International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 8, Number 2 (2015), pp. 87-95

http://www.irphouse.com

Hoffman Red Bricks Kiln Modification And Pollution Reduction

[1]Abdel rahim Mubarak Abu sinaina

[1]Brick & road research institute– Khartoum University
P.O.Box 321, code.11115, Khartoum, Sudan

[2]Ali Mohamed Hamdan Adem

[2]Sudan University of science & Technology, Faculty of Engineering
P.O.Box 407, Khartoum, Sudan

[3]Abdelrazig Mohamed Abdelbagi

[3]Physics Department, Science College, Shaqra University
P.O. Box 33, code 11911, Da wadami, Kingdom of Saudi Arabia
[3]Omdurman Islamic University, Faculty of Science
Box. 832, Omdurman, Sudan

[*]Corresponding author: Abdelrazig.M.Abdelbagi

ABASTRACT:

This study is aimed to an assessment of the red brick kiln types and successive development. Furthermore, the work on chimney in the upper draught technique has modified and improved, which was conducted on Soba brick plant Hoff-Mann Kiln in Khartoum, Sudan. Modification of kiln via exhaust pipes was decreased the time per stack of 0.5 hours with the total reduction of time /kiln is almost 31 hours of the production. However, the resulting outcome of the modification indicates that the 2.5% bricks crack instead of 5%. Thus, the reduction of firing time per stack is led to reduction in the fuel consumption. The sealing paper was reduced the losses to 2% instead of 4%. These developments were increased the mass of bricks productivity and a good quality with an economic benefit and decreasing in environmental contamination.

Keywords: Kilns, development, fuel consumption, quality, productivity, modification, environment.

INTRODUCTION:

Methods of the brick Kilns are produced in thermally insulated oven for controlling temperature that uses to achieve hardness of the bricks suitable for standard required, which are broadly divided into intermittent Kilns, semi-continuous and continuous Kilns. Brick kilns of different types due to contractions, methods of firing and processes were continuously developed. These general wide improvements had great influences on kilns superior outcomes such as production capacity of red brick, which is almost, covered the supply of rapid market demand. The green bricks in intermittent kilns are fired in the oven according to temperature schedule and time required for finishing quality and the cooled down for a new firing process [1].

The clamp kilns are types of an up-draft intermittent kiln built-in the form of a clamp and roofed over to protect the bricks from the rain. The clamp is opened at one end and wood placed in the flues and then fire at these openings, while the fire is gradually travelling to the opposite end by combustion of the coke and of the combustible matter in the bricks. The clamp is then turned left to burn until all the combustible matter consumed, so that the duration of firing depends on the size of the clamp.

The clamp kilns are very similar to our Sudanese traditional Kamena, so that the bricks are established in an open pattern up to 40 courses high forming a steep truncated pyramid[2]. The width depends on the fuel being burned and the fire boxes remain in the lower part of the structure. Hot air is generated in the fire boxes, which rise through the setting to the top and their escape into the open through strategically placed flues.

Horizontal draft kiln consists of a rectangular chamber and two or three five holes at one end. The other end is entirely closed except for four or five exhaust parts at the base of the wall through which flue gases pass into the chimney built into the kiln wall. Down-draft kiln is the most widely used type of intermittent kilns of round or rectangular in shape with 18 fire holes spaced equally around the outside of the kiln and primary air can pass through them. The kiln base is covered with checkered bricks used for better firing. The step grates consist of a number wide metal plates arranged across the fire hole are situated within the kiln at the back of the fire holes and serves to direct the combustion gases upwards into the crown of the kiln, and to protect the bricks nearest the fire hole from the heat of the fire[3].

Semi continuous kilns are combined with five or more intermittent kilns or chambers built together and arranged that so as the gases may pass from one to the other. The kiln is let off at one end and the first chamber fired in the same way as an intermittent kiln. The kiln gases instead of passing to the chimney are passed through the second chamber and the bricks in the second chamber then preheated to a fairly high temperature before the firing of the first chamber has been carried out. This process is repeated until the last chamber dismissed, which the flue gases are exhausted directly to the chimney when the firing of the kiln is completed [4].

