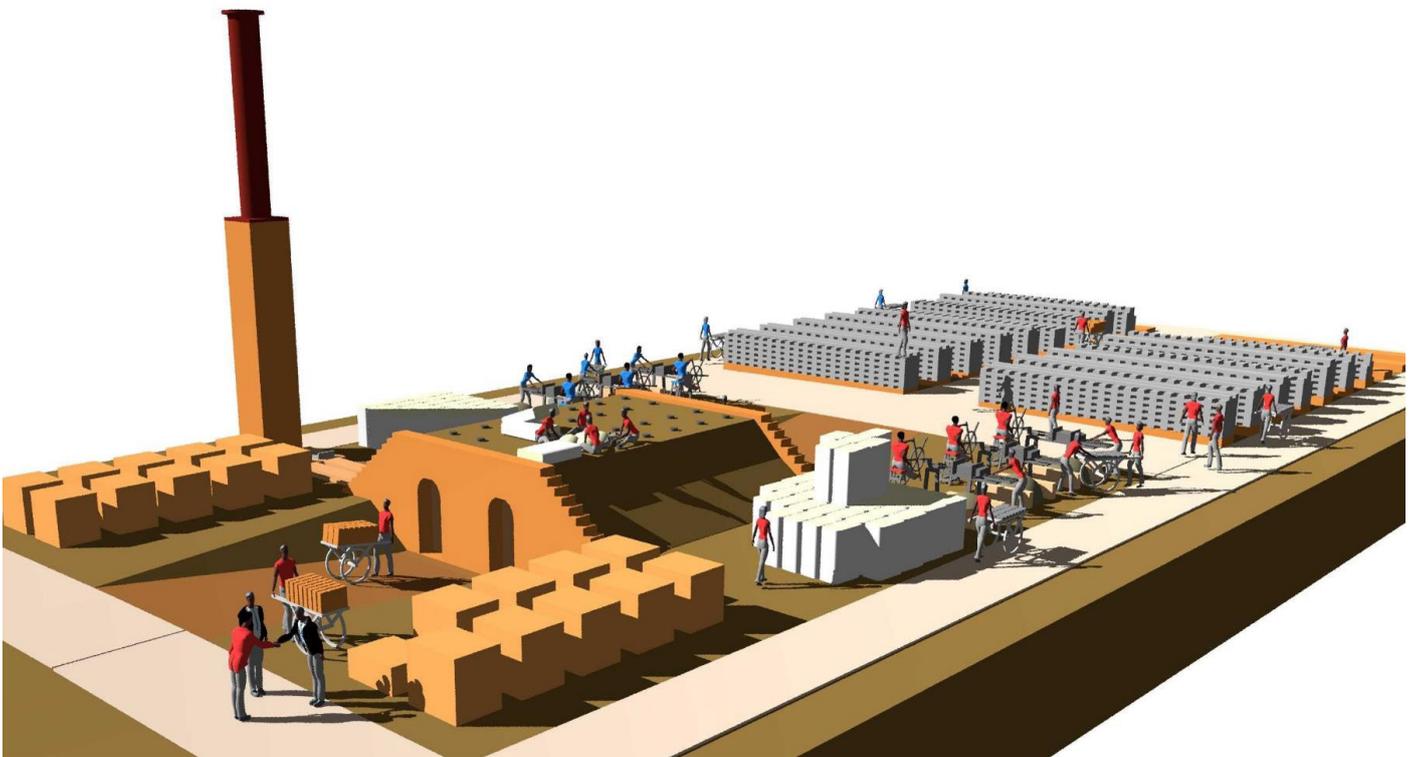


# SEMI INDUSTRIAL UNITS FOR LOW-CARBON CLAY BRICKS PRODUCTION

## OPERATIONAL MANUAL



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Agency for Development  
and Cooperation SDC

**skat** Swiss Resource Centre and  
Consultancies for Development

**PROECCO** **PRO**moting **E**mployment through  
**Climate** Responsive **CO**nstruction

# TABLE OF CONTENTS

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## INTRODUCTION AND BACKGROUND

1	PreFace	p 4
2	Author	p 5
3	Objectives	p 6
4	Flow chart on clay brick production	p 7
5	Production line installation	p 10

## PRODUCTION TEAM COMPOSITION

6	Production team composition	p 11
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## RAW MATERIAL

7	Introduction to raw material	p 14
8	Quarry prospecting and clay analysis	p 16
9	Excavation of clay at the clay quarry	p 19
10	Transfer the quarried clay to production unit	p 22
11	Stockpiling of clay at production unit	p 23
12	Quarry rehabilitation	p 24

## PRODUCT REALIZATION

13	Machinery requirement for semi mechanized zigzag kiln firing technology	p 25
14	Production records	p 30
15	Clay preparation	p 31
16	Crushing/Mixing/Moulding/Extrusion	p 32
17	Clay column cutting	p 33

## GREEN PRODUCT DRYING

18	Natural drying	p 34
19	Primary natural drying	p 35
20	Secondary natural drying	p 36
21	Sorting and recording green products	p 37

## FIRING

22	Zig-Zag kiln firing	p 38
23	Kiln loading	p 40
24	Kiln fuel	p 41
25	Kiln firing program and temperature control	p 42
26	Tools for firing monitoring	p 44
27	Initial firing description of zigzag kiln	p 45
28	Kiln unloading	p 49
29	Sorting/storage at finished goods yard	p 50

## MAINTENANCE

30	Machine maintenance	p 52
31	Kiln maintenance	p 53
32	Work safety issues	p 54

## QUALITY ASSURANCE AND QUALITY CONTROL

33	Quality plan	p 55
34	Process quality assurance and monitoring	p 56

## ANNEX

35	Model cases	p 59
36	Soil and finished product quality control	p 60
37	Maintenance	p 65
38	Forms	p 67

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## 1 Preface

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The clay brick industry is characterized by a multiplicity of raw materials and a plethora of products. Depending upon the investment capacity and financial strength of the enterprise, appropriate technology and marketing strategies would be employed for setting up a clay brick manufacturing operation.

The differentiation is made between:

- Start up small-scale technologies characterized by a large share of manual labour, few and simple machines
- Semi-industrial intermediate scale technology displaying a medium degree of mechanization with medium production capacity,
- Industrial Large scale technology with almost fully automated production facilities and enormous production capacities.

Zigzag is continuous type of kiln, with an average annual production of 3,000,000 to 9,000,000 bricks per year; its introduction to great lakes by PROECCO was done in its phase two after a blue print phase whereby its adaptation to local context proven that it would respond to existing modern bricks supply gap once scaled up. This would contribute to rapid urbanization observed in the region. This technology was firstly adopted by pioneers then by early adopters. The fact that this technology if properly optimized minimizes the environmental impact caused by brick making whereby its specific energy consumption ranges from 1 to 1.5 MJ/Kg while the traditional brick making ranges from 4 to 5 MJ/ kg makes it attractive for both private investors and public investment .

Additionally this technology creates 60-100 permanent direct jobs in its operation while its payback period ranges from 4 to 5 years.

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## 2 Author

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PROECCO (Promoting Employment through Climate Responsive Construction) is a project of The Swiss Cooperation Implemented by Skat Consulting ltd.

It supports the creation of descent jobs in starter, Semi-industrial and industrial brickyards. The people targeted by the project are the young laborers and innovative entrepreneurs willing to pioneer environment friendly modern production of bricks,tiles and slab blocks, as well as other actors of the supply chain who help to make modern brick walls and building affordable.

Skat Consulting is an owner-operated leading Swiss company specialising in international cooperation. It is dedicated to making available basic services and ensuring dignified living conditions and a healthy environment for all,its mission is to support governments, the private sector and civil society around the globe in improving people's lives by facilitating lasting solutions in water, building, energy and governance.

