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UNVERSTY COLLEGE

Constructional Technology

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Gypsum Manufacturing

Introduction:

Gypsum is a rock-like mineral commonly found in the earth's crust, extracted, processed, and used by Man in construction or decoration in the form of plaster and alabaster. Chemically it is $CaSO_4.2H_2O$ i.e. Calcium Sulfate dehydrate. Impurities: MgO , Al_2O_3, Fe_2O_3, SiO_2, $CaCO_3$, $MgCO_3$.

Raw Material:

Gypsum rock (**calcium sulfate dehydrate – $CaSO_4 .2H_2O$**) was formed in geological time through the evaporation of seawater. It is often laid down in beds, ranging in thickness from a few centimeters to several tens of meters. Because gypsum rock is slightly soluble in water, it is not usually found above ground in wet or damp areas, but may be found underground, where it is not affected by the water table. In dry regions it may also be found on the surface, sometimes in the form of gypsum sand

Gypsum rock is usually white or colorless, although it may sometimes have gray, yellow, pink, or brown hues. Gypsum is much softer than minerals of similar color, such as calcite or quartz, and is the only one that can be scratched with a fingernail. If a piece of gypsum rock is held over a flame it will turn cloudy and opaque and give off water. Some gypsum sand deposits contain only about 60 percent gypsum, and these are not very suitable for producing a plaster; those containing more than 80 percent would be most suitable. **The gypsum $CaSO_4$ is consist of 79.1% calcium sulfate and 20.9% water by weight. Two types of gypsum are available in nature: gypsum rock and gypsum earth. The gypsum earth requires much less machinery since it does not have to be crushed.**

Gypsum Plasters:

*** Obtained by Incomplete Calcination ($CaSO_4 .½H_2O$)**

1. Plaster of Paris : is formed by incomplete calcination at 100- 190°C. No admixtures are found.
2. Hard Wall Plaster: Plaster of Paris + Admixtures (Glue, Sand...)

- **Obtained by Complete Calcination ($CaSO_4$)**
- 1. Flooring Plaster ($CaSO_4$ with no impurities)
- 2. Hard Finish Plaster ($CaSO_4 + Al_2(SO_4)_3$) ($CaSO_4 + Na_2B_4O_7$)

The formation of Gypsum:

A common mineral, with thick and extensive evaporate beds in association with sedimentary rocks. Gypsum is deposited in lakes and seawater. Hydrothermal anhydrite in veins is commonly hydrated to gypsum by groundwater in near-surface exposures. Often associated with the minerals halite and sulfur.

Properties and Uses of Gypsum Plasters:

***Plaster of Paris**

1-Setting time ~5-20 min.

2-Used for sculpturing, ornamental work, small repair works.

***Hard Wall Plaster .**

1-Setting time ~1 hr.

2-Compressive strength ~7 MPa .

3-Admixtures result in increased plasticity & setting time& reduced shrinkage.

4-Can be used for plastering walls.

5-Production of prefabricated structural units.

6-Building work with bricks and blocks

***Flooring, Hard Finish Plaster**

1-Setting time ~1-16 hr.

2-Compressive strength > 7 MPa

3-Can be used for producing prefabricated units, masonry bricks & flooring & pavement bricks &tiles.

*Gypsum often serves as a fire proofing material even though its strength is destroyed by long continuous heat. It forms a powder covering the surface which acts as an effective insulator.

*Gypsum products tend to disintegrate when exposed to moisture. Therefore, they should not be used for exterior work & for moist interiors, (Non-Hydraulic material).

Other Uses of Gypsum:

Gypsum can indeed also:

1-Be added to some bread and dough mixes as a Calcium source and baking aid. Be used as a filler and fire retardant in plastic products.

2-Be used in Portland cement and special cement products for set and expansion control.

3-Be a source of Calcium and Sulfate Sulfur for plant growth.

4-Be used as a modeling material for tooth restorations.

5-Be an ingredient in many patching compounds. Be used with glass to fabricate large, lightweight architectural decorations.

6-Be used as a mold material to fabricate custom body parts for trucks and automobiles.

7-Be an aid in juice extraction of some fruits and vegetables

What is Gypsum Board?

Gypsum board, commonly known as drywall, is the technical product name used by manufacturers for a specific board with a gypsum coare and a paper facing. Gypsum board is the premier building material for wall, ceiling, and partition systems in residential, institutional, and commercial structures and is designed to provide a monolithic surface when joints and fastener heads are covered with a joint treatment system.

Making Gypsum Board:

1-To produce gypsum board, calcined gypsum is mixed with water and additives to form a slurry which is fed between continuous layers of paper on the board of the machine.