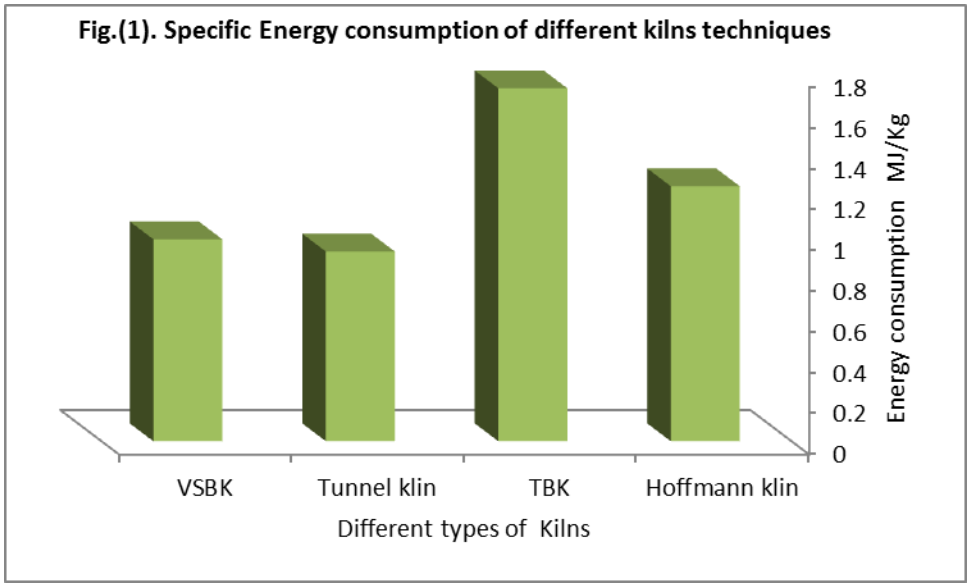
Continuous kilns may be defined as green bricks being made available for one part of the kiln and fired bricks withdrawn continuously from another. Fuel is fed regularly at more or less constant rate. In continuous kilns, the green bricks always stacked and beings stationary, while the fire moves all over to complete the firing process [5].

Hoffmann Kiln is referred to FRERICH HOFF-MANN in Germany, which is the most convenient type of kiln (6). The construction of the kiln is designed for circular ring-chamber with thick walls of the chimney at the center to which 12 underground radial flues converged from the inside wall of the chamber. The feed holes are organized in rows of 3 or more feed holes across the width of the crown and topped fired kiln, fed with fuel (gas oil, heavy fuel oil, and gas)(7). The output of this type is quite limited due to the relatively small span of the arch which determines the Kiln size. Normally outputs are about 5 million bricks per year, with a maximum of 10 million bricks. Modern Hoffmann kilns are well insulated in order to keep the input heat within the kiln more as possible.

Moving-ware continuous kilns is car tunnel kiln, consist of a long tunnel with a fixed firing zone at a suitable position, normally in the middle section of the kiln. Behind the firing zone is the cooling zone and in front of it in the preheating zone (8).

The bricks to be fired are placed on specially designed cars. Car tops are built above a metal chassis that built of refractory material. These cars run on rails through the channel and thick asbestos rope may also be provided between adjacent car decks so as to ensure that a seal. The sides of these cars are specially shaped to match in a recess in the kiln side walls and a sand seal is provided beneath the cars on each side of the kiln so to restrict air leakage from the space below the cars into the channel chamber [9]. Top-Fired Kilns are fitted with oil injectors placed in the crown of the kiln throughout the firing zone. The oil injected into the kiln is burnt with the very hot air taken from the kiln cooling zone [10].

The vertical shaft brick kiln (VSBK) consists of one or more shafts located inside the rectangular brick structure and lined with refractory bricks. The gap between the shaft wall and the outer kiln wall is a filled with insulating materials (clay, rice husk, ashes). A comparative specific fuel-consumption and energy efficiency of brick firing –process of different technologies is displayed in Fig.(1)[11].