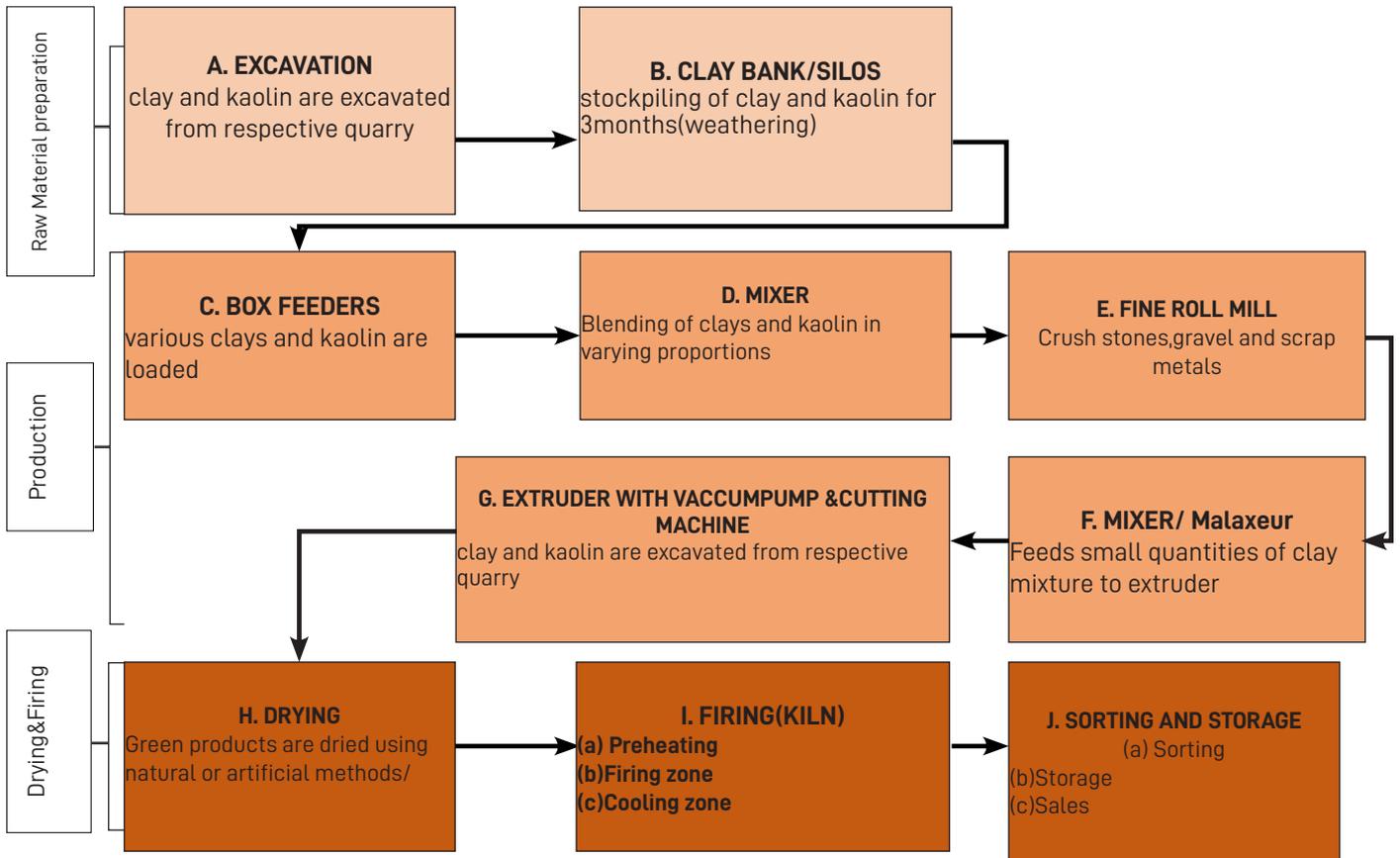
## 3 Objectives

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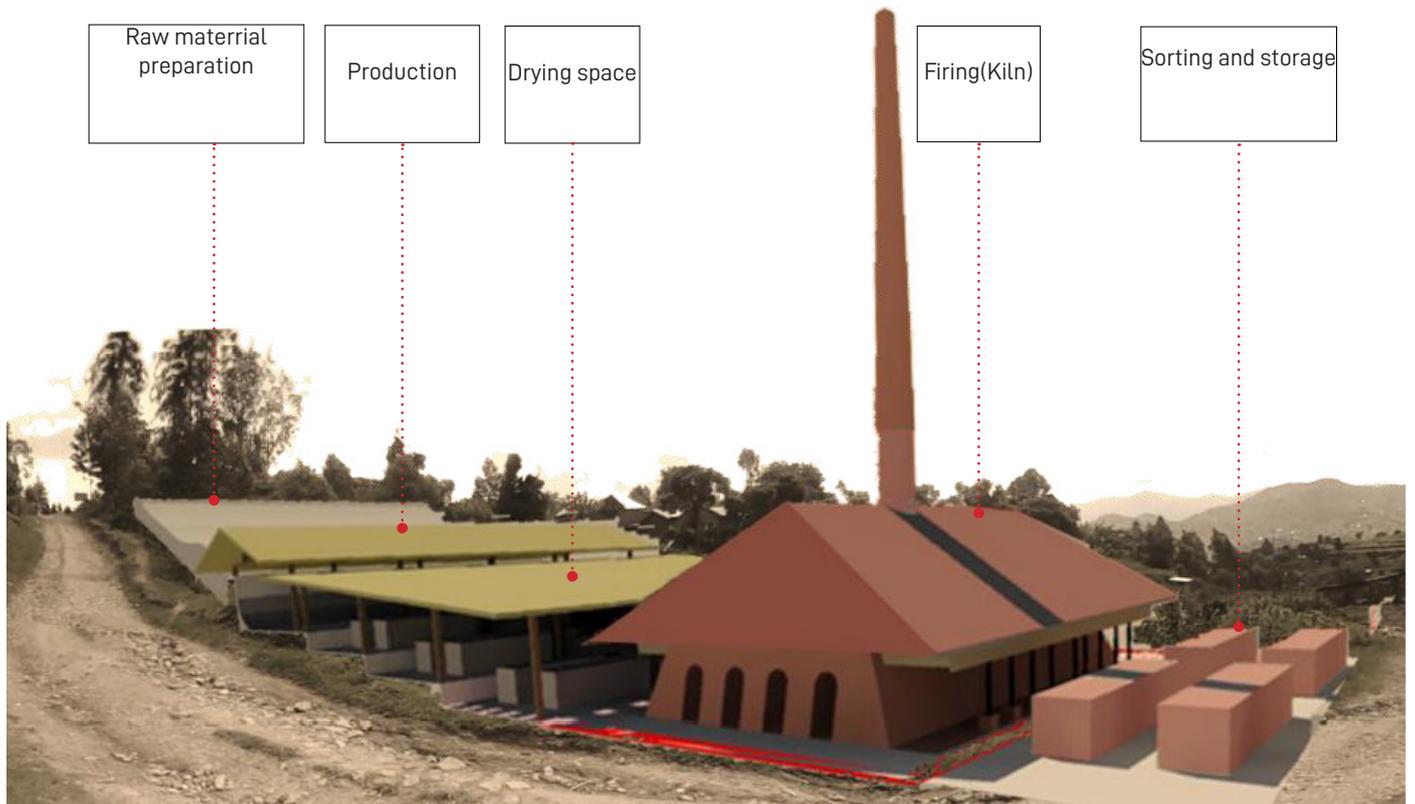
The primary objective of this guide is to enable the decision makers, Inspectors, brickyard designers, Investors and production managers to have a clear understanding on the requirements in the installation and operationalization of semi-industrial low carbon brickyards installed commercial purpose.

In this guide, we shall dwell only on zigzag kiln as a means of firing clay products with a permanent production setup. In addition to that we shall describe the investment and operation requirements for brickyards with Zigzag kiln of various sizes.

4 Flow chart on clay brick production

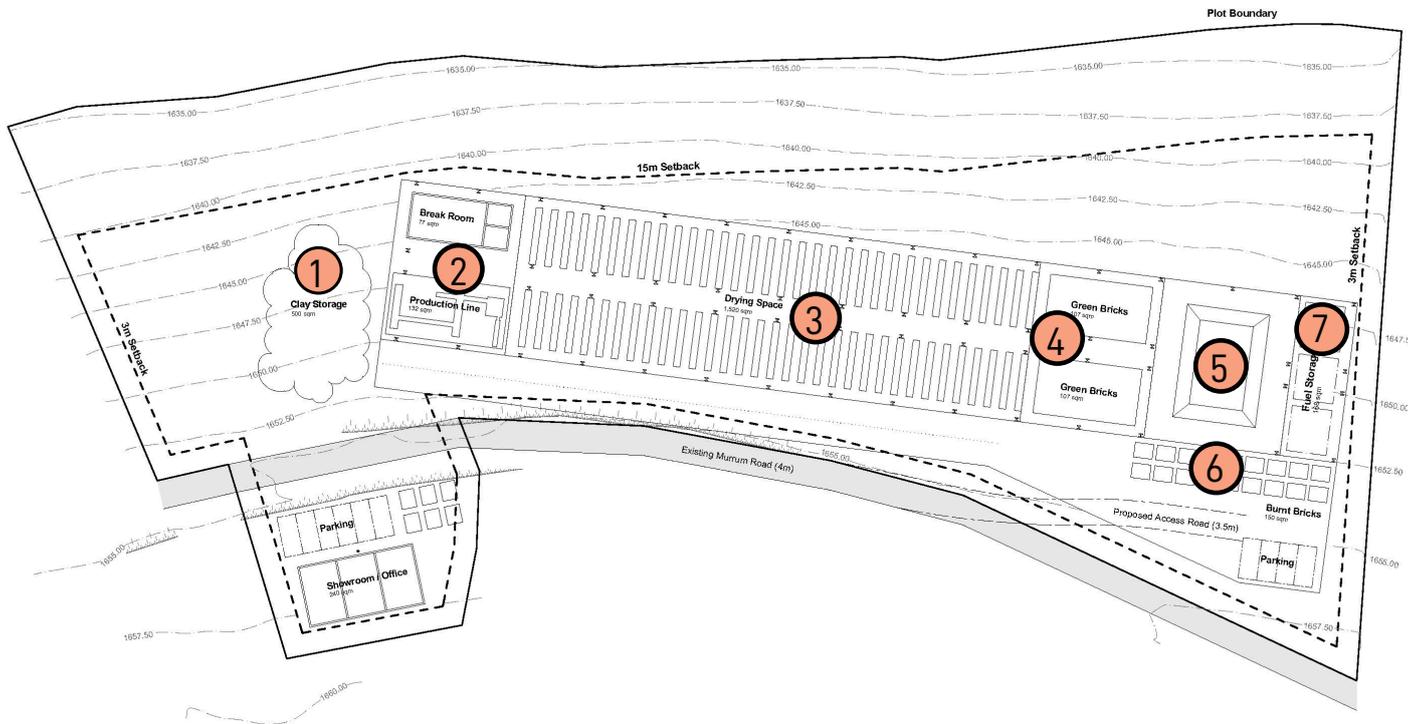


Flow chart on clay brick production



Clay brick production assimilation

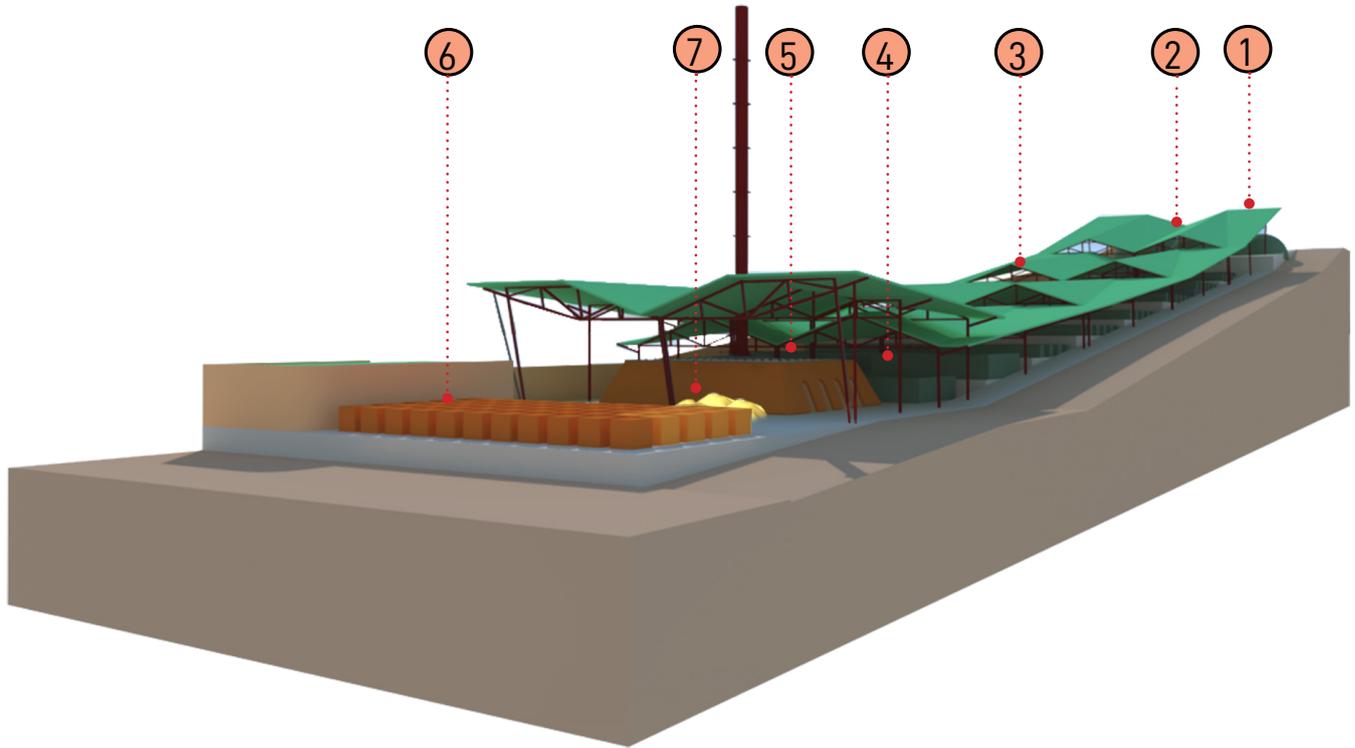
# INTRODUCTION AND BACKGROUND



## LAYOUT OPTIONS

### THE PRODUCTION SET-UP/LAYOUT

1. Extracted clay storage and weathering area
2. Bricks production area
3. Bricks drying area
4. Dried bricks stock
5. Kiln firing
6. Fired bricks storage area
7. Fuel storage



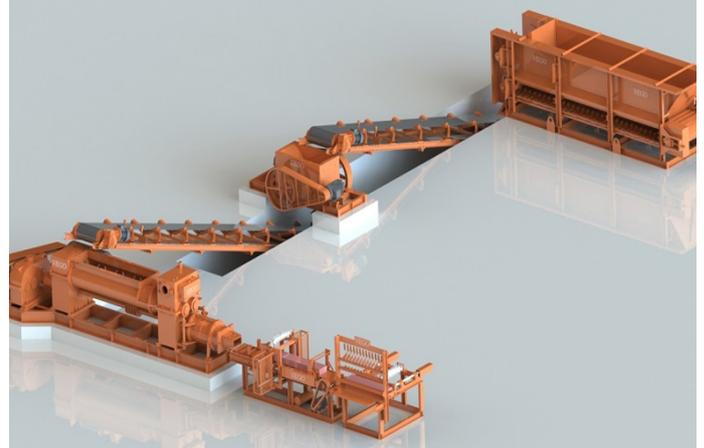
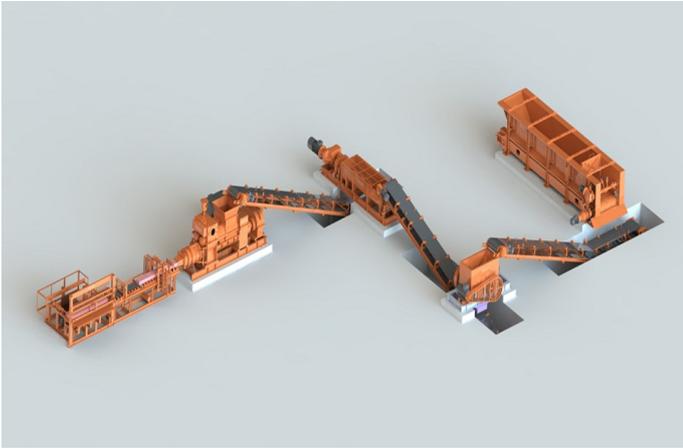
LAYOUT OPTIONS

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1. Extracted clay storage and weathering area
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# INTRODUCTION AND BACKGROUND

## 5 Production line installation



The clay bricks production line should be installed considering the effect of gravity on the production process, minimization of intervening human resource motions and safety of operators granted (non exposure to Moving belts, Mixing blades, Rollers, etc.).

## 6 Operation Team Composition

The operation of a semi-industrial brickyard unit requires a management team and a production team.

The management team deals with overall administration and finance of the brickyard, this includes but not limited to, sales, human resource management, marketing and planning for the future of the production unit.

The production team deals with overall production management starting from raw material to final product ready for sale.