2-As the board moves down a conveyer line, the calcium sulfate crystallizes or rehydrates, reverting to its original rock state.

3-The paper becomes chemically and mechanically bonded to the core.

4-The board is then cut to length and conveyed through dryers to remove any free moisture.

5-Gypsum manufacturers also rely increasingly on “synthetic” gypsum as an effective alternative gypsum ore.

The Modern Use of Gypsum in Construction:

Plasterboard The modern use of Gypsum as a building material was discovered in 1888 when the American (Augustine Sackett) invented the machine for producing plasterboards (also known as wallboards and dry walls) composed of several layers of paper with Gypsum in-between. In Eastern and Western Europe, there are currently more than 200 factories producing plasterboards.

Production processes:

Gypsum processing plants vary widely in scale and level of technology. They range from plants producing one or two tons per day using low-cost manual technologies to plants of a thousand tons per day that are highly mechanized and capable of producing different types and grades of gypsum plaster or plasterboards

There are five basic stages in gypsum processing:

1**. Excavation** is sometimes carried out by digging out an area of ground where the gypsum is located using open-cast techniques. To reach deeper deposits drift or shaft mines may be needed.

2. **Crushing the gypsum rock** is advisable before processing further, especially if subsequent heating is to be done in a pan rather than a shaft kiln. Crushing will ensure a product that is more uniform and requires less energy to heat. Crushing can be done manually with a hammer or handheld roller, but mechanical crushing is faster and less laborious. Most clay-crushing equipment, such as that used for brick-making and pottery, would be suitable. Crushing should reduce the gypsum to grains of less than a few millimeters across. Gypsum sand does not need crushing

3. **Screening** with a sieve (manual or motor-driven) will remove large grains that have not been crushed properly and which may contain impurities.

4. Grinding, for example in a ball, rod, or hammer mill, is necessary if the gypsum is to be used for high-quality plasterwork or for molding, medical, or industrial applications. Unlike with other types of cement, such as lime and Ordinary Portland Cement, special mills for mineral grinding may not be required and the relatively soft gypsum could be pulverized in agricultural mills, which are generally widely available.

Natural or marine gypsum shall be crushed to about 25 to 30 mm size and then ground to pass 60 percent through a 150-micron sieve.

5. Heating

maybe done in a number of ways involving a range of technology levels and costs.

1- The simplest method is to mix the gypsum stone and fuel in a mound or in a shallow pit in the ground and burn it.

2-Medium scale batch production might be carried out in an excavated hillside kiln, a shaft kiln with alternate fuel and stone layers, or a permanent walled kiln.

3- An alternative method is to heat the gypsum in large pans or on a flat metal plate positioned above a kiln. Industrial production may be carried out in a purpose-built enclosed batch kiln, a continuously fed vertical shaft kiln, a specially designed large kettle, or in rotary kilns. Kiln-based systems are more efficient than burning the gypsum in mounds or pits, and even a small kiln may use less than half of the fuel of a pit or mound.

It is easiest to judge when enough heat has been applied if an indirectly heated pan or metal plate is used. When the temperature of the surface is increased steam will be produced and the material seems to boil. The temperature is maintained until this ‘first boil’ is completed, which removes all but a quarter of the water, and leaves hemihydrate plaster.

If the temperature is allowed to rise further this will start to convert to anhydrous plaster. Allowing the material to cool naturally after firing will help to remove some residual water left in the mass. It is also important to stir the material continuously to help the steam escape. If the material is heated in a kiln, then it is more difficult to know when the removal of water has taken place, and fuel usage and loading would need to be judged from experience.

As a rough guide, a field kiln might require 0.2 tons of wood for every ton of raw gypsum burned, or 70 liters of fuel oil, although kiln efficiencies will vary widely and so would the optimum amount of fuel to use.

Calcination Process:

***Gypsum rock when heated to 100-190°C looses ¾ of its water.**

$CaSO_4 .2H_2O \rightarrow CaSO_4 .½H_2O + 3/2\ H_2O$

Plaster of Paris, This is low burning process and named as INCOMPLETE CALCINATION.