Due to the successive development of red brick industrial system, with high performance technologies in efficient energy fuels consumption, environmental impact has to be considered to improve air pollution contamination [12]. The kilns are the main source of air pollution gases emission in urban area due to the large amount of fuels used in the combustion of low efficiency for red brick production (Streets& Waldhoff, 1999)[13]. The huge amount fuel wood is used for brick production leads to the emission of greenhouse hold gases such as carbon dioxide, carbon monoxide, nitrous oxide, nitric oxide, nitrogen oxide and methane that has a negative impact on ambient air pollution (NOX; Alam & Starr, 2009)[14].

MATERIAL AND METHODS:

The Soba brick plant was constructed on the Blue Nile River shore owing to the availability of raw material, which can be renewed during the flood season every year [15]. The factory is Hoffmann Kiln-Upper drought type of the production capacity of 10 million Bricks per year [16]. The plant core section is classified to the excavation area, processing and shaping line, drying and firing section. The plant output and the excavation and clay wining were becoming affordable and more economically when mechanical clay wining exceeded 20 m^3 per day of bricks production [17].

The equipment of the clay lining is multi-buckle-excavator, shale planner and loader according to the nature of the deposits at the site. The dump truck conveys the prepared clay by the excavator and then transported to the plant for mixing processes. According to the laboratory test, the clay was mixed with a certain counted percentage of additives as needed using a loader, then adding sufficient water to the mix and left for a time as long as possible a week or more for better fermentation[18]. The line was feeding with box-feeder and mix material conveyed by slat conveyor to the wet-pan-mill, with a capacity range of 4-18m^3/hr for grinding the mix. The wet-pan mill was crushed and pushed the compound mix through perforated slab; hence clay comes out in the form of noodles.

This was achieved by an adjustable clearance between the gaps of the two rollers of the mills in a form of thin layers. The material after mixing homogeneously and become more plastic and compact is taken to a vacuum pressing machine with a capacity of 5000 brick/hr.

The formed clay column is passed via die and then transferred to the cutting table through a horizontal roller conveyor that assist in transferring the formed clay from the chute of the press to the cutting table, which is relaying of friction between the clay mass and the roller conveyor.

In this plant drying method of four movable shelves had been used to dry wet green bricks set on 20 wooden shelves of 10 designed dryers [19]. The hot air is drawn from the kiln cooling zone and that used for drying the bricks [20]. Air mixture and fans are used for circulating heated air through the chamber within two days, while the chamber doors were closed. Then the chamber door opened partially in the ambient air to another two days to finalize the drying period within 4 days. Green dried bricks were stacked inside Hoffman Kiln, while the firing air batteries are moving to complete the firing cycle regularly, such as preheating, full firing and cooling in 4

days duration. The Hoffman Kiln is a top fired kiln with an up-draught suction method. The burners are located in the top crown of the kiln and the suction of draught directed upwards. Therefore, temperature is distributed more at the highest crown than that at the bottom of the kiln. The method of upper-draught Hoffman Kiln has several disadvantages were come out such as too much temperature variation through the kiln cross-section; the bricks at the top of almost is overheating.

The main exhaust fan draws the gases to the chimney that leads in ambient air and increased the pollution and with a top fired oil system [21]. Pipe gas channels were modified the connection of the main exhaust fan to the underneath of the Kiln, which converts the existing exhaust gases from the top crown section to a down section kiln. A pipe of dimension 2700mm long, 100mm diameter is composed of a heat resistant material in order to withstand the temperature of the preheating zone of about 250^{o}C. Theses pipes were provided by a proper sealing ring at the top to serve as a sealing cover, which was inserted inside the kiln linking between the bottom of the kiln and the main exhaust pipe system through the exhaust-valves.

The function of these pipes is to withdraw the heat from the kiln top crown of the higher temperature, concentration to the bottom of the kiln with the lower temperature concentration with the assistance of a suction exhaust fan. These suction pipes should be inserted during the firing process at the preheating zone when the temperature is about 150^{o}C or after a brick water smoking period in order to avoid water condensation on the top of the exhaust valve. Therefore, the water droplets were affected on dried green bricks and that can lead to the bricks crack.

