in brick manufacturing factory.
4. Fixed kiln should be reduced.
5. Use of zigzag kiln should be increased.
6. The height of chimney should be increased.
7. Zigzag Kiln can be used for large production.
8. Strong regulations and laws should be introduced and enforced.
9. A thorough study may be conducted regarding various systems of brick manufacturing in Bangladesh to make a detail comparison among various methods.

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REFERENCES

[1] MOEF, “Bangladesh Climate Change Strategy and Action Plan 2008”, Ministry of Environment and Forests Government of the People’s Republic of Bangladesh. Dhaka, Bangladesh.

[2] People’s Republic of Bangladesh, “Supporting Implementation of the Bangladesh Climate Change Strategy and Action Plan” Asian Development Bank, February 2009.

[3] WEO, World energy outlook, 2007, International Energy Agency

[4] A.H. Mondol, “Implications of renewable energy technologies in the Bangladesh power sector: Long-term planning strategies”, Doctoral Dissertation**,** Rheinischen Friedrich-Wilhelms-Universität.

[5] Rout UK (2007) Modeling of endogenous technological learning of energy technologies - an Analysis with a Global multiregional energy system model. Dissertation, University of Stuttgart

[6] M.N. Islam, “Energy context in Bangladesh”. In: Islam AKMS and Infield DG (Ed), Photovoltaic technology for Bangladesh. Bangladesh University of Engineering and Technology, Dhaka, Bangladesh and Lough Borough University, 2001, UK, pp 1-18.

[7] BPDB (2006) BPDB Annual Report 2005-06, Bangladesh Power Development Board, Dhaka, Bangladesh

[8] ADB (1998) Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS) Bangladesh, Asian Development Bank, Manila, Philippines, p 187

[9] Shrestha RM, Anandarajah G, and Liyanage MH (2009) Factors affecting CO_2 emission from the power sector of selected countries in Asia and the Pacific. Energy Policy 37: 2375-2384

[10] DEA, Brick kiln: Reducing carbon emissions from brickwork makings in Bangladesh, Danish Energy Agency, Amaliegade 44, DK 1256 Copenhagen K, 2010

[11] G. Kiely, Enviuronmental Engineering, New York: McGraw-Hill International Edition, 1998, ch 8

[12] Emissions data from environmental reports for proposed Russell, Palmer, and Pioneer Renewable Energy plants (Massachusetts) Boardman coal fired plant in Portland, OR and the PVEC gas fired plant in Holyoke, MA.

[13] Ellen Baum, "BLACK CARBON from BRICK KILNS" Clean Air Task Force, 2010 (http://www.scribd.com/doc/33842169/Black-Carbon-from-Brick-Kilns)

[14] Bernhard G. Gunter, "The Impact of Development on CO_2 Emissions: A Case Study for Bangladesh until 2050", Bangladesh Development Research Center (BDRC), USA

[15] Free Wikipedia, **"**List of countries by carbon dioxide emissions" (http://en.wikipedia.org/wiki/List of countries by carbon dioxide emissions)

[16] Azad, Abul K.; S. W. Nashreen; and J. Sultana, "State of Energy Consumption and CO2 Emission in Bangladesh", AMBIO: A Journal of the Human Environment, Vol. 35, No. 2, 2006, pp. 86-88.

[17] Taub, D., Miller, B. *et al.* Effects of elevated CO_2 on the protein concentration of food crops: a meta-analysis. Global Change, Biology 14, 565-575 (2008).