The table below summarizes the Production team composition:

Job Category	Supervisory level	Related upskilled labor	Responsibilities / Role
Management	Maintenance technician / Foreman	2-3 Extruder operators by machine	<ul style="list-style-type: none"> <li>• Ensure the timely delivery of good quality clay at the site</li> <li>• Maintain production activity logs</li> <li>• Ensure good conditions of the machinery</li> <li>• Ensure the availability of competent machine operators and Kiln Fire Master</li> <li>• Monitor the drying process and ensure that the drying protocol is strictly followed</li> <li>• Ensure that the drying losses are reduced to the barest minimum (&lt; 5%).</li> <li>• Adhere to the kiln production schedule on a daily/ weekly/monthly/annual basis.</li> <li>• Strive for continuous improvements on the efficiency, consistency and productivity of the drying and kiln firing processes.</li> <li>• Manage and reconcile fuel used for the kiln firing, ensure that the kiln fuel received is of the desired quality level or else reject it.</li> <li>• Ensure that only quality products exit from the kiln to the construction site.</li> <li>• Coordinate the maintenance activities for both machines and kiln.</li> <li>• Ensure the optimization of existing infrastructure and human resources.</li> </ul>

## PRODUCTION TEAM COMPOSITION

Job Category	Job tittle	Qualification	Responsibilities / Role
Management	Production manager	<ul style="list-style-type: none"> <li>•Should have earned a technical diploma from a vocational institute, preferably in ceramics, though not necessary</li> <li>•Preferably from a ceramic industry background but not mandatory</li> <li>•Should have good robust health as working conditions are harsh</li> <li>•Preferably have knowledge of all phases of clay brick production</li> <li>•Must possess excellent interpersonal skills to facilitate positive working relationships with all levels of management and staff</li> <li>•Ability to respond decisively to emergencies</li> <li>•Ability to exercise sound judgment in problem solving</li> <li>•Knowledge of all relevant safety regulations and strong commitment to safety</li> <li>•Promote proper safety practices and accident prevention</li> <li>•Ability to effectively direct, motivate and coach the activities of others</li> <li>•Strong written/verbal communication, analytical, and mechanical skills</li> </ul>	<ul style="list-style-type: none"> <li>• Develop and implement the production plan or schedule.</li> <li>• Coordinate production activities, ensure compliance with the production schedule in accordance with the market demand.</li> <li>• Comply with the quality control standards during the production process, hence enabling the production of quality products.</li> <li>• Reconcile the product input and output to determine efficiency of production (losses).</li> <li>• Monitor and control the production cost to be within the set budget.</li> <li>• Provide support in the development of health and safety guidelines and ensure adherence to the set standards.</li> <li>• Manage production staff, determining the staffing levels, performance monitoring and training.</li> <li>• Prepare periodic reports on the production activities.</li> <li>• Have a respectful environment to work with subordinate staff / peer group and senior staff.</li> <li>• To train employees in all aspects of production process, clay quarrying, clay preparation, shaping and cutting, drying operation, kiln loading and unloading, kiln firing and kiln fuel management.</li> <li>• Must be hands-on, team oriented and committed to business improvement processes.</li> <li>• Other duties as assigned by the senior team.</li> </ul>

## PRODUCTION TEAM COMPOSITION

Job Category	Supervisory level	Related upskilled labor	Responsibilities/ Role
Technicians	Machinist	10-20 production line operators 1	<ul style="list-style-type: none"> <li>• Set up the machines to start a production cycle.</li> <li>• Ensuring the availability of needed raw materials to initiate the production activities according to requests from sales department</li> <li>• Fix issues that may impact quantity/quality during the shift.</li> <li>• Carry out routine maintenance.</li> <li>• Maintain a production activity logs.</li> <li>• Communicate with team members and support teams to ensure continuous production of high-quality products with minimal time material waste.</li> <li>• To ensure the presence of a clean and safe working environment in accordance with approved health and safety standards.</li> <li>• Be performance driven and accountable.</li> <li>• Must be hands-on, team oriented and committed.</li> </ul>
	Fire master	4-6 Fire master Helpers per shift of 8 hours	<ul style="list-style-type: none"> <li>• Monitor the drying process and ensure that only well dried bricks are loaded into the kiln.</li> <li>• Implement continuous improvements on the efficiency, consistency and productivity of the drying and kiln firing processes.</li> <li>• Manage and reconcile fuel used for the kiln firing, ensure that the kiln fuel received is of the desired quality level or <b>else reject it.</b></li> <li>• Maintain the firing activities logs.</li> <li>• Coordinate the kiln firing launch, firing process, cooling and unloading.</li> <li>• Coordinate the rotation schedule of fire master helpers, ( e.g: 6:00 AM-2:00 PM, 2:00 PM - 10:00 PM, 10:00 PM-6:00 AM)</li> <li>• Must be hands on, team oriented and committed.</li> </ul>

## 7 Introduction to raw material



Clay and Loam have been used for producing bricks for thousands of years, or rather from the beginning of time. The term "clay" or "loam" are usually applied to all very fine-grained, plastic raw materials, regardless of their origin, granulometric composition, mineral association and chemical constitution. It is precisely these varying attributes of the individual clayey materials that are responsible for the differences in their technical behaviors.

Clay and loam are products of rock weathering. Weathering, the severity of which depends on climate, vegetation and geographical situations, produces a weathering crust over all newly formed soil constituents – even though its distinctive features vary wildly throughout the world.

The clay characteristics must include plasticity, which actually permits the shaping or moulding when mixed with water; they must have enough air-dried strength to maintain their shape after shaping process.

Upon being shaped and dried, the shaped product is subjected to high temperature in a kiln, where transformation in the form of chemical bonding occurs, the resultant product is mechanically strong and product color is pleasing

### Types of Clay

Clays occurs primarily in three principal forms, all of which have similar chemical compositions but different physical characteristics.

**Surface Clays:** Surface clays may be the up thrusts of older deposits or of more recent sedimentary formations. As the name implies, they are found near the surface of the earth.

**Shales:** Shales are clays that have been subjected to high pressures until they have nearly hardened into slate.

**Fire Clays:** Fire clays are usually mined at deeper levels than other clays and have refractory qualities.

All three types of clay are composed of silica and alumina with varying amounts of metallic oxides. Metallic oxides act as fluxes promoting fusion of the particles at lower temperatures. Metallic oxides (particularly those of iron, magnesium and calcium) influence the colour of the fired brick. The clay brick manufacturer minimizes variations in chemical composition and physical properties by mixing clays from different sources and different locations in the pit. Chemical composition varies within the pit, and the differences are compensated for by varying manufacturing processes. As a result, brick from the same manufacturer will have slightly different properties in subsequent production runs. Further, brick from different manufacturers that have the same appearance may differ in other properties.

The grain size distribution has a decisive influence on the technological behaviour of clay materials for brickmaking. The finest grained fractions, being especially important. Contents of less than  $2\mu\text{m}$  in size ( $\mu = 0.001\text{mm}$ ) are generally termed the clay fraction. Those from  $2\mu\text{m}$  to  $63\mu\text{m}$  as the silty-clay fraction and those larger than  $63\mu\text{m}$  as the sand fraction.

The above described size grading of clays is very important, as it allows us to either use the clay or reject it outright.

Fine-grained clays often have high drying shrinkage that create problem during the clay brick manufacturing process. Over 25% fractions smaller than 2 $\mu$ m display drying sensitivity. It is also observed that very fine-grained carbonates also reduce the drying shrinkage.

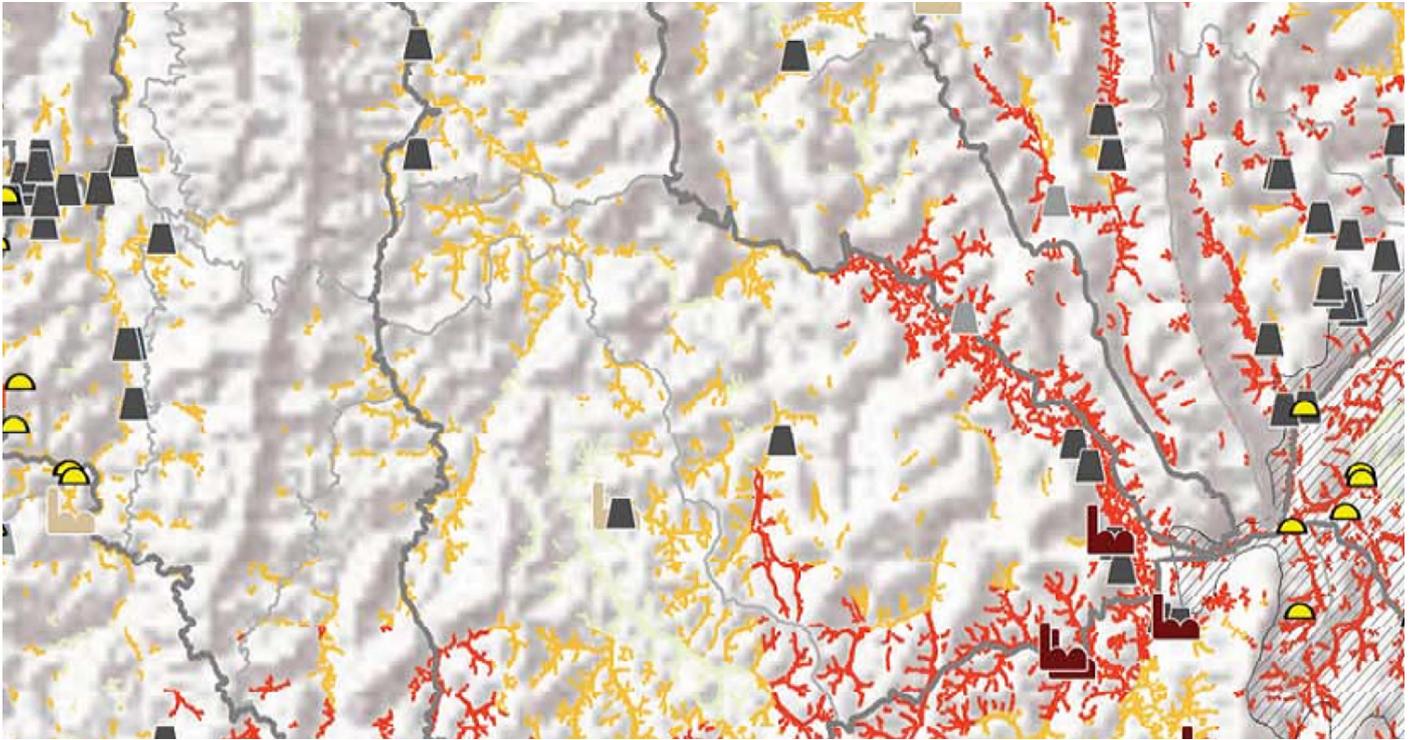
On account of the widespread availability of Kaolin within Rwanda and the great lakes region, it has become a popular replacement for sand in clay brick making process. Sand availability in Rwanda is scarce and thus expensive, while Kaolin is available across Rwanda particularly.

The advantage with using Kaolin is two-fold:

Firstly, it replaces sand. Sand is a coarse-grained product and thus abrades the metal parts of the machinery, reducing their useful life. Kaolin, on the other hand, has a greasy feel and does not abrade.

Secondly, Kaolin has a unique property, that it reduces drying time of freshly extruded products. This property is a big help especially in areas where green bricks are dried naturally.

8 Quarry Prospecting and Analysis



Map of clay potential zones in Rwanda



Soil sampling

Once the suitable site is selected according to the criteria indicated by the geologist, a series of tests will be run by the "Ceramic raw materials & products testing Laboratory", in order to ensure that the site will be economically viable. Quality and quantity of clay will be assessed so that there will be little risk for waste. The clay quality is expressed in terms of [percentage (%)] of clay, silt and sand, and in clay quantity [volume ( $m^3$ )].



*Soil sampling etiquette*



*Sieve analysis*

## **SOIL SAMPLING / Echantillonnage du sol:**

Observation to the changing of soil layers, type of soil, nearby basic infrastructure, landscape, collection of field coordinates. Then the team proceeds with the collection of samples to be brought to the laboratory. Soil samples are collected in basins according to their layers and depth. Each sample is labeled (name of site and the depth).

## **SIEVE ANALYSIS / Test de tamis:**

The sieve analysis concerns the particles larger than 0.08 mm of diameter, ranging from fine to coarse sand. It is useful to determine the distribution of the coarser, larger-sized particles

## **SEDIMENTOMETRIC SOIL TEST / Teste des sedimentometrie:**

A portion of the soil sample (specimen 1) is used for the sedimentometric soil analysis or hydrometer test that is needed to determine the distribution of the finer particles of the soil contents. This process is also known as Bottle Test, determining the proportion of clay and sand particles in the soil.