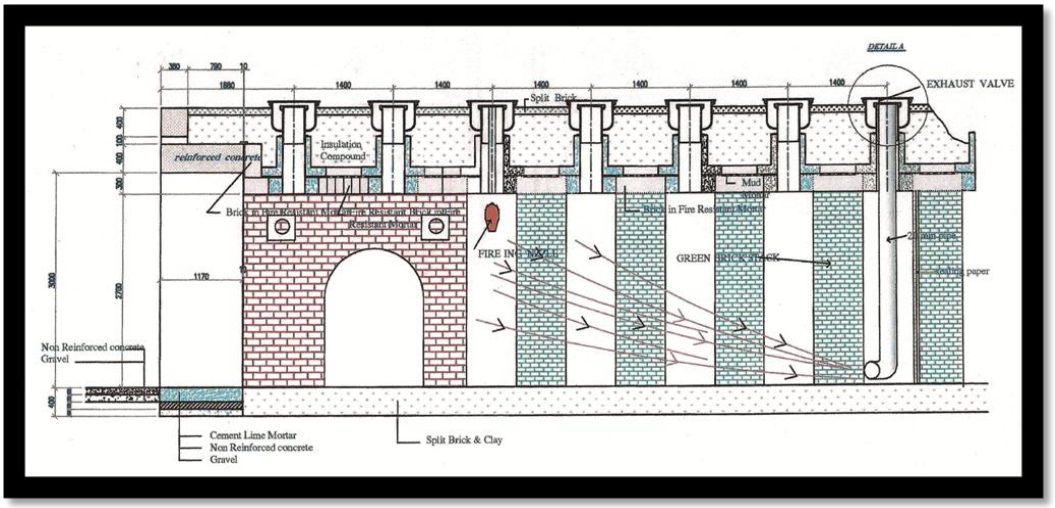


Fig. (2) Modified down-draught suction pipe.

Experimental work had been performed during the kiln firing process using these suction pipes and different measuring devices such as thermostats, thermocouples, Seger cones for temperature measurement.

Seger cones are pyro-metric devices that used to gauge heat work during the firing of the bricks [22]. Seger cones have different types that are used for indicating a certain temperature equivalent. Three cones are used to carry different ranges of temperature, so the first cone carries an equivalent temperature above the expected temperature, the second one to be within the expected temperature, and the third will be below the expected temperature.
The three similar sets 950, 830, 700 ^{o}C, respectively were positioned within the stack of the bricks before firing. The positions of the cones were attached at the top, the second in the middle and the third positioned at the bottom of the stacks. The three cones after firing in order to assess the deformation and the effect of heat upon them and then the temperature equivalent had been obtained.

Table (1).Seger cones test result.

Seger cones position	Equivalent temp.	Brick quality
At the top of the stack	950^{o}c	Well Fired with red color
At the middle of the stack	830^{o}c	Fired with red color
At the bottom of the stack	830^{o}c	Fired with red color

A suitable sealing paper was being selected and then fixed properly after 7 raw of a series of stacks of dried green bricks being set in the kiln for firing as a new limited section. During the firing process, hot gases were being withdrawn forward by an exhaust suction fan and that trapped by a sealing paper in order to keep the heat within this specified limited section [23]. The temperature of this preheating section will then increase gradually till it reached 85^{o}C of the sealing paper position.

Fig(3). Stacking of green bricks, before sealing paper and after Sealing-paper and suction-pipes at the top of kiln.

RESULTS AND DISCUSSION:
The time taken to fire the new stack of green bricks was reduced to 2.5 hours instead of 3 hours, however the reduction of time per on stack 0.5 hours and the total reduction of time /kiln is almost 31 hours. In spite of that is leaded to reduction in the fuel consumption as a result of the reduction of firing time per stack. Kiln controlling heating systems is very important for both kiln productivity and quality, therefore the

sealing paper method has been used [24]. The sealing paper is a type of selected papers with unique specifications used to be fixed after a series of stacks of dried green bricks being set inside the kiln in order to be fired. This paper was fixed properly to provide a proper seal covering the entire cross-section of the last stack of bricks. Otherwise air leakage will occur in feed more pollution to aerosol in ambient air.