***When calcination is carried out at temperatures above 190°C all water is removed.**

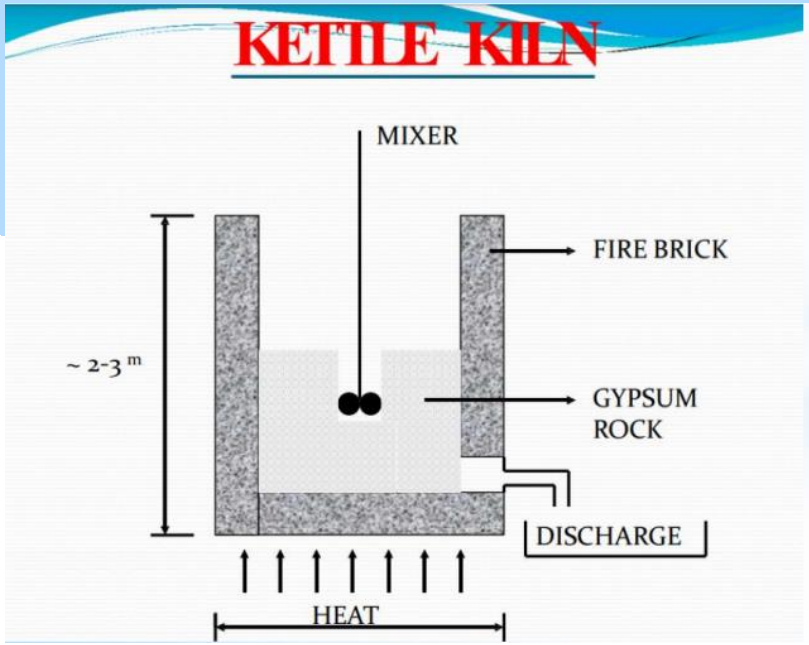
$CaSO_4 .2H_2O \rightarrow CaSO_4 + 2H_2O$ gypsum anhydrite.

This is high-burning process & COMPLETE CALCINATION.

***Both of these products form gypsum rock by recombining with water.**

$CaSO_4 .½H_2O + 3/2H_2O \rightarrow CaSO_4 .2H_2O$ $CaSO_4 + 2H_2O \rightarrow CaSO_4 .2H_2O$

*Calcination process is carried out in two types of kilns. Kettle Kilns Rotary Kilns.



Kettle method:

The kettles employed for calcination are 2.5 or 3.0 m in diameter and about 2.0 m in height. The pulverized material is chuted into the kettle and temperature raised gradually so as to drive off the mechanically held water. At about 100°C the hole mass bubbles up violently and then sinks. At 150°C the combined water begins to boil out and between 170 and 200°C the process is stopped. The kettle process requires about 2 to 3 hours to calcine a charge, yielding 5 to 6 tons. The calcined product then cooled gradually