*Sedimentometric soil test*

## RAW MATERIAL



*Mini brick extrusion*



*Shrinkage test*



*Firing test*



*Different type of briquette after firing test*

### **SHRINKAGE TEST:**

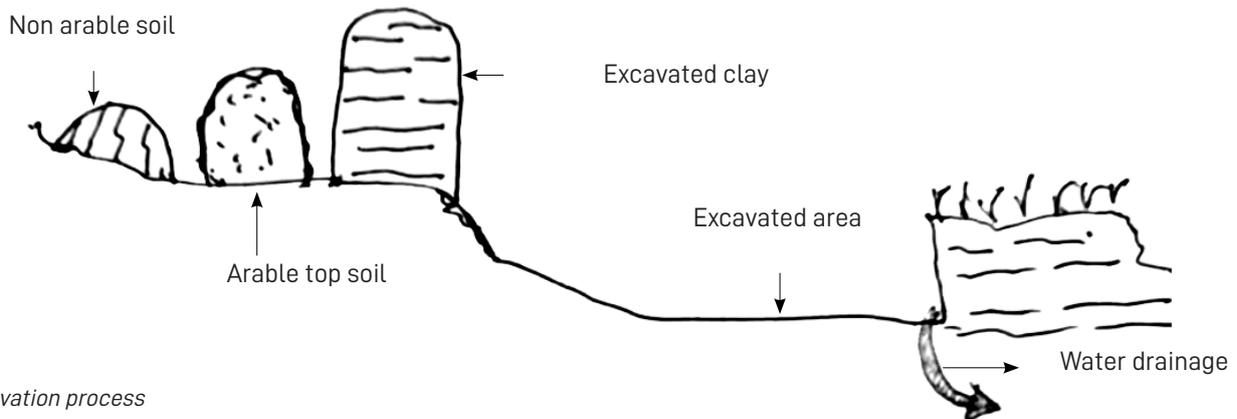
The other part of the soil sample (specimen 2) is moulded with a mini extruder to fabricate a briquette that will be used for the clay shrinkage test. The briquette is measured, then dried and measured with precision again.

Finally, after being fired in the kiln, the briquette is measured once again. The shrinkage test gives an idea on the brick dimension reduction during the drying and firing and helps to know the measurements of the mould to be fabricated.

### **FIRING TEST / Test de cuisson:**

The firing test gives an idea on the brick color, shrinkage rate of the clay and helps to determine the best firing temperature in the kiln.

## 9 Excavation of clay at the clay quarry



*Clay excavation process*

The job of clay excavation is best left to experts. It is best undertaken by a professional geologist. The evaluation begins, therefore, with correlation from borehole to borehole and the identification of stratification. Correlation is usually dependent on the results of the test work carried out on the exploration samples. A detailed description of the geological structure and quality variation can then be made and should include plans and profiles. From the information got, production planning and quality evaluation can be made.

Ownership of minerals varies greatly from country to country. In Rwanda, the owner of the mineral land has to engage with the Rwanda Environment Management Agency, better known by the acronym, REMA. REMA through partner agencies conducts an Environmental Impact Assessment (EIA) of the mineral land. EIA, is an important document that outlines the quarrying activities and how the land after complete excavation has to be restored.

A general overall site development plan has to be made in order to take into account all relevant factors, before any detailed work is started. This general plan should have:

**1.Location of mineral deposit:** From the exploration work carried out whilst searching for raw materials, it should be possible to fix reasonably accurately the extent of mineral deposit.

**2.Location of waste disposal sites:** Waste disposal should be planned in such a way as not to sterilize mineral. There are several examples to be found where this decade's mineral is buried under last decades' waste disposal. It is understandable that it is desirable to minimise the distance that overburden and waste material is carried, but short-term gain is usually at the cost of medium-term loss.

## RAW MATERIAL

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Excavator

**3. Transport access:** Transport costs will inevitably become a major part of the cost of finished goods, not only in terms of manufacturing costs, but also need to add the delivery cost to the customer. It is therefore very important that all modes of transport are considered.

**4. Energy Supply:** For a very large requirement of mineral, where the manufacturing plants are setup to produce 1000 tons of finished goods per day, then the clay quarrying activity too would be a large exercise. In such cases, it will be necessary to house staff on site. In such cases, source of power supply has to be ensured to provide lighting and water supply to residents.

**5. Drainage:** Generally, open-cast mining is resorted to in almost all clay quarries. As a result, the excavated clay leaves behind a huge pit, in which water could collect, especially in areas that receive high rainfall. Therefore, it is imperative that such clay quarries have good drainage system, so that clay quarrying activity can continue through the rainy season.

Because of the plastic nature of the clay, it becomes difficult for rubber-tired vehicles to drive in water laden areas.

It also becomes expensive as high-powered pumps are to be requisitioned to pump out water from the pit.



Manual excavation of clay

#### **6. Effect of local and residential and other industrial activities in proximity:**

Certain industries can be affected by the dusty environment, e.g., food and electronics industries. Residential complaints against dust and noise can often be minimised if care and consideration are given to these

#### **Drag-line Excavator/problems at the planning stage itself.**

The problems of noise are particularly difficult to estimate since their nuisance is often mitigated or increased by the surrounding environment. In rural residential areas, the mining agency could provide relief to the residents by providing good roads, establishing a school for children of the area, a primary health centre as a community development program.

**7. Environmental Issues:** After the clay is exhausted from the mining area, the mined area must be restored by way of filling up the mined area and making it suitable for agriculture.

#### **Methods of Extraction:**

**a. Manual Digging:** This is the most popular means of extracting clay. It is cheap but laborious, yield is less, as the activity depends on human labour.

**b. Mechanical Extraction:** It could be by blasting or using extraction equipment. Blasting is a rare occurrence for clay extraction but cannot be ruled out. Extraction equipment will include:

Drag-line Excavator, Bulldozer, Wheel Loader, and Excavator.

### 10 Transfer the quarried clay to the production unit



Clay loading activities

The quarried clay needs to be transported to the Factory for processing.

The cheapest way is to engage labour to carry bucketful of clay on their head and walk to the factory with the load. This can happen if the clay quarry and the factory are within less than a kilometre apart.

As the distance between the two stations increase, then there is need to use mechanized ways to transfer the quarried clay. The most preferred way is to load the quarried clay onto Dump Trucks, which upon reaching the factory, drops the clay at the designated spot.

Other means of transportation will depend largely on the distance between quarry and the factory. If the distance is very large, then rail wagons too could be used or by road vehicles.

Water based transport too could be used, if such a facility exists at both ends, at quarry and at factory too.

## 11 Stockpiling of clay at production unit



*Removing the foreign material such as roots*



*Clay storage*

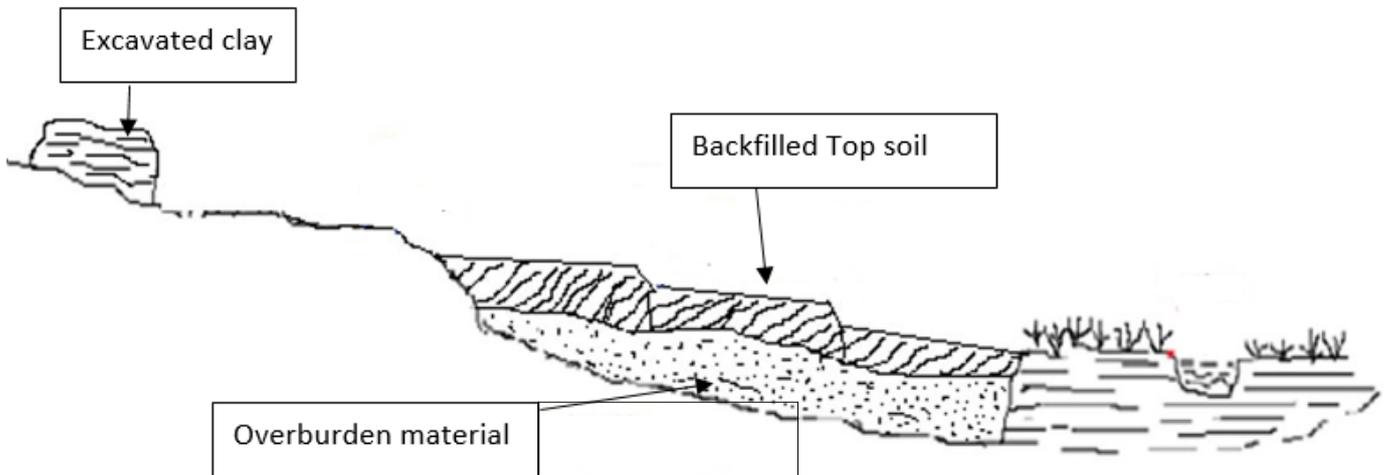
The most common types of raw materials storage depend largely on the production capacity of the plant. However, the popular methods of storage are listed below:

- Open-air storage
- Storage Sheds
- Large Volume feeders
- Tempering, ageing and souring silos
- Dry material silos

Each clay delivery received at the factory is dropped off at the clay stocking site. With several such clay droppings, the clay stockpiling gets stratified into layers. The best way to use the clay is to pick from different areas of the strata. This gives a sense of blending of the different areas and homogenized clay is available for processing. In an ideal condition, the clay would need to be tumbled, so that fresh surface is exposed, and then watered. With such tumbling and subsequent watering, the clay will develop improved plasticity.

The required storage capacity of the clay will depend on the production capacity of the brickwork. Normally, a minimum of one month's clay stock should always be present at the Brickwork. With regular watering of the clay stockpile, the clay lumps loosen up and develop plasticity. This is very important for good shaping of bricks at the Extruder.

## 12 Quarry rehabilitation



Quarry rehabilitation process



Rehabilitated quarry under use for rice agriculture

The Mining and Quarrying Code of practice (RS 566:2011) stipulates that all sites excavated for mining purposes should be rehabilitated once the mining activities are completed. Even if it is not easy to restore to its previous condition, the objective of the clay quarry rehabilitation is to convert the post-clay extraction landscapes into attractive areas depending on the modified ecological conditions. The quarry rehabilitation is necessary to allow future use of the extracted areas in agreement with the District authorities and local communities and in compliance with the local land-use plan.

The rehabilitation process happens in two steps: Reclamation and Recultivation.

13 Machinery requirement for semi mechanized zigzag kiln firing technology



*Box Feeder with Rubber Belt Bottom Used in Clay Brick Industry*



*Box Feeder with Metal Slat Bottom Used in Clay Brick Industry*

**Box Feeders are for storage of unprocessed clay.**

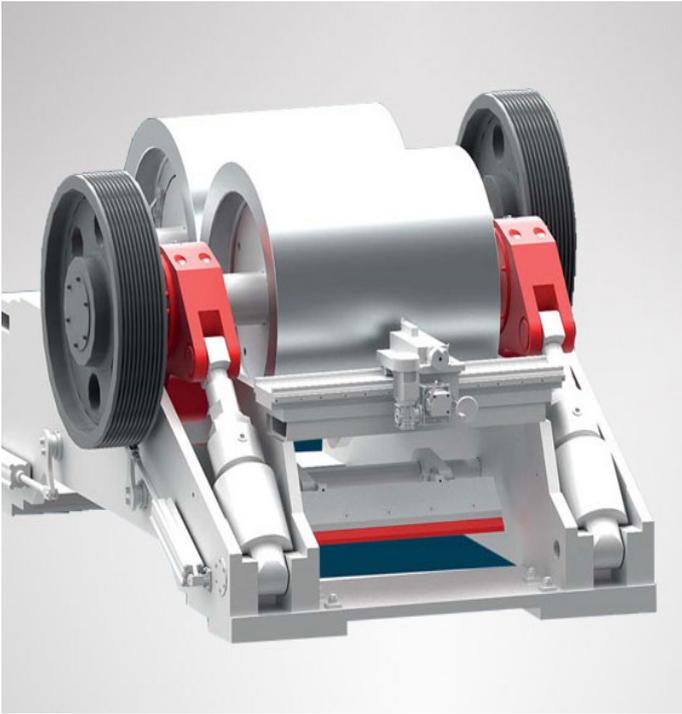
Box Feeders are rectangular boxes of appropriate size, with a drive motor, designed for even, continuous and controlled dosing and storage of clay or kaolin. Slat feeders are mainly used for handling wet material while rubber belt feeders are suitable for dry and dusty material. At the material drop end, there is a clod breaker, consisting of a series of clods mounted on a shaft, driven by a separate motor, which breaks the big clay lumps into smaller lumps as it falls off from the Box Feeder onto the next belt conveyor.

There is a spring-loaded scraper mounted on the belt / slat to remove any material sticking to it.

