# ANALYSIS OF DRYING PROCESS IN CERAMIC TILES INDUSTRIES

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**ABSTRACT**

*Ceramic tiles industries is clay based industries .Ceramic industries process differentiate in many steps .But most important process of ceramic tlies industries is drying process. Drying is the most energy consuming process in ceramic tiles industries. Drying process separate in two part 1. Drying with the dryer 2. drying with the kiln .In this studies we studied the behavior of the drying curve with the temperature increase in process .And also do the mass balance and energy balance of the whole drying process and find the energy needed for the drying process and energy loss from the drying process*

**Keywords:-** *Ceramic , Drying ,Kiln, Mass balance ,Energy balance*

## 1. INTRODUCTION

Generally the term 'ceramics' (ceramic products) is used for inorganic materials with possibly some organic content, made up of non-metallic compounds and made permanent by a firing process. In addition to clay based materials, today ceramics include a multitude of products with a small fraction of clay or none at all. Ceramics can be glazed or unglazed, porous or vitrified. Firing of ceramic bodies induces time-temperature transformation of the constituent minerals, usually into a mixture of new minerals and glassy phases. Characteristic properties of ceramic products include high strength, wear resistance, long service life, chemical inertness and non toxicity, resistance to heat and fire, (usually) electrical resistance and sometimes also a specific porosity.

Two types of energy are used in the ceramic industry; electric energy and chemical energy. The electric energy is used in two different ways; mechanical energy when used in the motor and fan of the machine, and thermal energy when used to heat the kilns and furnaces. The chemical energy of petroleum fuel is all converted into thermal energy through combustion reaction. Energy used in the ceramic industry is predominantly occupied by petroleum energy. The drying process in the ceramic industry is the greatest energy consumer second to the firing process. Drying means loss of moisture from the surface of the substance by evaporation, and the drying speed depends on the temperature and humidity.

**Ceramic Manufacturing Process:**
Figure below shows the general process flow diagram of ceramic manufacturing process.

**(1) Raw Materials Procurement & Weighing**
The raw materials used in the manufacture of ceramics range from relatively impure clay materials mined from natural deposits to ultrahigh purity powders prepared by chemical synthesis. Naturally occurring raw materials used to manufacture ceramics include silica, sand, quartz, flint, silicates, and alumino silicates. The first step in the process is to weigh the raw materials required to manufacture a ceramic tile including all types of frit, feldspar and various clays. All the raw materials are accurately weighed, so that the quality of the product can be stabilized.