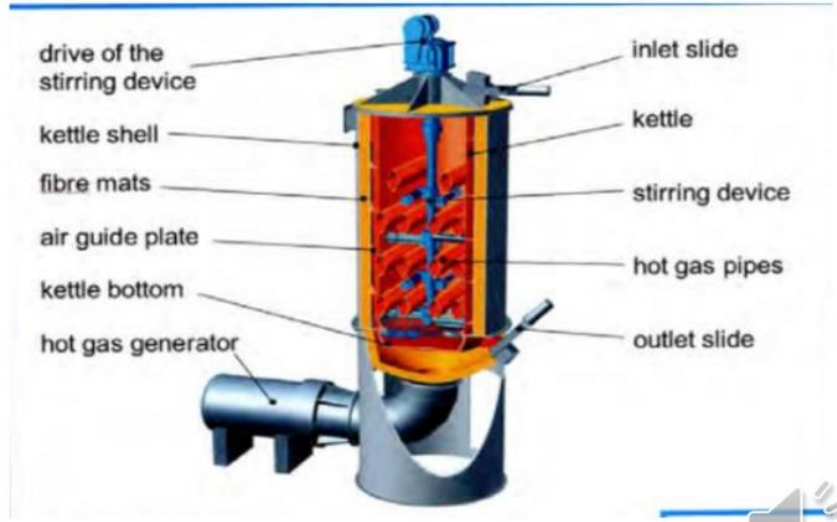
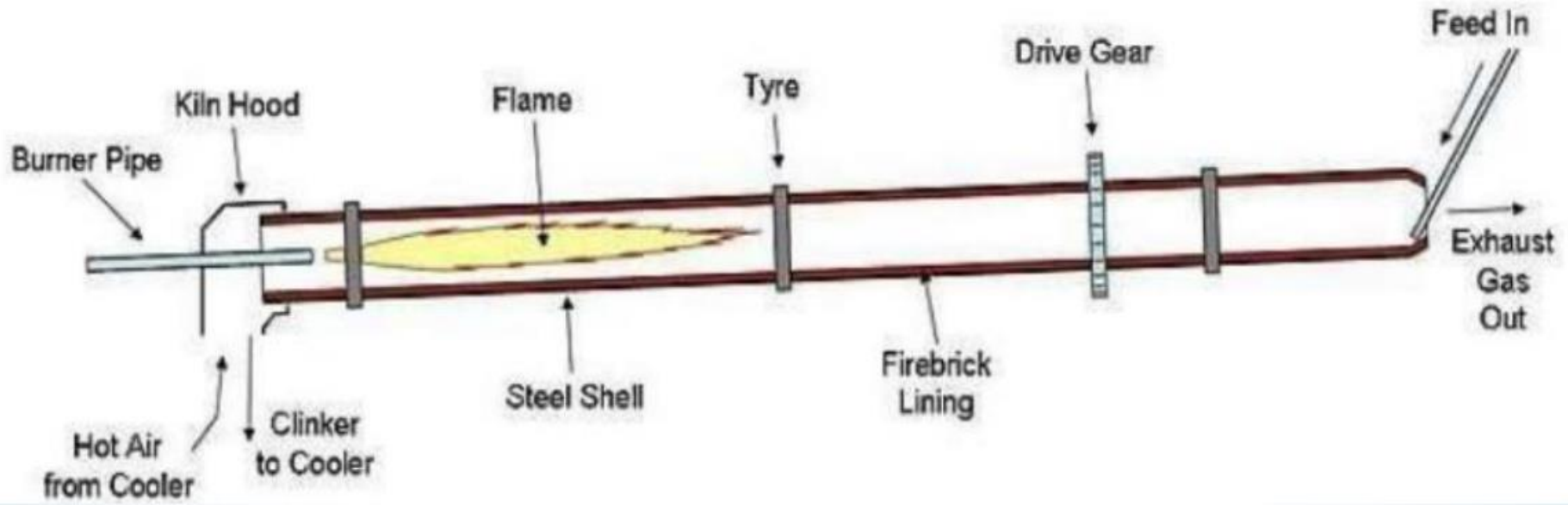
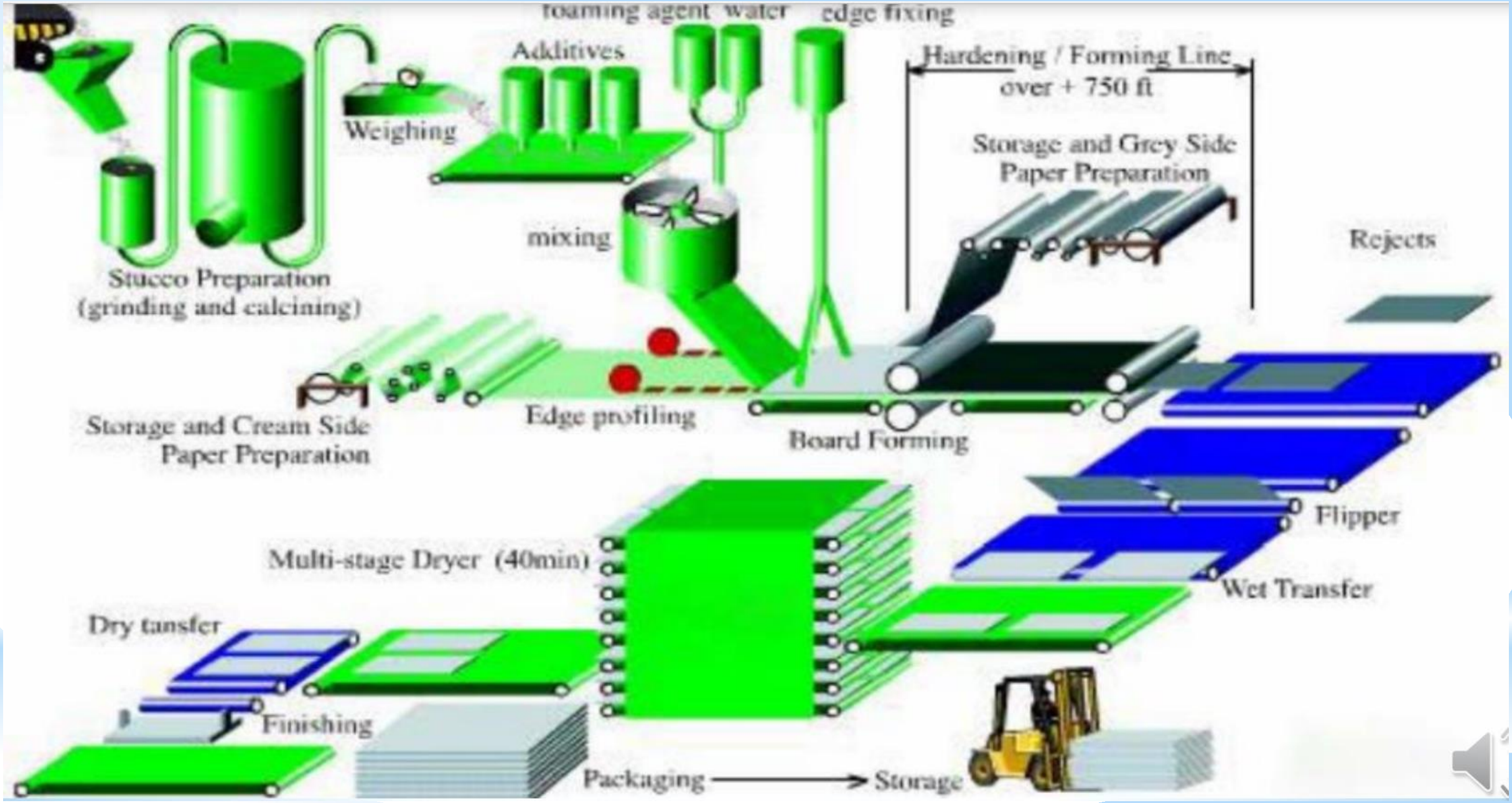