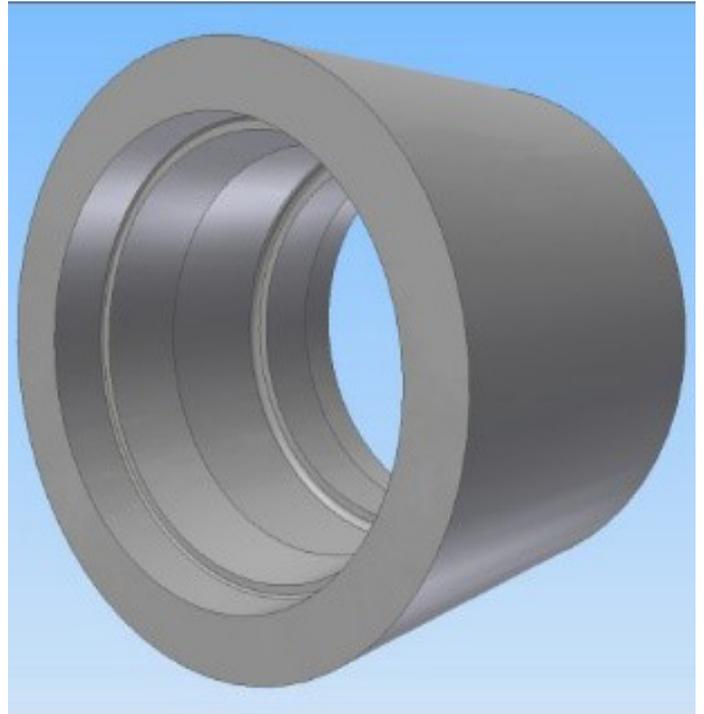
The task of mixing different types of clay in appropriate proportions can be achieved by using two or more box feeders. The box feeder also serves as a buffer and temporary storage to avoid unnecessary interruptions.

Box Feeders come in different capacities of output /hr, which can range from 1 ton to 100+ tons/hr. The drive motor may range from 7.5 to 22 kW. The Box Feeder capacity could range from 1 ton to 200 tons. These parameters solely depend on the production capacity of the clay brick plant.

## PRODUCT REALIZATION / REALISATION DU PRODUIT



Fine Roller Mill



View of Roller Shell

Roller Mill consists of two rolls mounted on horizontal spindles carried on bearings on a heavy cast iron frame. The shale, kaolin, and clay particles are broken down between the rolls by pressure. The rolls move in opposite direction. The two rolls have different rotational speed, the difference being 10% of the other.

The granules of hard materials such as shale, kaolin, sand and clay contained in the raw material are crushed down to sizes less than 1 mm by a fine roller mill. This fine grinding process is vital for quality control. It helps to eliminate surface cracks caused by the differential thermal stress between particles and the clay body, thus improving the surface smoothness of the finished products.

Roller Mills come in different capacities conforming to production output of a clay brick plant. The shell width could range from 500mm to 1200 mm, while the diameter could be from 450mm to 1200mm.

One of the main problems faced by Brickworks is there is heavy erosion of metal from the centre of the shell. This occurs as the clay feed is directed towards the centre of the shell, rather than spreading it across the width of the shell. This aspect needs to be taken care of seriously by Brickwork owners, else, the clay feed will just pass through without any grinding action.

A pair of spring-loaded scrapers mounted on the roller frame help to remove any material sticking to the rollers.



*View of the Paddles inside the Double-Shaft Mixer*



*Top View of the Double Shaft Mixer*

Double-shaft Mixer has two shafts fitted with flat blades, all inclined in the same direction running in a double "U" shaped trough. The adjustable blades lift and cascade the material over itself giving the mixing action and propel it along to the discharge end.

Normally positioned just prior to the Extruder in the plant layout for mixing clay and kaolin with water being sprayed into the trough to increase the moisture content of the clay mix to make it a homogeneous mass and compatible for smooth extrusion.

The capacities of Double-shaft Mixer vary from small to large and are designed to match clay brick production capacities of brick plants.

The variation ranges from 2135x585 mm trough size to 3735x1300mm, and the corresponding output 8-10 tons/ hr to 70-100 tons/hr, and power requirement from 11kW to 75 kW.

# PRODUCT REALIZATION

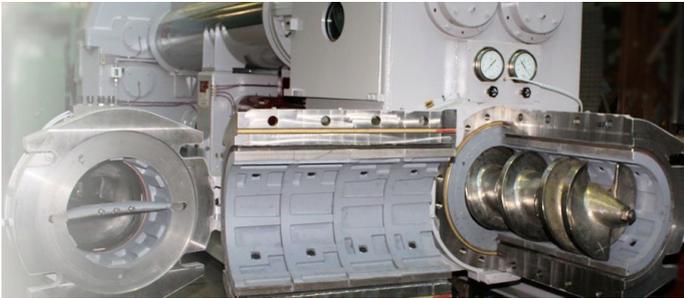
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*Single Stage Extruder without Vacuum Chamber*



*Two Stage Extruder with Vacuum Chamber*



*Extruder Barrel opened to show the augers*

De-airing extrusion is used in most modern brick making. Basically, the extrusion process involves forcing of clay along a cylinder by means of augering action through a mould to form a rectangular column of given cross-section.

Sometimes, the clay is forced through a die to form perforated column.

The extrusion process can be classified into three major types according to the moisture content of clay - soft extrusion for 25-30%, semi-stiff extrusion for 20-25% and stiff extrusion for 15-20% of moisture content.

The choice of right type of extrusion, therefore, depends on the moisture content and plasticity of the raw material used. A modern extruding machine usually consists of a single/double-shaft pug sealer, a de-airing chamber and an auger extruder. The refined clay from the double shaft mixer is fed into the mixer / pug sealer before entering the de-airing chamber. In the de-airing chamber, the air trapped in the clay is removed (the de-aeration process).



*Slug Cutter aka Primary Cutter*



*Multi Wire Cutter*

As the extruded clay column exits the die mouth, it meets with the Primary Cutter. The job of Primary Cutter is to cut measured lengths of the column, also called as "slug". The column or slug cutter measures and cuts the clay column to a fixed length by a high tensile wire attached to a transverse cutting arm moving along with a horizontal frame carrying the clay column. The cut length can be adjusted mechanically. The Primary Cutter could be manual or mechanized. For large production units, a mechanized Cutter will do duty. Manual Primary Cutter will not be able to match up with the speed of the cutting action required.

The slug travels on a series of rollers towards the Multi- Wire Cutter. The Multi-Wire brick cutting machine is uniquely designed for high capacity and flexibility. The cut clay column is fed into the multi-cutter via oil resistant belt conveyors and force through parallel wires by a mechanical pusher arm driven by heavy-duty gear motor. The cutting wires are high tensile and exceedingly wear resistant. The wires are held in place by pneumatic tensioning devices which are uniquely designed to ensure wires holding in constant tension and to facilitate replacement of broken wire and adjustment of wire positions.

Bricks can be accurately cut into required sizes leaving minimum amount of waste clay. The bricks can be chamfered on edges by roller blades. The wire cutting frame can be conveniently changed for cutting different product sizes.

## 14 Production records



Production recording



Temperature recording

At the beginning of every month the sales manager shall forward to the Operations Manager a list of products on demand based on Standing Orders.

The Product Order Form shall be used for new products under trial. The Procedure "Product Design and Development" shall be followed.

A Weekly Production Program shall be drafted based on the above and it's then forwarded to the Production Machine Operators for execution. A copy of the Production Program shall be issued to the sales manager.

Production recording is a requirement in order to monitor the productivity and take timely action.

The recorded data are the basis of any improvement recommendations on productivity, quality, costing and maintenance.

Below is the list of records that should be kept:

1. Green bricks production per each machine
2. Involved labor per production on daily basis
3. Drying progress daily
4. Kiln loading data
5. Firing data (fuel consumption, temperature recording, no. of workers)
6. Unloading data (bricks grading)

15 Clay Preparation



*Crushed and mixed raw material entering the extruder*



*Brick column during extrusions and moulding*

According to the product on schedule, the right mold must be mounted onto the extruder barrel/mouth.

In case of manual extrusion, a well-prepared is compacted into the box and then the box is closed and locked. Maximization of the extrusion process must be considered by ensuring that the drying space is availed at the right time to receive freshly extruded products.

The proper working parameters of the moulds (dimensions, weight, squareness etc.) shall be inspected and tested by the operators Foreman once a day.

Good handling practice shall be emphasized at this stage to avoid dents, scratches as well as deformation. Orderly arrangement of the products in the dryers shall be ensured with due regard for effective drying.

### 16 Crushing/Mixing/Moulding/Extrusion



*Crushed and mixed raw material entering the extruder*



*Brick column during extrusions and moulding*

According to the product on schedule, the right mold must be mounted onto the extruder barrel/mouth.

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17 Clay column cutting



*Clay column cutting*



*Direct handling from the cutting table*

As the extruded clay column exits the die mouth, it is cut into fixed measured bricks dimensions by a high tensile wire, fixed to a swinging frame. The cut dimensions are adjusted mechanically.

The wire cutting dimensions and angles shall be set to give the expected plastic sizes and shapes with reference being made to the dimensions list provided by the lab.

## 18 Natural Drying



*Green product drying (first stage on the left and second stage on the right)*

The extruded clay bricks are laid out on the drying area in stacks. In this phase the clay must lose all its moisture content through evaporation to the air.

In most cases, the freshly extruded clay brick would be having a moisture content of 19-22 %. After this process, the moisture content is brought down to 2%, before the product can be loaded into the kiln for firing. The intervening time is the Drying Time.

Clay bricks are exposed to the danger of cracking or deformation, if dried too rapidly. The process of evaporation causes differences in moisture concentration within the brick and because clay shrinks to varying degree as water evaporates, stresses arise within the green product. The magnitude and effects of these stresses on the green product depend on the shape and on the plastic properties of the clay, as well as on the geometrical form of the product and the operating conditions during the drying process. The freshly, moulded product may acquire stresses during shaping in addition to those occurring during subsequent drying and thus increase the risk of drying failure.

## 19 Primary natural drying



*Vertical primary drying*

The bricks coming straight from the extruder are transferred to a drying shed and piled together for a period of 3-5 days depending on the weather conditions. The bricks are piled by rows in case of horizontal drying, otherwise, they are laid on wooden boards and stacked on shelves after being cut, according to the capabilities of the production facility.

## 20 Secondary natural drying



*Circular piling during secondary drying*



*Rectangular piling during secondary drying*

Bricks from the primary drying phase are now piled in 6-10 layers high. The bricks are now more resistant and can withstand the load of more bricks stacked on top of each other. This may be done in rectangular or circular shapes. This operation allows the bricks to be exposed to air circulation, facilitating the moisture evaporation and speed up the drying process.

21 Sorting and recording green products



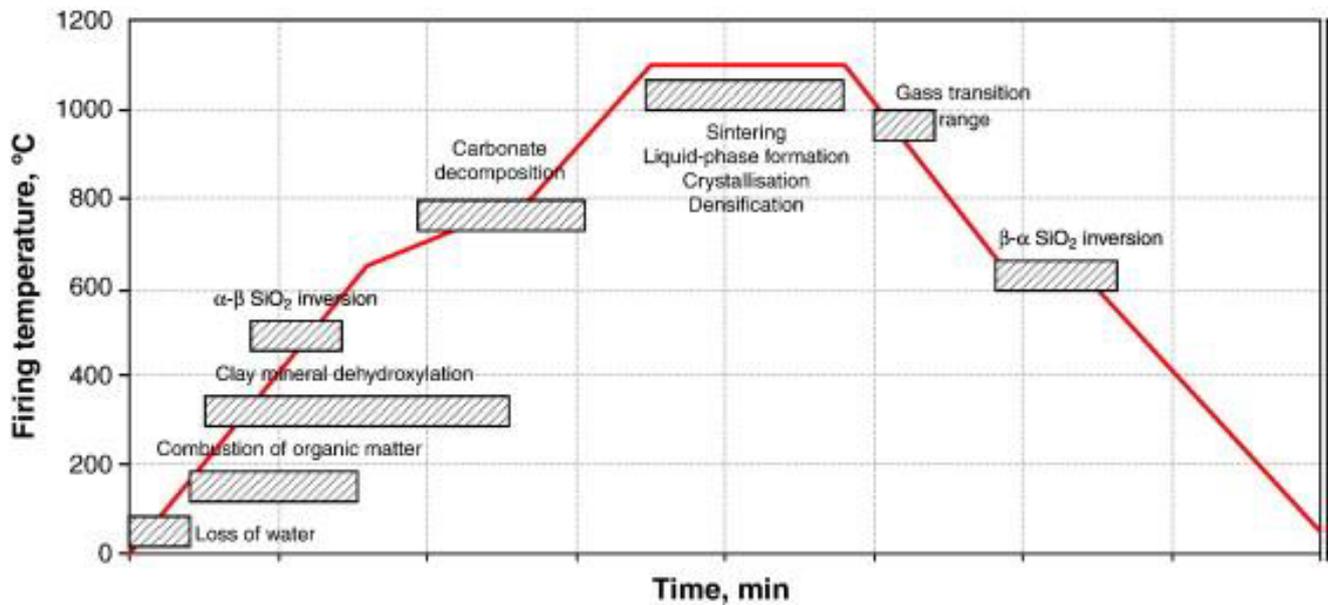
*Drying loss*



*Counting ,sorting and recording*

The Kiln Loading form is filled with the recorded quantities of products loaded as well as with the non- conformities, which at this stage are referred to as drying breakages. These are counted and sent back to the clay silo for recycling.