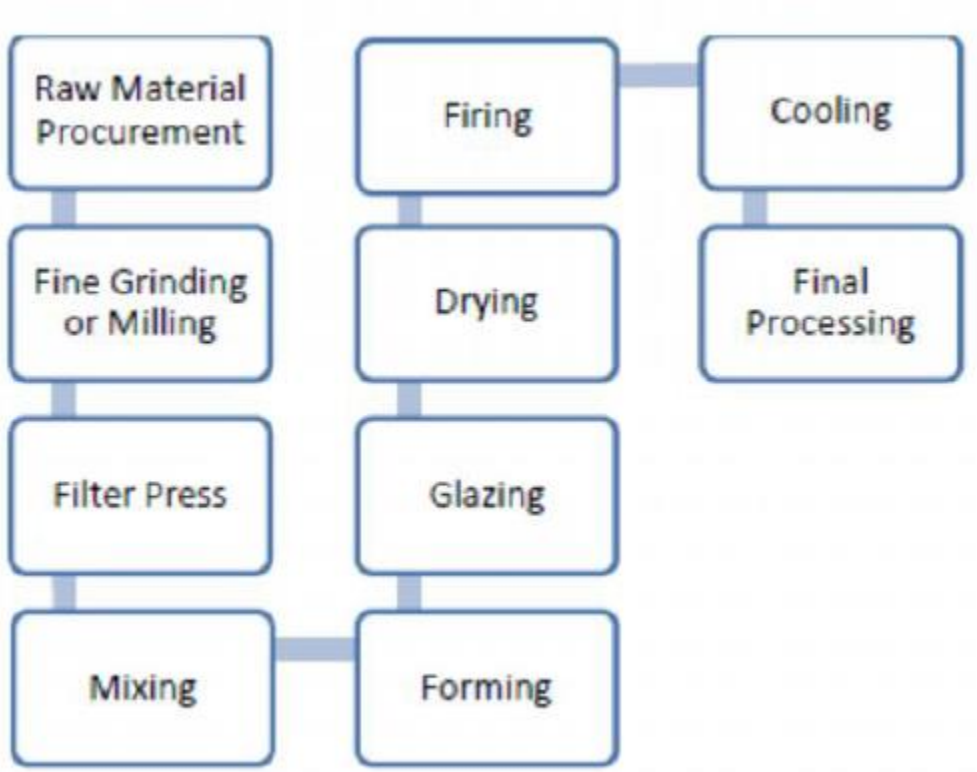


**Fig -1**: Manufacturing process of ceramic tiles

**(2) Fine Grinding & Milling**

The basic beneficiation processes include crushing, grinding, and sizing or classification. Primary crushing is used to reduce the size of coarse materials, such as clays, down to approximately 1 to 5 centimeters. The most common types of crushers used are jaw crushers, cone crushers, gyratory crushers, and roll crushers. Secondary crushing or grinding reduces particle size down to approximately 1 millimeter in diameter. Fine grinding or milling reduces the particle size down to as low as 1.0 micrometer in diameter. Ball mills are the most commonly used piece of equipment for milling.

**(3) Filter Press**

During the process to make clay and ceramic slurries used for the manufacture of dinnerware, insulators, china etc, the clay slurry goes through a dewatering step prior to further processing and molding into the desired form. These slurries are extremely dense and heavy and typically require dewatering at 225 PSI feed pressure to obtain a solid cake.

**(4) Mixing**

The purpose of mixing or blunging is to combine the constituents of a ceramic powder to produce a more chemically and physically homogenous material for forming. Pug mills often are used for mixing ceramic materials. Several processing aids may be added to the ceramic mix during the mixing stage. Binders and plasticizers are used in dry powder and plastic forming; in slurry processing, deflocculants, surfactants, and antifoaming agents are added to improve processing. Liquids also are added in plastic and slurry processing. Binders are polymers or colloids that are used to impart strength to green or unfired ceramic bodies.

Mixing ensures a uniform distribution of clay in the solution. It also prevents the sedimentation of clay which is desirable for the process of ceramic formation. Pug Mills are most commonly used for mixing in ceramic production.

**(5) Spray Drying**

Ceramic tiles are typically formed by dry pressing. Prior to pressing, many facilities granulate the ceramic mix to form a free-flowing powder, thereby improving handling and compaction. The most commonly used method of granulation is spray-drying. The slurry is injected into a drying chamber with hot gases. As the hot gases come in contact with the slurry, a powder is formed and collected in a cyclone or fabric filter. Spray dryers generally are gas-fired and operate at temperatures of 70° to 570°C. After spray drying, the water content of the granules is between 35-40%.

**(6) Powder Storage**

The granules have to be kept in a storage bin for a few days so that its composition becomes even more homogeneous. This process makes the granules more pliable and less likely to stick to the mold. The size of powder storage bin needed will be determined by the production capacity of the plant. Generally, the most suitable size is capable of holding 400 tons of powder.

**(7) Shaping**

In the forming step, the ceramic mix is consolidated and molded to produce a cohesive body of the desired shape and size. Forming methods can be classified as either dry forming, plastic molding, or wet forming. Once the composition of the powder becomes homogenous, it is taken to the press where it is molded and squeezed under high pressure (of the order of hundreds of tons) to form a biscuit or Greenware tile body. The press can be for a small trim tile or a massive 24x24 inch tile.

**(8) Glazing**

Glazes resemble glass in structure and texture. The purpose of glazing is to provide a smooth, shiny surface that seals the ceramic body. Not all ceramics are glazed. Those that are glazed can be glazed prior to firing, or can be glazed after firing, followed by re firing to set the glaze.

**(9) Speed Body Drying**

The drying process in the ceramic industry is the greatest energy consumer second to the firing process. Drying means loss of moisture from the surface of the substance by evaporation, and the drying speed depends on the temperature and humidity. When the substance is dried and moisture is lost, particles are put close to each other, resulting in shrinkage.

**(10) Firing**

Firing is the process by which ceramics are thermally consolidated into a dense, cohesive body composed of fine, uniform grains. This process also is referred to as sintering or densification. Ceramics generally are fired at 50-75% of the absolute melting temperature of the material. Ceramic products also are manufactured by pressure firing, which is similar to the forming process of dry pressing except that the pressing is conducted at the firing temperature. The application of pressure enhances the densification of the ceramic during firing. Because of its higher costs, pressure firing is usually reserved for manufacturing ceramics that are difficult to fire to high density by conventional firing. In hot pressing, hydraulic presses and graphite dies commonly are used. In hot isotactic pressing, the pressing medium typically is a gas, such as argon or nitrogen.