Then sealing the paper should be burnt off in order to insure the flow of heat forward to preheat another new section of cold dried stacks of green bricks. In some cases, if the sealing paper was not being burnt out, the paper will remain in position until the gases are sufficiently heated to burn the paper at about 300^{o}C. This high temperature will cause a sudden heating of the adjacent cold brick and this will lead to the brick cracks. Consequently, the sealing paper has improved on bricks up to 95% and reduced the losses to 2% instead of 4%, hence for this reason the best productivity and quality was achieved with the minimum time.

The experimental modification of the plant is indicated that the high temperature, concentration at the top of the kiln had been withdrawn and distributed downwards to the bottom balancing the heat all over the kiln cross-section. However, the resulting outcome of the modification indicates that the stacks of the fired bricks were appeared of a good quality, and almost similar in red color with 2.5% bricks cracks instead of 5% and losses of 2% of bricks reduction compared to 4% before modification for the quality of bricks. Seger cones for heat indication during the testing shows a little temperature variation between the readings at the top of the stack, in the middle and the bottom of the kiln.

Experimental work had been carried out, during the kiln firing process and the heat flow through the preheating zone using the instruments such as; the sealing paper, the controlled exhaust valves, the suction pipe dampers, the hooked rod and the temperature gauge. Moreover, the exhaust gases were condensed during the cycling process in stacks and that decrease the air pollution fired, while bricks at the bottom practically with less firing and in different colors.

CONCLUSION:

In conclusion, manure and wood fuel used in the area for brick production contributes substantially to ambient air pollution. In spite of that and due to the continuous successive work being carried out on brick kilns manufacturing techniques such as their types, constructions, firing process, pollution reduction, specific fuel consumption, brick productivity, quality, and stack emission, a superior outcomes and good results had been encountered. Accordingly the modification of the kiln was decreased to 2.5 hours instead of 3 hours that achieving a 0.5 hours of time per stack, which is led to reduction in the fuel consumption. The resulting outcome of the change indicates that the stacks of the fired bricks were appeared of a good quality and almost similar in red color and losses of bricks reduction compared to the bricks before modification for the quality of bricks. Thus, the sealing paper has improved on bricks quality and reduced the losses, hence for this reason the best productivity and quality was obtained with the minimum time. The paper used for ventilation sealing

arrangements by providing adequate temperature loss from the kiln and reduction of gas emission was cur the exposure to pollution. Therefore, improvements in brick quality and reduction of energy loss in unit bricks can be led to reducing of gas emission (Schilderman, 2002). Additionally, the distribution of energy in the kiln and condensation of the gases inside the kiln could lead to less contribution of contamination in air. The study of air pollution in the area could be used for further evaluation in order to assess aerosol contamination on a Blue Nile bank from different brick kiln factories in the area.

REFERNCES:

[1] Alam, S. A. & Starr, M. (2009). Deforestation and greenhouse gas emissions associated with fuel wood consumption of the brick making industry in Sudan. Science of the total environment, 407, p. 847–852.

[2] Ishtiag Abdalla a, c, Sahar Babiker Abdalla b, d, Kamal El-Siddig d, Detlev Möller a, Andreas Buerkert, (2012) Effects of red brick production on land use, household income, and greenhouse gas emissions in Khartoum, Sudan, Journal of agriculture and rural development in the tropics and sub-tropics, Vol. 113 No. 1p. 51–60.

[3] Sameer Maithel et al, (2012) Brick Kilns performance assessment and a roadmap for cleaner brick production in India, A Shakti sustainable energy foundation and climate works Foundation supported initiative, report.

[4] Singh, A. L. & Sarfaraz Asgher, M. (2005). Impact of brick kilns on land use/land cover changes around Aligarh city, India. *Habitat International*, 29, 591–602.