## 22 Zig-Zag Kiln Firing



Kiln firing diagram

Firing is the final ceramic engineering process by which the product gains mechanical strength, colour, insoluble in water and resistant to a majority of chemical attacks.

The firing behaviour of clay brick bodies depends on the composition of the body, firing temperature, maturing temperature, firing shrinkage, grain size distribution, chemical composition and structure of the clay.

The first activity of clay brick firing occurs at around 100°C, when the residual water in the ceramic body evaporates off. At 150°-200°C, the organic matter burns off. Then, between 400°-600°C, the chemically held water, or water of crystallization is released.

In the temperature range of 900°C, the carbonates decompose. At the maturing temperature, different for different clays, the sintering action happens, when the densification of the product occurs.



## 23 Kiln loading



*Fish bone pattern loading*

Filling the chamber with dried bricks: Each day, possibly seven days a week, one to two chambers are loaded and the same number of loaded chambers are unloaded. The loading of the chambers is done by workers in alternating shifts.

On hot days, they can include the worker delivering the green bricks in their alternation. Since there is no sufficient space for side loading, front-loading tricycle barrows are used inside the chambers.

For a typical 8-chamber Zig Zag Kiln, every chamber can be loaded with approximately 5000-5500 bricks (210x100x55mm of 1.4kg each or 220x105x55 of 1.5kg).

The setting of the bricks inside the chamber is done according to the fishbone principle. To allow air flow for the smoke gas, the lowest two layers of bricks must be crisscrossed by passages. The bricks are usually set at 25 mm ( $\pm 10$ mm) to each other.

For the dried bricks to be introduced, the residual moisture content must be less than 2%. The kiln operator must be informed if the residual moisture is high, to slowly increase the preheating temperature. Too wet bricks inside kiln will lead to shattering of bricks as moisture withdrawal is just too rapid.

## 24 Kiln fuel



Fuel stock at the site

The fire master Foreman shall inform the Production Manager to buy stocks of fuel by raising a purchase request. At reception, the fuel shall be inspected by a team of two people. These will make sure that the quality and quantity of fuel are met.

The firemaster Foreman has to constantly monitor the fuel stock levels, and when the stock goes low a report shall be filed and a new purchase request issued.

The Production Manager shall then follow the procedure to acquire more stock.

## 25 Kiln firing program and temperature control



*Kiln fuel top feeding*



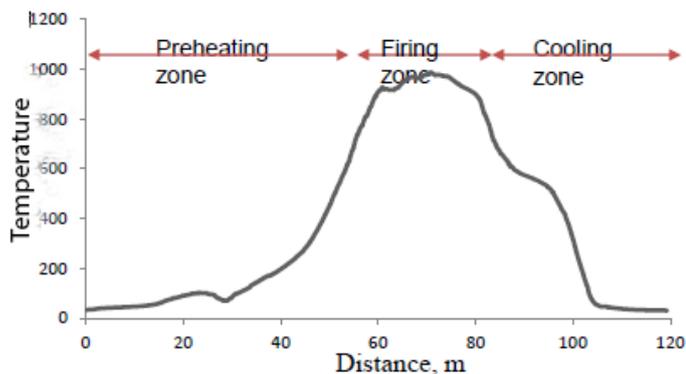
*Zigzag kiln valves*

In a Zig-Zag kiln, fuel is fed into the firing holes by group of firemen. A fireman would collect the solid fuel in his/her fist and drop into the firing hole.

The fireman starts feeding the chamber from one end and goes across the entire width to feed all the Firing Holes till he/she reaches the other end.

Typically, in 24 hours, one chamber would be fired.

Temperature recording in a kiln, such as the temperatures of hot gases in the flue ducts and the chimney, kiln outer walls and final products, are necessary to locate undesired heat losses in the kiln. Reducing undesired heat losses in the kiln reduces consumption and wastage of solid fuel, improves the quantity of good quality bricks, and increases revenue. Measurement of temperature of bricks in the firing zone is necessary for proper controlling and monitoring of kiln operation.



Kiln firing diagram



Firing curve monitoring

color	approximate temperature °C
faint red	500
blood red	580
dark cherry	635
medium cherry	0690
cherry	0745
bright cherry	0790
salmon	0845
dark orange	0890
orange	0940
lemon	1000
light yellow	1080
white	1205

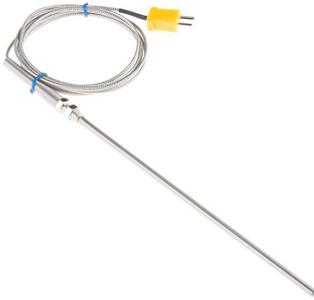
Kiln firing color chart



Firing temperature monitoring using a temperature gun

The temperature control during firing is a requirement in order to produce good quality products. This is done using a digital aid/or a manual thermometer or temperature gun, kiln firing thermocouples and a digital displayer. It is recommended to record the temperature variations at every hour; this enables proper monitoring of any defect related to firing temperature instability.

## 26 Tools for firing monitoring



*K Type Thermocouple*



*Digital displayer*



*Thermometer gun*



*Chimney thermometer*

**K-Type thermocouple** is best suited for this temperature measurement. It is inexpensive and easily available with thermocouple suppliers.

The **thermocouple probe** of sufficient length is inserted deep into the firing zone from the fuel feeding holes in the kiln roof so that it just about touches the hot brick surface to be measured. The indicator attached at the other end will give the temperature of the hot surface. Should allow the thermocouple to stay in that position for at least 3 minutes to absorb the heat and indicate the correct temperature.

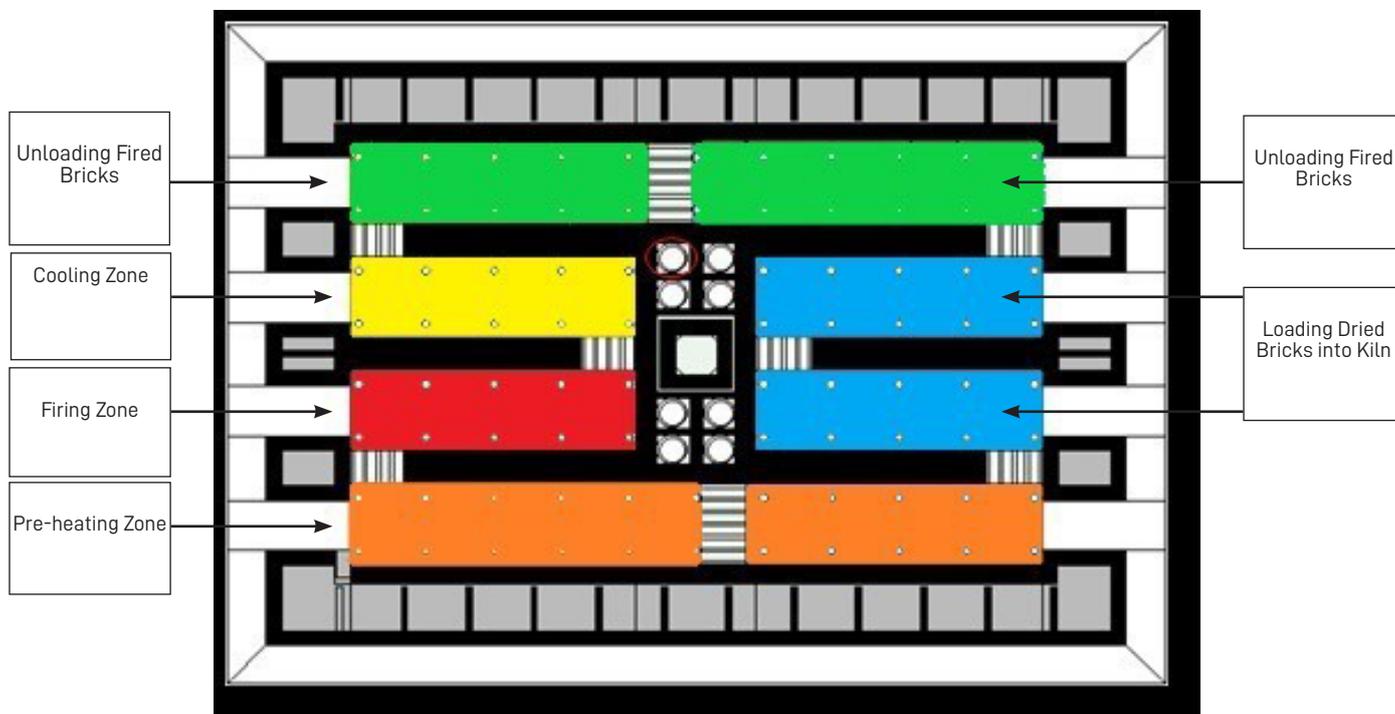
It is a hand-held, lightweight and easy to use thermometer which is used to measure the temperature of hot, hazardous and hard-to-reach surfaces in the kiln. They have faster response time and high accuracy. This instrument can be used only to measure the temperature of a surface.

For NDZKs, the smoke gas temperature in flue ducts of chimney

should be around 80°C to 150°C to create sufficient draft to operate the kiln; temperatures higher than 150°C, results in undesired heat losses via flue gases and also causes damage to the metal shell of the chimney. The commonly used gauges are of the type mercury filled temperature gauges and bimetallic temperature gauges.

If the smoke gas gets too hot, the closest smoke gas valve needs to be reduced or totally closed. For a possibly necessary quick solution, the smoke gas valve in an empty chamber can be opened accordingly.

## 27 Initial firing description of zigzag kiln



A cross-sectional view of Zig-Zag Kiln

### •1st day of the firing process

After the stacking in the cross-connections is completed, a sealing paper is attached. Before setting this paper, the closest Smoke Gas Valve will be opened to 50%, to allow the paper to be pulled and held in position.

Afterwards, the valve is reset to approx. 25-30%, to achieve a slow preheating of the bricks. If the preheating is too fast, the bricks can develop cracks or spalling. This also depends on the state of drying of the bricks loaded in this chamber.

The Smoke Gas Valve is further opened in steps every 4 hours.

When a preheat temperature of 200/250 ° C in this chamber is reached, preheating of the next loaded chamber starts. The preheating is carried out with the smoke gas, which is drawn by means of the chimney.

### •2nd day of the firing process

This newly filled chamber is sealed with paper as before, and is to be handled as described under day 1. Then the paper of the previous chamber is burned with a torch from above.

The 2nd chamber is also preheated from 50 ° C to 200/250 ° C. The chamber from the first day is then heated from 200/250 ° C to 550/600 ° C, again with the smoke gas. The smoke gas valve from

the second day remains open until the start of the chamber on the third day.

### •3rd day of the firing process

The 3rd chamber is filled and put into operation as described under Day 1.

The smoke gas valve from the first chamber is closed before the start of the third chamber.

The chamber of the first day is heated with fuel to 900°C (or to the predetermined set point temperature). The 2nd chamber is heated as described above.

### •4th day of the firing process

On the 4th day, the 4th chamber is filled (as on Day 1).

### •5th day of the firing process One more chamber is filled.

The process is repeated as described above (each step is shifted by one chamber).

The 1st chamber is cooled from 900/850°C to 550/500°C.

### •6th day of the firing process

The process of the previous chamber is repeated but shifted forward by one chamber.

The 1st chamber is cooled from 500/550°C to 100/50°C.

The smoke gas valve is opened approximately 25% to support the cooling of the bricks.

Furthermore, the covers of the firing holes are removed to obtain a further cooling of the bricks. These covers are not replaced until the chamber is filled again.

# FIRING

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## •7th day of the firing process

The bricks are unloaded from the 1st chamber.

The quality is then checked, sorted and then transported to Finished Goods Yard to be stacked there accordingly.

The 1st chamber is continuously heated with fuel (to 900°C or the pre-determined set point temperature) by the end of the 4th day. The 2nd chamber is heated as described under day 3. The 3rd chamber is preheated as described under day 2.

It is necessary to check and document the faults which are present and how they must be improved (regarding material mixing, shaping, drying, loading of the chambers, preheating and firing temperature). After unloading a chamber, it must be checked that the smoke gas openings have been cleaned with the duct connection.

Case study on Valve adjustment/ Setting during ZZK firing during 24 hours

Assumption:

- Three first chambers are loaded with dried bricks,
- The chamber two has reached the preheating temperature of 550-600o C due to its connection with chamber which is being fired using fire wood in the temporary fire box
- The chamber two reached the preheating temperature of 550-600o C at 1:00 PM

## Here is the procedure of:

- In this context the valve1 was previously set at 50% (30 cm outer height of screw shaft) to allow the paper between chamber 2 and 3 to be pulled and held in position.