**(11) Packing**

The finished products are then packed and stored or shipped.

## 2. OBJECTIVE

The objective of this study was to improve the use of the energy consuming in drying process. Here in ceramic tiles manufacturing process the drying process is second most energy consuming process after the firing process. For know about the energy consumption we have to analysis the process. So we visit the one company and analysis the manufacturing process and from the analysis we do the mass balance and energy balance of drying process for the know about the energy consumption .

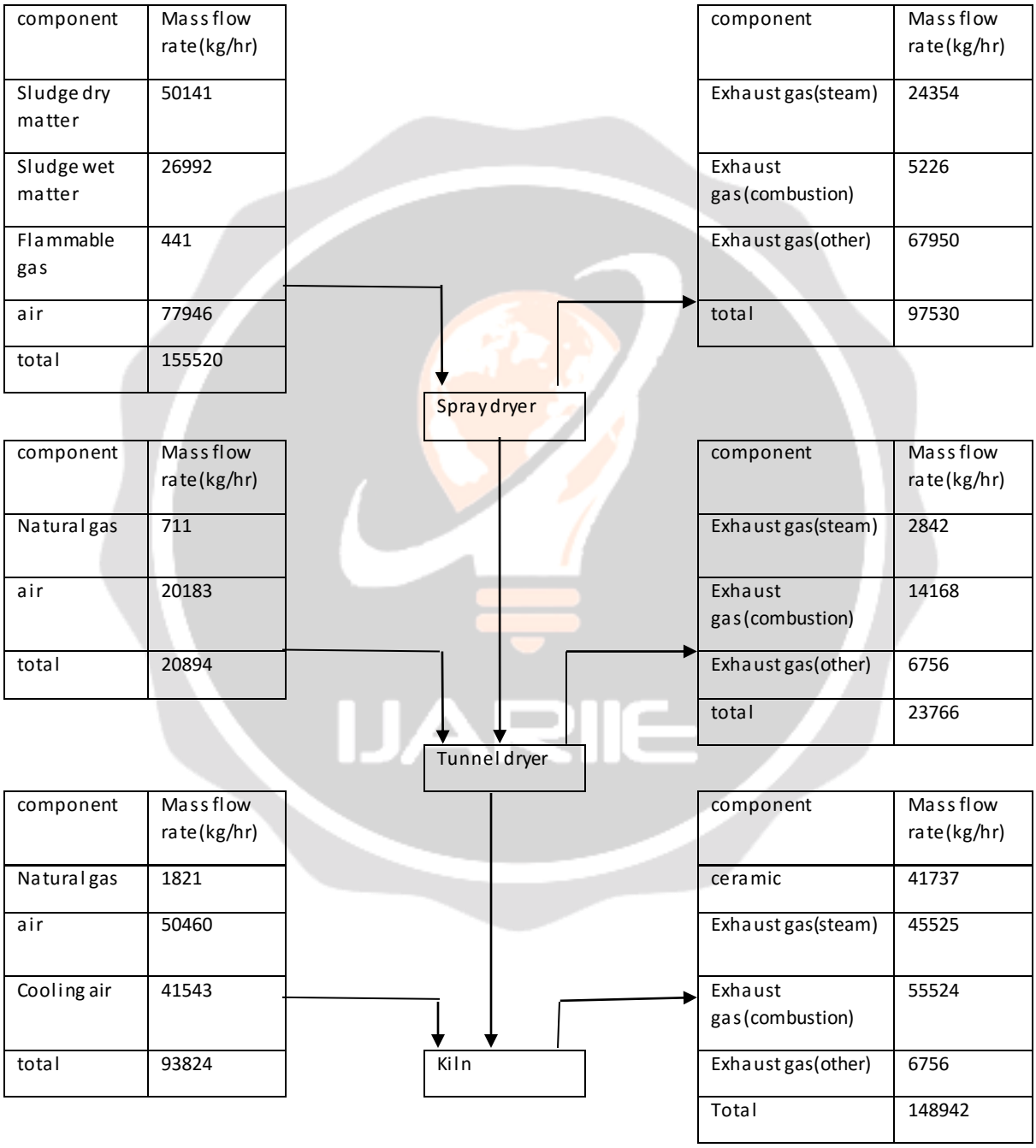


**Fig -2**: Mass balance of drying process

## 2. ENERGY BALANCE OF DRYING EQUIPMENT

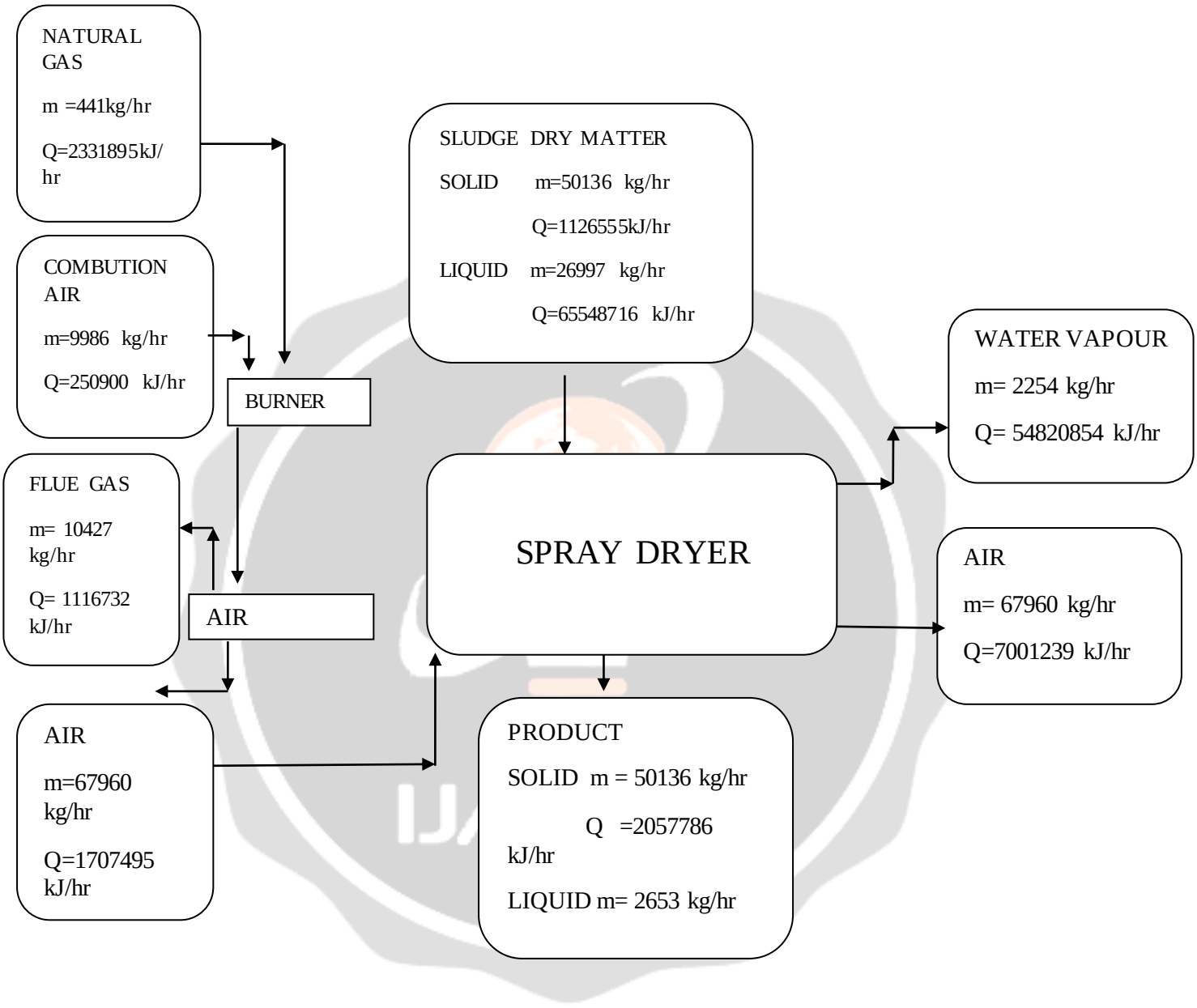


**Fig -3**: Energy balance of spray dryer

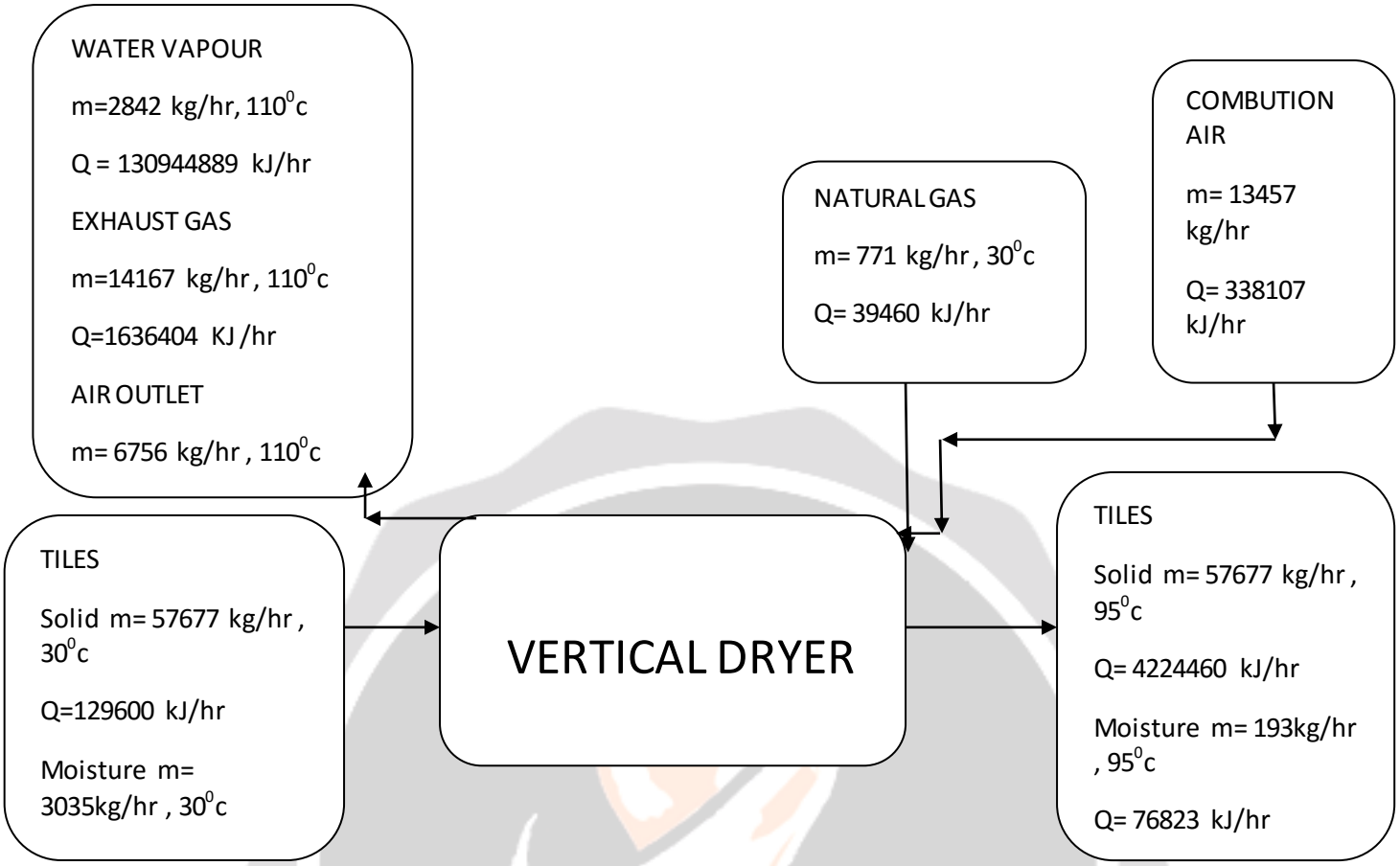


**Fig -3**: Energy balance of vertical dryer

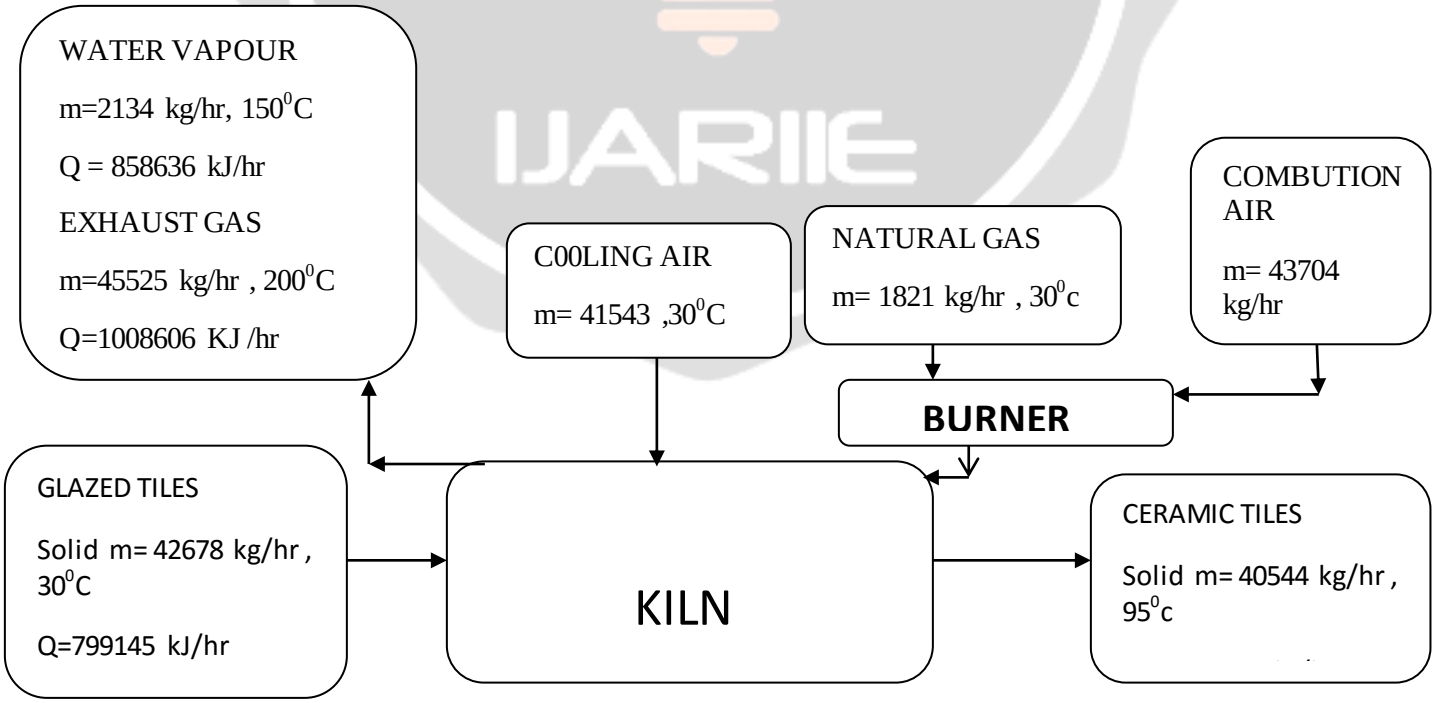


**Fig -4**: Energy balance of kiln

## 3. DESCRIPTION OF THE PROCESS

### 3.1. Drying process

The drying process in the ceramic industry is the greatest energy consumer second to the firing process. Drying means loss of moisture from the surface of the substance by evaporation, and the drying speed depends on the temperature and humidity. When the substance is dried and moisture is lost, particles are put close to each other, resulting in shrinkage. Fig. 3 shows the relationship between the drying time and speed. The constant rate drying period is the period when balance is kept between moisture shifting from inside the substance to the surface and moisture evaporation from the surface.

The first falling drying rate period is the period when moisture shifts from inside the substance to the surface with reduced moisture evaporating from the surface. The second falling drying rate period is the period when evaporation takes place inside and vapor diffuses to the surface, without moisture shifting from inside the substance. Cracks due to drying is caused during the period when the green body shrinks that is, when the temperature gradient is steep under drying conditions between the constant rate drying period and first falling drying rate period, or when the temperature is excessively low. It is essential to have a correct understanding on these conditions before starting the drying process.