[5] Jensen, R. & Peppard Jr, D. M. (2004). The traditional brickmaking industry and the rural economy of Vietnam. *Journal of Asian and African Studies*, 39 (3), 193–207.

[6] Tim Jones, (1995) Gate Technical Brief, Hoff-man kiln.

[7] Gerhard Merschmer, (2000), GATE Technical Brief, Firing of clay Bricks, http:/ www2.gtz.de/ Basin/ gate/ th13/ clay firing.

[8] NIFES (1993), Evaluation of continuous VSBK in china, overseas development Administration, London.

[9] G.F.C Roger and Y.R Mayhew (1995) Transport properties of fluid, 3rd edition. Research education association, mechanical engineering hand book (1999), discat way, New Jersey.

[10] B. Sengupta, Central Pollution Control Board, comprehensive industry document with emission standards, guidelines and stack height regulation for vertical shaft bricks kilns (VSBK), pollution regulation and pollution control measures, COINDS/71/2007, Website: www.cpcb.nic.in.

[11] Kelvin Mason؛ Kay Austin PAT Brif, (1998) Evolving a standard to compare Energy Efficient of Brick firing process.

[12] Ishaq, M., Khan, M. A., Jan, F. A. & Ahmad, I. (2010). Heavy metals in brick kiln located area using atomic absorption spectrophotometer: a case study

from the city of Peshawar, Pakistan. *Environmental Monitoring and Assessment*, 166, 409–420.

[13] Le, H. A. & Oanh, N. T. K. (2010). Integrated assessment of brick kiln emission impacts on air quality. Environmental monitoring and assessment, 171, 381–394.

[14] Abdalla A.Salam Ahmed, Ahmed Adam Ibrahim, Seif Eldeen Hamed, Samir Ibrahim Saad, (2005)Nile basin capacity building network, towards the improvement of the protection methods against bank erosion, NBCBN, river morphology research cluster, group II.

[15] Charles W. Schmidt, Focus, Modernizing Artisanal brick kilns a global need Environmental health perspectives, volume 121, number 8, 2013.

[16] El-Karouri, M. O. H. (1979). Effect of soil salinity on the productivity of arid lands, with special reference to the Sudan. In J. A. Mabbutt (Ed.), Proceedings of the Khartoum workshop on arid lands management.

[17] Davies, H. R. J. & Walsh, R. P. D. (1997). Historical changes in the flood hazard at Khartoum, Sudan: lessons and warnings for the future. Singapore Journal of Tropical Geography, 18 (2), 123—140.

[18] Bond TC, et al. Bounding the role of black carbon in the climate system: a scientific assessment. J Geophys Res Atmos 118(11):5380–5552 (2013); http://dx.doi.org/10.1002/jgrd.50171.

[19] Mubarak, A. R., Elshami, O. M. E. & Adam, A. E. (2010). Short-term effects of tillage on N mineralization from farm yard manure in semi-arid tropical vertisol. Research Journal of Agriculture and Biological Sciences, 6 (2), 157–160.

[20] Omer, A. M. & Fadalla, Y. (2003). Biogas energy technology in Sudan. Renewable Energy, 28, 499–507.

[21] Streets, D. G.&Waldhoff, S. T. (1999). Greenhouse-gas emissions from biofuel combustion in Asia. Energy, 24, 841–855.

[22] Tahir, S. N. A., Rafique, M. & Alaamer, A. S. (2010). Biomass fuel burning and its implications: deforestation and greenhouse gases emissions in Pakistan. Environmental Pollution, 158, 2490–2495.

[23] Thompson, J. L., Gebauer, L. & Buerkert, A. (2010). Fences in urban and peri-urban gardens of Khartoum, Sudan. Forests, Trees and livelihoods, 19, 379–391.

[24] Ahmad MN, et al. Hydrogen fluoride damage to vegetation from peri-urban brick kilns in Asia: a growing but unrecognised problem? Environ Pollut 162:319–324 (2012); http://dx.doi.org/10.1016/j.envpol.2011.11.017.