## AT 1:00 PM the following are to be done

- Open valve 3 to position 1/3, close valve 2 to position 2/3,
- Burn the paper between chamber 2 and 3 using a torch from above,
- Starting feeding row 3 with sawdust lifting the temperature by 30degrees per hour until 950 keep firing firewood until the next day in the morning around 5:00 AM.
- Keep loading the forth chamber
- Firing degrees are reached approximately at 01:00am. At 5:00 PM the following are done
- Open valve 3 to the position 2/3 (40 cm outer height of screw shaft) and close the valve 2 to the position of 1/3 (20 cm outer height of the shaft)
- Shift one row forward (row 4) with top feeding (note that the first rows won't reach the 950 degrees and won't be fully fired)

## At 9:00 PM the following are done

- Open valve 3 totally and fully close valve 2 Move the fuel feeding to the next row (row 5) complete and close chamber 4 by 01:00 AM

## At 01:00 AM the following are done

- Open valve 4 to position 1/3 (20 cm outer height of the screw shaft)
- Close valve 3 to position 2/3 (40cm outer height of the screw shaft)
- Shift feeding to row 6 load chamber 5 At 05:00 AM the following are

done

- Open valve 4 to position 2/3 and close valve 3 to position 1/3
- shift feeding to row 7

## At 09:00 AM the following are done

- Open valve 4 fully and fully close Valve 3
- Shift feeding to row 8
- Finish loading of chamber 5
- Unload the first chamber

## AT 1:00 PM of the next day do the following

- Open valve 4 to position 1/3, close valve 3 to position 2/3,
- Starting feeding row 9 with sawdust lifting the temperature by 30degrees per hour until 950 keep
- Keep loading the sixth chamber
- Firing degrees for chamber 2 are reached approximately at 01:00am.
- Keep on following the sequence as described for 24 hours.
- With this sequence you will note that there are always 2 chambers dried, you will have to keep the temperature of the chemney normal to 200 ° C with a maximum temperature 250 ° C.

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## 28 Kiln unloading

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*Kiln unloading*

The fired products are off-loaded in the sequence of first in - first out (tunnel kiln) and in reverse for the intermittent kiln. The offloaded bricks that present all the physical characteristic of a quality product are put on a safe area and shall be categorized under Standard grade.

## 29 Sorting/storage at the finished goods yard



Broken fired products

### **BROKEN FIRED PRODUCTS**

These are piled out of the loading area to enable the wheel barrow to carry them to the grinding area. It is this scrap that is turned into grog and later recycled to be used in making other products such as fire cement and refractory materials. Excess scrap is heaped at the dumping ground from where it awaits to be re-purposed for example as sublayer for quarry roads.



Commercial products

### **COMMERCIAL PRODUCTS**

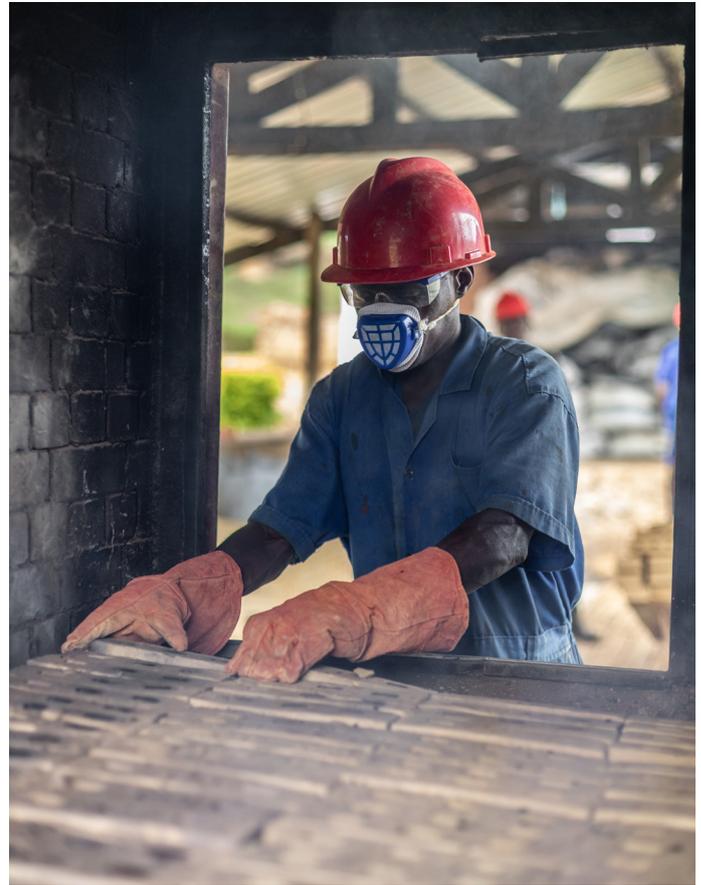
Although these products have defects and may show signs of warping, breakage, etc., they are still useful in some aspect of construction. These products are arranged in the yard in the area reserved for commercial grade products, to avoid being mixed with Standard grade products.



Overfired bricks piled outside the kiln

**OVER FIRED PRODUCTS:**

These are products that have been exposed to very high temperatures during firing and have changed to a very dark colour and have shrunk extra-ordinarily. These products are stocked in the yard in the section that is clearly demarcated "Over fired products" to avoid being mixed with Standard and Commercial grade products.



Offloading bricks from the kiln

**UNDER FIRED PRODUCTS:**

These are products that have been exposed to low temperatures during firing. Since these products are not well fired, they are taken back for re-firing. These products are returned to the kiln loading area and are stocked in the section that is clearly demarcated "Under fired products" to avoid being mistaken with other grades products.

## 30 Machine maintenance



*Screw shaft worn out to be replaced*



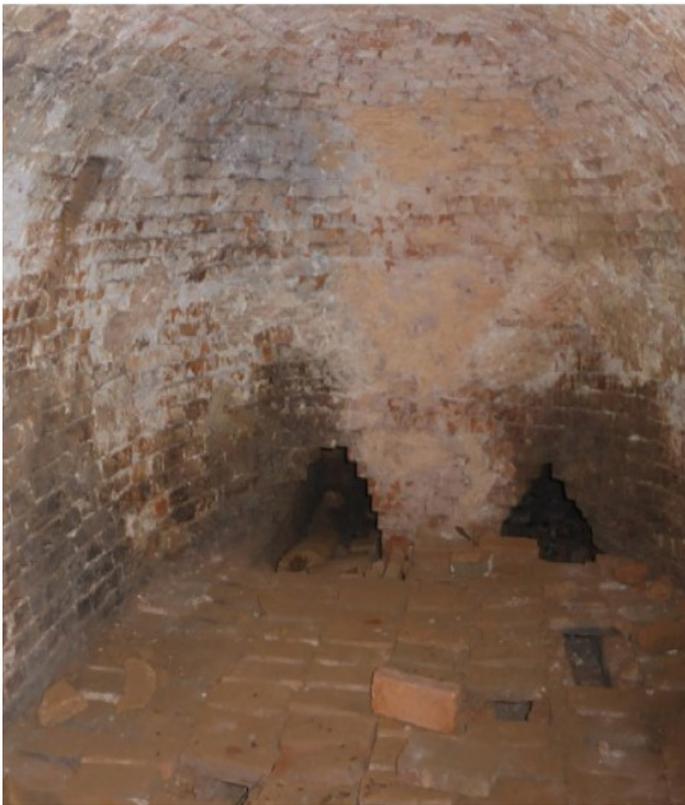
*Screw shaft with new full pitch distance*

Maintenance is a work that is carried out to preserve an asset (a machine etc.), in order to enable its continued use and function above a minimum acceptable level of performance, over its design or service life without unforeseen renewal or major repair activities.

It helps in maintaining and increasing the operational efficiency of brickyard facilities.

This maintenance activities may be carried out before the breakdown (preventive maintenance) or after breakdown (curative maintenance).

## 31 Kiln maintenance



*Kiln before maintenance*



*Kiln after maintenance*

After offloading the chamber, it shall be swept clean of any debris from damaged products by the firing team before being inspected by the Firemaster. A chamber inspection consists of checking for and repairing any cracks that may have appeared during the firing cycles. Repairs are made using fire-resistant material like chamotte or kaolin.

For a NDZZ, the status of chimney steel sheet should be inspected in order to evaluate its corrosion status that may lead to accident if not properly done. In case the initial thickness of the steel sheet has considerably been deteriorated by rust, the chimney should be replaced or the corroded part of the chimney.

## 32 Work safety issues



*Workers in personal protective equipments and available clean water at the site*



*Workers in personal protective equipments and available clean water at the site*

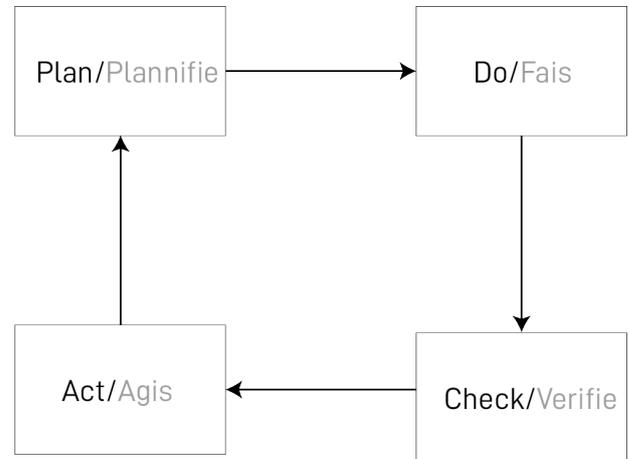
As per ministerial order number 2 of 17/05/2012, determining the conditions for occupational health and safety, the following measures are the minimum requirements to ensure the safety and wellbeing of the personnel at work:

1. Reasonable duty hours (8 hours shifts)
2. Provision of clean drinking water
3. Food facilities at the work place
4. Medical insurance scheme (mutuelle de sante)
5. Presence of aid kits in the work place
6. Uses of personal protective equipment (PPE)

## 33 Quality plan



Quality planning parameters



Quality planning cycle

During each production cycle, there are quality control activities that must be carried out. These activities are done as per a pre-planned schedule. Quality Planning and Quality Management are the fundamental processes put in place to oversee all activities and tasks needed to maintain a desired level of excellence, with the goal of delivering a quality product as per customer's requirements and market demand.

The complete quality control process consists of:

**Plan** - the stage where the quality control processes are planned.

**Do** - use a defined parameter to develop the quality

**Check** - the stage to verify if the quality parameters are met

**Act** - take corrective action if needed and repeat the work.

Quality control characteristics: process adopted to deliver a quality product to the clients at best cost. The goal is to learn from other organizations so that the quality can be improved over time.

## 34 Process quality assurance and monitoring

The soil suitable for perforated bricks production should meet the requirement of adequate mixture of its components which are clay, silt and sand. Apart from clay soil mixture proportion the production of bricks requires to take into consideration the following parameters :

Le sol approprié pour la production de briques perforées

### 1. Raw Materials Mixture

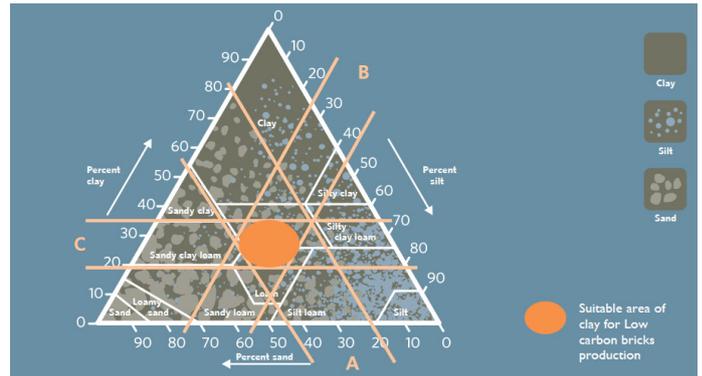
Dry Shrinkage: 4-5%

Total Shrinkage: 6-7%

Sand Content: 20%-35%

	Elements	Size	recomended value
1.	Sand	2mm-0.063mm	20-45%
2.	Silt	0.063mm-0.002mm	25-45%
3.	Clay	<0.002mm	20-35%

*Ideal distribution of grain size for low carbon bricks*



*Suitable soil for perforated bricks*

### 2. Clay Bank at Brickwork

Moisture Content (Clay bank) : 12% - 18%

Moisture Content in the Silos (Kaolin bank) : 4% - 8%

Roller gap (Crushed particle size from High Speed Rollers): < 1 mm



*Watering of clay silo*

### 3. Extrusion

Moisture Content of column at Extruder exit: 20% - 21%, which enables proper handling straight from the cutting table.