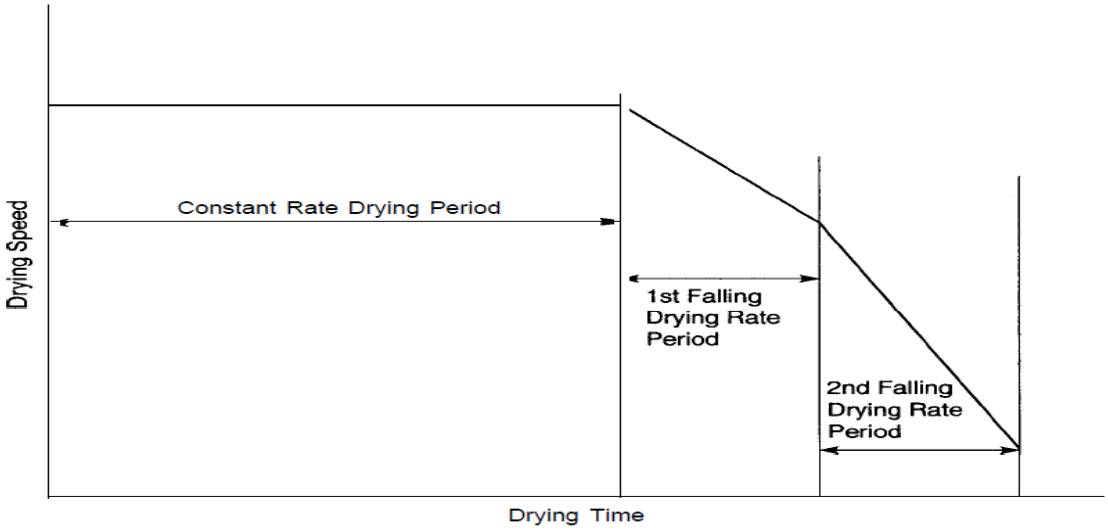


**Fig -5**: Drying Time vs Drying Speed

Two types of drying process done in the manufacturing of ceramic tiles.

1. Drying through spray dryer
2. Drying through vertical dryer

**1. Drying through spray dryer**

The aqueous suspension of raw material resulting from wet ball milling (solids content ~ 60 to 70 %) is sprayed under pressure to produce fine droplets which contact a stream of hot air. Drying of the droplets produces highly uniform, more or less spherical hollow granules (with a moisture content of typically 5.5 to 7 %). This form of powder has high flow ability, facilitating accurate filling of the press dies and the subsequent pressing of quite large single tiles. Today, certain companies are specialized in the preparation of spray dried powder. They deliver the prefabricated material directly to the plants of the ceramic industry where further processing then takes place.

**2. Drying through vertical dryer**

These are essentially a long tunnel structure through which a line of dryer cars loaded with the green ceramic ware is pushed. High temperature air is fed into the tunnel at the discharge end, and this is induced to flow towards the entry end by one or more fans. As the airflows down the dryer, it transfers heat to the product and its humidity content increases. Recirculation fans are normally installed, thereby increasing turbulence and the drying efficiency. The length of the tunnel dryer depends on the rate of product throughput required, and the water content of the ceramic material.

Ceramic tiles loaded drying cars are transported into the chambers which are sealed when full. In modern works, the whole operation is highly automated. The chamber temperature is raised at a controlled rate either directly – by the injection of warm air – or indirectly, via heat transfer surfaces. Recirculation of air is used to improve drying efficiency. Heat transfer is mainly through convection, plus a little radiation from the hot air and from heated surfaces. Specific temperature-humidity profiles are followed to suit the particular ceramic product. Chamber dryers are particularly useful in situations where various ceramic bodies are manufactured; where the bodies have a high water content; or when production is intermittent. It is also relatively easy to build on extra chambers if necessary.

**3.2 FIRING PROCESS**

**Firing through roller hearth kiln**

These are essentially refractory tunnels served by rail tracks carrying kiln-cars. The latter have refractory decks on which dried ware is set in defined stable patterns. The cars are pushed through the kilns at set intervals, counter currently to a flow of air drawn by fan(s) to an exhaust duct near the car entry zone. Most tunnel kilns are now gas-fired, with a maximum temperature in the firing zone near the center of the kiln. Incoming ware is preheated by hot gases from the firing zone, whilst incoming air cools the fired ware and is itself preheated for its combustion role. The firing chamber and kiln-cars are usually sealed against secondary air with a sand seal. The latest kiln constructions are sealed by water or other improved mechanical solutions. The aim of these procedures is to reduce firing times and energy consumption by having a gas-tight firing chamber. Single-deck roller kilns are now almost universally used for wall and floor tile production, and firing schedules have been reduced to less than 40 minutes. Tiles travel over driven rollers, and the heat required for firing is provided by natural gas-air burners located at the sides of the kiln. The main heat transmission mechanisms are convection and radiation, and as the kilns are non-muffled, the heat transmission coefficients are raised, reducing the firing cycle and energy consumption .The following figure shows the cross-section of a roller hearth kiln.

The firing process uses a kiln featuring great energy consumption, and natural raw materials are used to produce ceramics. It is essential to have a correct understanding on the following thermal changes (drying, dehydration, decomposition, combination, inversion, vitrification) before working out the firing curve. Fig. 4 shows the heat curve of the porcelain.