Fig: Design of Kettle gypsum kiln

Rotary Kilns




foaming agent water
edge fixing
Additives
Weighing
Hardening / Forming Line
over + 750 ft
Storage and Grey Side
Paper Preparation
mixing
Rejects
Stucco Preparation
(grinding and calcining)
Storage and Cream Side
Paper Preparation
Edge profiling
Board Forming
Flipper
Wet Transfer
Multi-stage Dryer (40min)
Dry tansfer
Finishing
Packaging
Storage

Gypsum Products Properties

1) Fire Properties:

- Due to the natural composition of Gypsum, gypsum plasterboards are inherently fire resistant.
- In nature, Gypsum occurs in the form of crystals.
- The presence of water in Gypsum (H_2O), one square meter of plasterboard of 15mm thickness contains around 3 liters crystal water.
- Through the action of fire, the crystal water evaporates and a protective layer of Gypsum is formed.
- Behind this layer, the material under fire attack, remains at constant temperature around 100°C as long as water is released from the Gypsum.
- The inclusion of glass fibers in Gypsum boards enhances their fire protection performance by maintaining the integrity of the board in a fire.
- Gypsum is a powerful fire retardant element in the construction sector due to its non-combustibility and ability to delay for up to 4 hours - according to the number of plasterboards in the corresponding system - the progression of fire.

2) Acoustic Properties :

- The Gypsum Industry has a beneficial impact on noise reduction as it produces special acoustic grade plasterboard which offers greater sound extinction which can be applied where a particularly high performance is required.
- Drywall systems provide effective sound insulation because they are designed to provide a physical barrier to sound, incorporate a sound break and minimize reverberation.
- Between the two sides of the partition there is an air cavity, which interrupts the flow of sound.
- Because the two sides of the partition are separate it is harder for impact sound to pass through.
- These characteristics mean that a typical drywall partition in a house can be only 75mm thick. A comparable masonry wall would need to be 110mm thick to achieve the same sound performance.

3) Thermal Properties :

•Lightweight building techniques (plasterboard on the framework)can supply excellent thermal performance since the construction has a cavity that can be filled with the required amount of insulation.

•The interior plasterboards protect the insulating material and contribute, together with the vapor barrier, in preventing indoor humidity from getting in, or being trapped in, the insulation material.

• Gypsum equilibrates humidity and heat peaks.

•Gypsum is capable of storing humidity when a room is humid and automatically releasing this humidity if the indoor air becomes too dry.

•Plasterboards have also a “heat-storing” ability. Small temperature increases are absorbed and radiated back later when the temperature in the room decreases.

4) Aesthetics and Design:

•A richness of forms can be created in plasterboard or stucco.

•For architects, building with gypsum products allows them to unleash their creativity thus allowing them to answer, even more dramatically, to the demands of their customers while remaining within an affordable budget.

•In short, Gypsum allows the creation of stunning interiors in any and all styles, from the Classical to the Modern.

5) Ease of Installation:

•One of the principal reasons for this rapidly growing popularity is the ease of installation.

•To construct an internal wall, for example, a frame is erected, a plasterboard is fitted to it, joints are filled, and the wall is created.

•The operation is clean, dry, and uncomplicated.

•A gypsum finish can also be applied to the surface of the plasterboard in order to achieve a superior finished appearance.