*Regulated moisture in the clay column during extrusion for proper handling*



*Regulated moisture in the clay column during extrusion for proper handling*

## 4. Drying

Moisture Content of dried product should be  $< 2\%$



*Bricks under drying process*



*Bricks ready for firing with moisture  $< 2\%$*

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## 5. Firing

The firing schedule to follow pre-established norms

Moisture content of Kiln Fuel to do not exceed  $8\%$ .



*Fuel stock*

# QUALITY ASSURANCE AND QUALITY CONTROL

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## 6. Sorting

When the bricks are unloaded from the kiln, they are simultaneously being checked for quality against set norms of RBS: RS EAS 94 / RS EAS 54.

Those that are underfired / overburnt / blackened are all to be kept separately and stacked separately in the Yard too.

Random samples are tested against set quality parameters.



*Green bricks sorting*



*Bricks sorting after firing*



*Bricks sorting after firing*

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**35** Model cases/case study

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*A semi industrial unit at Rwamagana District -Muyumbu Sector in Rwanda*



*A semi industrial unit at Rwamagana District -Gishari Sector in Rwanda*

## 36 Soil and finished product quality control

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring of quarrying activities	Routine inspection of clay and kaolin quarries  Identify areas in the respective quarries to excavate for clay and kaolin	Nominated person at the production site.	Monthly once
2	Monitoring routine testing of raw materials	Routine checks of clay and kaolin received at Brickwork: <ul style="list-style-type: none"> <li>• L.O.I.</li> <li>• Granulometry</li> <li>• Shrinkage of clay</li> <li>• Sand content in kaolin</li> </ul>	Sample of clay and Kaolin to be sent to SKAT-BMC	Quarterly once

Quality Control Activities: QUARRY

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring of clay mix, clay being blended kaolin in a pre-determined ratio	Routine monitoring of clay & kaolin Mix	Nominated person at the production site.	Initially daily. Later, as the worker gains confidence the system, the testing could be scaled down to once weekly

Quality Control Activities: Clay mix

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the Roller Mill operation.	<ul style="list-style-type: none"> <li>• Check the clay-Mix fall onto the Roller shells</li> <li>• If fall is not spread across the roller shell face, then ensure that it falls across the entire face by developing a suitable jig.</li> <li>• Check for gap between the two rolls, which ideally should be less than 1.00mm</li> </ul>	Nominated person at the production site.	Daily. Once systems are in place, this check could be done weekly.

*Quality Control Activities: Roller mill*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the moisture content of the clay mix at the Extruder Mouth	<ul style="list-style-type: none"> <li>• The moisture contents should be in the range of 18-21%</li> <li>• Initially the test will need to be done through a laboratory dryer and using weighing scales</li> <li>• Later on, once confidence built up, the test could be done by "feel" method</li> </ul>	Nominated person at the production site.	Hourly during extrusion operations

*Quality Control Activities: Moisture content at extruder*

## ANNEX

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the clay Mix column existing from the Extruder Die Mouth	<ul style="list-style-type: none"> <li>The clay mix column existing from the Extruder Die Mouth should conform to the Exit Regulation test, i.e. the column should be existing uniformly across the die mouth face.</li> <li>The Die cores are not out of position.</li> </ul>	Nominated person at the production site.	During extrusion operations to be recorded hourly

### Quality Control Activities: Extruder mouth

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the extruded green bricks/blocks being set for drying at drying station	<p>The freshly extruded green bricks are laid out on the drying floor as per set parameters, to allow ambient air to facilitate quick drying.</p> <ul style="list-style-type: none"> <li>Checking for the quality of drying</li> <li>Check for drying problems/deformities such as warpage, cracking</li> <li>Change stacking style as bricks get dry</li> <li>Bricks before being sent to kiln should have moisture content of &lt;2%</li> </ul>	Nominated person at the production site.	During drying operations, to be checked every shift

### Quality Control Activities: Drying

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the fuel for kiln firing	<ul style="list-style-type: none"> <li>Checking for the quality of the fuel for kiln firing</li> <li>Check for moisture content</li> <li>Check for granulometry of the kiln fuel</li> </ul>	Nominated person at the production site.	<ul style="list-style-type: none"> <li>During kiln firing operations, to be checked every shift.</li> <li>Granulometry to be checked with every receipt of kiln fuel</li> </ul>

### Quality Control Activities: Kiln fuel

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the kiln firing	<ul style="list-style-type: none"> <li>• Checking for the quality of the products being sent to the kiln for firing, no cracked, broken or deformed product enters the kiln.</li> <li>• Product stacking in the kiln chamber follows stacking norm</li> <li>• Pyrometer readings are recommended</li> <li>• Damper positions are maintained as per set norms</li> </ul>	Nominated person at the production site.	During kiln firing operations, to be checked every hour

*Quality Control Activities: Kiln*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the quality of the fired products exiting the kiln	<p>Checking for the quality of the products exiting the kiln:</p> <ul style="list-style-type: none"> <li>• Checking for fired dimensions</li> <li>• Checking for fired weight</li> <li>• Checking for squareness</li> <li>• Checking for surface quality</li> <li>• Checking for warpage</li> <li>• Checking for under-fired products</li> <li>• Checking for over-fired products</li> <li>• Checking for water absorption</li> <li>• Checking for strength</li> </ul>	Nominated person at the production site.	The fired products exiting from kiln chamber to be checked for bottom, middle and top rows for parameters mentioned under "process".

*Quality Control Activities: Fired products*

S.No	Activity	Process	Person Responsible	Frequency
1	Monitoring the quality of the fired products kept in the finished goods yard	<p>Checking for the quality of the products exiting the kiln:</p> <ul style="list-style-type: none"> <li>• Checking that each product type is kept together</li> <li>• For the same product type, the first and second quality types to be stacked differently</li> </ul>	Nominated person at the production site.	The fired products in the stockyard are to be analysed for quality and inspection done with every entry of fresh goods to the yard

*Quality Control Activities: Fired products in stockyard*

37 Maintenance

Who	HOW	WHERE	WHEN	PROCEDURE
TRAINED MACHINE OPERATOR UNDER FOREMAN/ PRODUCTION MANAGER SUPERVISION	FOLLOW PROCEDURE	AT OPERATION SITE	BEFORE CRUSHER OPERATIONALIZATION	PREPARE SPARE PARTS (GEARS, BEARINGS, BOLTS AND NUTS) AND TOOLS (SPANNERS, GREASE PUMP ETC.
			DAILY AFTER OPERATION	WITH HELP A SOFT CLOTH WIPE DRY THE MACHINE
				WITH HELP OF A PLASTIC SHEETING COVER THE HOPPER TO KEEP MOISTURE AND EASY THE NEXT OPERATION
				IN THE RECORD BOOK;RECORD BREAKDOWNS AND THE MAINTENANCE ACTIVITIES DONE
			WEEKLY	DO A GENERAL MAINTENANCE OF THE MACHINE (CLEANING, LEVELLING, LUBRICATION OF MOVING ELEMENTS (GEARS,BEARINGS ETC.)
			AFTER 100 HRS OF OPERATION	CHANGE ENGINE OIL

Crusher maintenance instructions

Who	HOW	WHERE	WHEN	PROCEDURE
MACHINE OPERATORS	FOLLOW PROCEDURE/ SUIVEZ LE PROCEDURE	AT OPERATION SITE	DAILY AFTER OPERATION	WIPE DRY THE MACHINE WITH A SOFT CLOTH
				COVER THE MOLD WITH A PLASTIC SHEETING TO KEEP MOISTURE AND EASY THE NEXT OPERATION
				IN THE RECORD BOOK;RECORD BREAKDOWNS AND THE MAINTENANCE ACTIVITIES DONE
			WEEKLY	WITH HELP OF A SCRAPER REMOVE CLAY IN THE CLAY BOX AND IN THE MOLD HOLDER
				GENERAL MAINTENANCE OF THE MACHINE (CLEANING, LEVELING, LUBRICATION OF MOVING ELEMENTS, SPECIFICALLY BEARINGS ETC.)

*Manual extruder machine maintenance instructions*

38 Forms

MAINTENANCE CHECKLIST FOR A VACUUM PUMP EXTRUDER						
No	Machine part	Current status	Action taken	Involved staff	Schedule for next check	Comments
1.	Driving system	Motor (temperature during operation, - sound,bearing,tightness				
		V belts,pulley and coupling status				
		Oil level				
		Oil quality(Viscosity)				
		Availability of consummables(oil,grease,bearing,V belts,Diesel)				
2.	Vacuum pump/ and vacuum chamber	Oil level				
		Oil quality (Viscosity )				
		Barometer status				
		Leakage level of vacuum chamber				
		Pressure level				
3.	Mixer	Pedals status				
		Centricity of mixer shaft				
		Distance/clearance between pedals and the mixer cuve				
		Bearing status				
		Status of pedals				
4.	Auger shaft	Centricity of auger shaft				
		Distance/ clearance between pedals and the auger shaft holder				
		Dimensions of the mould				
		Perforation percentage				
		Weight of green product				
5.	Mould	Centricity of the mold nucleus				

Checklist for a vacuum pump extruder

MAINTENANCE CHECKLIST FOR A 30HP DIESEL ENGINE POWERED CRUSHER						
No	Machine part	Current status	Action taken	Involved staff	Schedule for next check	Comments
1.	Driving system	Motor (temperature during operation, sound, bearing, tightness) V belts, pulley and coupling status Oil level Oil quality (Viscosity) /l Availability of consumables (oil, grease, bearing, V belts, Diesel)				
2.	Double rollers	Distance between rollers Status of bearings Centricity of shafts				
3.	Coupling system	Status of the fan electricity and the pedals Status of rubber for chock absorption Coupling status on engine side and crusher side Bearing status				
4.	Cooling system	Connection between the tank and the engine, and the filling of water				
5.	Engine pump	Air circulation status once the engine resist in switching on				

Checklist for the motorized crusher

MODERN BRICKS PRODUCTION MONITORING ...../...../20.....							
1.CLAY							
Activity	Date/Period	men	women	equipment used			
excavation							
transportation							
2.CLAY PREPARATION							
	period/date		men	women			
2.1.manual clay preparation	...../...../202.....						
2.2.mechanised clay preparation	...../...../202.....						
machine code	operation hours/day	QTY crushed (nbre of bricks)	diesel used (litters)	type of breakdown		change of engine oil	change of gears oil
RCM.....			.....			✓	✓
3.MOLDING AND PRIMARY DRYING							
machine code	MEE.....	MEE.....	MEE.....				
green brick dimensions Lxhxh(cm)							
green brick weight(kg)							
QTY of bricks mold/per machine							
labor	.....men and.....women	.....men and.....women	.....men and.....women				
change of smoothening material	✓						
change of cutting wires	✓						
mold adjustment	✓						
type of breakdown							
repair	✓						
replacement	✓						
4.SECONDARY DRYING							
total bricks dried= ..... bricks	time taken for drying		results(number of good bricks from the batch)	Labor			
	from(date)	to(date)		men	women		
primary drying			.....bricks				
Secondary drying			.....bricks				
<b>Note:</b>	1. In order to succeed the daily production monitoring; brick batches labering is necessary						
	2.Please follow the instructions attached for a safe operation of the machines						
COMMENT							
BRICKYARD MANAGER/FOREMAN NAMES & SIGNATURE:							

Modern bricks production monitoring

KILN FIRING MONITORING FORM 202.....												
type of the kiln:.....												
<b>Bricks loaded</b>												
	chamber/ zone1	chamber/ zone2	chamber/ zone3	chamber/ zone4	chamber/ zone5	chamber/ zone6	chamber/ zone7	chamber/ zone8	chamber/ zone9	chamber/ zone10	chamber/ zone11	chamber/ zone12
QTY of bricks loaded												
Bricks dimensions (LxHxh) (cm)												
<b>temperature monitoring</b>												
firing date time	chamber/ zone1	chamber/ zone2	chamber/ zone3	chamber/ zone4	chamber/ zone5	chamber/ zone6	chamber/ zone7	chamber/ zone8	chamber/ zone9	chamber/ zone10	chamber/ zone11	chamber/ zone12
...../.....h.....												
...../.....h.....												
...../.....h.....												
...../.....h.....												
<b>FUEL USED</b>	saw dusts(bags)			cofee husks(bags)			fire wood(stere)			maize cobs(bags)		
<b>LABOR</b>	men			women								
QTY of well fired bricks												
QTY of underfired bricks												
QTY of overfired bricks												
Bricks dimensions (cm)												
<b>Note:</b> write a detailed observation at the back												
<b>BRICKYARD MANAGER/FOREMAN NAMES &amp; SIGNATURE:</b>												

Kiln firing monitoring form

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