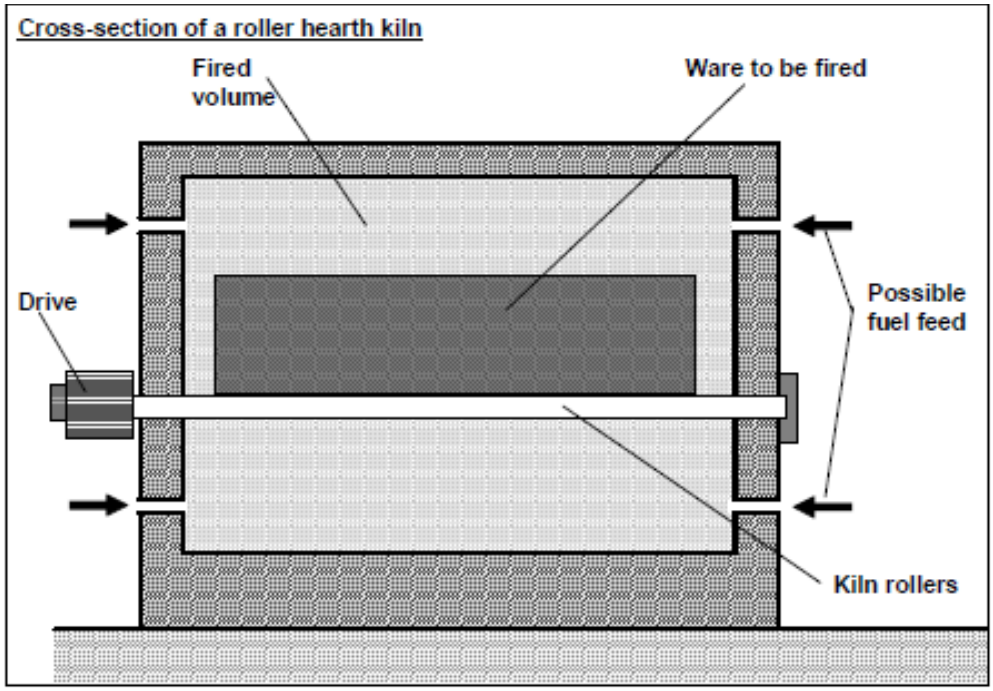


**Fig -6: cross section of kiln**

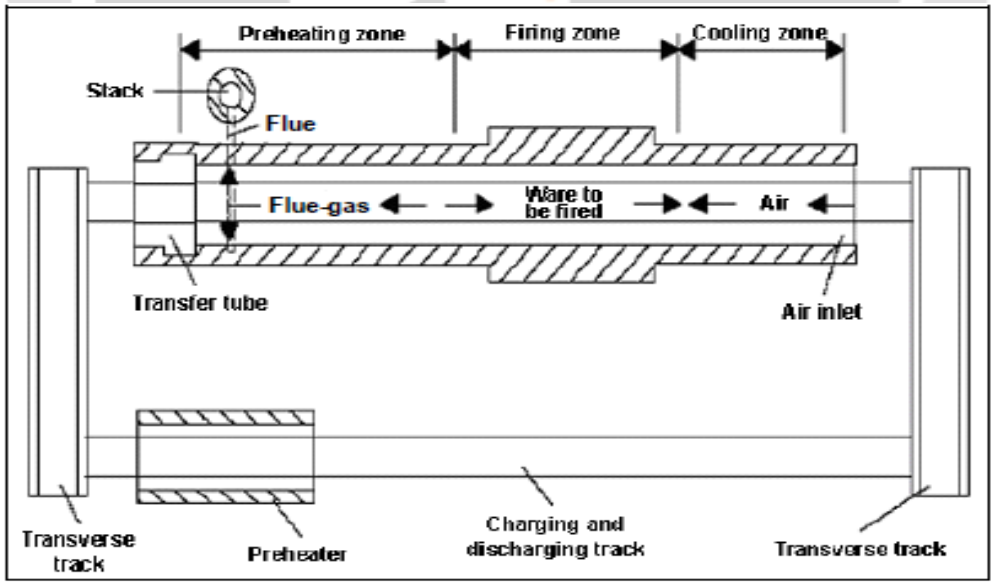


**Fig -7: side view of kiln**

## 4. CONCLUSIONS

The main conclusions drawn from the study were as follows:

**1.** From the energy balance of the drying equipment we can show that most of the energy loss through the flue gas .In kiln half of the energy loss through the flue gas so for energy conservation we have to recover this flue gas from the kin or reuse this flue gas.

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